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Contents

Contributors ........................................................................................................................................................... v

Preface .................................................................................................................................................................. vii

Review Preparation Guide ................................................................................................................................. ix

Standard Abbreviations ................................................................................................................................... xiii

USMLE Step 1 Common Laboratory Values ...................................................................................................... xv

1. Anatomy ........................................................................................................................................................... 1
   TAIHUNG DUONG, PhD
   Questions ..................................................................................................................................................... 1
   Answers and Explanations ......................................................................................................................... 30
   Bibliography ......................................................................................................................................................... 55

2. Physiology .......................................................................................................................................................... 57
   GABI NINDL WAITE, PhD, BRIAN G. KENNEDY, PhD, AND STEPHEN ECHTENKAMP, PhD
   Questions ..................................................................................................................................................... 57
   Answers and Explanations ......................................................................................................................... 82
   Bibliography ......................................................................................................................................................... 108

3. Biochemistry .................................................................................................................................................... 109
   MICHAEL W. KING, PhD
   Questions ..................................................................................................................................................... 109
   Answers and Explanations ......................................................................................................................... 132
   Bibliography ......................................................................................................................................................... 174

4. Microbiology ................................................................................................................................................... 175
   JAMES D. KETTERING, PhD
   Questions ..................................................................................................................................................... 175
   Answers and Explanations ......................................................................................................................... 198
   Bibliography ......................................................................................................................................................... 228

5. Pathology ....................................................................................................................................................... 229
   KAREN D. TSOULAS, MD, EdD
   Questions ..................................................................................................................................................... 229
   Answers and Explanations ......................................................................................................................... 256
   Bibliography ......................................................................................................................................................... 288
### Contents

6. Pharmacology............................................................................................................................................... 289  
   BERTRAM G. KATZUNG, MD, PhD  
   Questions ................................................................. 289  
   Answers and Explanations ........................................ 307  
   Bibliography ......................................................... 333  

7. Behavioral Sciences ................................................................. 335  
   HOYLE LEIGH, MD  
   Questions ................................................................. 335  
   Answers and Explanations ........................................ 342  
   Bibliography ......................................................... 348  

8. Practice Test 1 ........................................................................ 349  
   Questions ................................................................. 349  
   Answers and Explanations ........................................ 359  
   Bibliography ......................................................... 371  

9. Practice Test 2 ........................................................................ 373  
   Questions ................................................................. 373  
   Answers and Explanations ........................................ 382  

10. Practice Test 3 ..................................................................... 395  
   Questions ................................................................. 395  
   Answers and Explanations ........................................ 404  

11. Practice Test 4 ..................................................................... 417  
   Questions ................................................................. 417  
   Answers and Explanations ........................................ 426  

12. Practice Test 5 ..................................................................... 439  
   Questions ................................................................. 439  
   Answers and Explanations ........................................ 449  

13. Practice Test 6 ..................................................................... 461  
   Questions ................................................................. 461  
   Answers and Explanations ........................................ 470  

14. Practice Test 7 ..................................................................... 481  
   Questions ................................................................. 481  
   Answers and Explanations ........................................ 491  

Index ................................................................................................. 503  

Color insert appears after the Index.
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Success on the United States Medical Licensing Examination (USMLE) Step 1 requires a thorough understanding of the basic sciences covered in the first and second years of medical education. To offer the most complete and accurate review book, we assembled a team of authors and editors from around the country who are engaged in various specialties and involved in both academic and clinical settings. The author team was asked to research and write test questions using the parameters set forth by the National Board of Medical Examiners (NBME).

All the subjects, types of questions, and techniques that will be encountered on the USMLE Step 1 are presented in this book.

*Lange Q&A: USMLE Step 1* is designed to provide you with a comprehensive review of the basic sciences as well as a valuable self-assessment tool for exam preparation. A total of 1200 questions are included in this edition.

### Key Features and Use

- Approximately 150 questions are covered in each of the basic sciences: Anatomy, Physiology, Biochemistry, Microbiology, Pathology, Pharmacology, and Behavioral Sciences.
- Questions are followed by a section with answers and detailed explanations referenced to the most current and popular resources available.
- Seven practice tests simulating the USMLE Step 1 are included at the end of this text.
- We believe that you will find the questions, explanations, and format of *Lange Q&A: USMLE Step 1* to be of great assistance to you during your review. We wish you luck on the USMLE Step 1.

*The Editor and the Publisher*
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If you are planning to prepare for the USMLE Step 1, then this book is designed for you. Here, in one package, is a comprehensive review resource with 1200 examination-type basic science, multiple-choice questions with referenced, paragraph-length explanations of each answer. In addition, the last section of the book offers seven comprehensive practice tests for self-assessment purposes.

This introduction provides specific information on the USMLE Step 1, information on question types, question-answering strategies, and various ways to use this review.

**The USMLE Step 1**

The USMLE Step 1 has approximately 350 multiple-choice test items, divided into seven blocks of 50 questions, which are administered via computer.

Students are allotted 1 hour to complete each question block. The exam is designed to test knowledge of Anatomy, Physiology, Biochemistry, Microbiology, Pathology, Pharmacology, and Behavioral Sciences. The questions have been proffered by senior academic faculty to test comprehension of basic science concepts that they feel are relevant to the future successful practice of medicine.

To correctly answer these test questions, examinees may be required to recall memorized facts, to use deductive reasoning, or both. A minority of the questions will employ graphs, photographs, or line drawings that require interpretation.

The application materials you receive for the USMLE Step 1 will more fully discuss the exam procedure, rules of test administration, types of questions asked, and the scope of material you may be tested on.

**Organization of this Book**

This book is organized to cover sequentially each of the basic science areas specified by the National Board of Medical Examiners. There are seven sections, one for each of the basic sciences, plus three integrated practice tests at the end of the review. The sections are as follows:

1. Anatomy (including gross and microscopic anatomy, neuroanatomy, and development and control mechanisms).
2. Physiology (including general and cellular functions, major body system physiology, energy balance, and fluid and electrolyte balance).
3. Biochemistry (including energy metabolism, major metabolic pathways of small molecules, major tissue and cellular structures, properties, and functions, biochemical aspects of cellular and molecular biology, and special biochemistry of tissues).
4. Microbiology (including microbial structure and composition, cellular metabolism, physiology, and regulation, microbial and molecular genetics, immunology, bacterial pathogens, virology, and medical mycology and parasitology).
5. Pathology (including general and systemic pathology and pathology of syndromes and complex reactions).
6. Pharmacology (including general principles, major body system agents, vitamins, chemotherapeutic agents, and poisoning and therapy of intoxication).
7. Behavioral Sciences (including behavioral biology, individual, interpersonal, and social behavior, and culture and society).
8. Practice Tests (each includes 50 questions from all seven basic sciences, presented in an integrated format).

Each of the chapters is organized in the following order: Questions, Answers and Explanations, and Bibliography. These sections and how you might use them are discussed below.

**Question Formats**

The style and presentation of the questions have been fully revised to conform to the USMLE Step 1. This will enable you to familiarize yourself with the types of questions to be expected, and provide practice in recalling your knowledge in each format.

Following the answers in each chapter is a list of suggested references for additional consultation.

Each of the seven basic science chapters contains multiple choice questions composed in the Single Best Answer query format (example question 1). This is the most frequently encountered format in the USMLE Step 1. It generally contains a brief statement, followed by five options of which only one is entirely correct. The answer options on the USMLE are lettered A, B, C, D, and E. Although the format for this question type is straightforward, the questions can be difficult because some of the distractors in the answer list are partially correct.

An example of this question format follows:

**DIRECTIONS (Question 1):** Each of the numbered items or incomplete statements in this section is followed by answers or by completions of the statement. Select the one lettered answer or completion that is best in each case.

1. Liquefaction necrosis is the characteristic result of infarcts in the
   (A) brain
   (B) heart
   (C) kidney
   (D) spleen
   (E) small intestine

   The correct answer is (A). There are two ways to attack this style of question. If after reading the query an answer immediately comes to mind, then look for it in the answer list. Alternatively, if no answer immediately comes to mind, or if the answer you thought was obvious is not a choice, then you will need to spend time examining all of the answer options to find the correct one. In this case, anything you can do to eliminate an answer option will increase your odds of choosing the correct answer.

   With this in mind, scan all of the possible answers. Eliminate any that are clearly wrong and all that are only partially right. Even if you can eliminate one or two of the answer choices by this method you will have significantly increased your chance of guessing the right answer from the remaining choices. Always answer every question, even if you have to guess among all five answer choices, because there is no penalty for a wrong answer. Your test score is dependent only on the number of correct answers obtained.

**Strategies for Answering Single Best Answer Questions**

1. Remember that only one choice can be the correct answer.
2. Read the question carefully to be sure that you understand what is being asked.
3. If you immediately know the answer, look for it in the answer choices.
4. If no answer is immediately obvious, quickly scan all the five answer choices for familiarity.
5. Eliminate any answer that is completely wrong or only partially correct. This increases your odds of picking the correct answer from a lesser number of remaining answer choices.
6. If two of the remaining choices are mutually exclusive, the correct answer is probably one of them.
7. Always answer every question even if you have to guess.
8. Don’t spend too much time with any one question.

To finish each 60-minute session you will need to answer a question about every 70 seconds.

**Practice Tests**

The seven 50-question practice tests at the end of the book consist of questions from each of the seven basic sciences. This format mimics the actual exam and enables you to test your skill at answering questions in all of the basic sciences under simulated examination conditions.
The practice test section is organized in a similar format as the seven earlier sections: Questions, Answers and Explanations, and a Subject List. The Bibliography for the practice tests is at the end of Chapter 14.

How to Use this Book

There are two logical ways to get the most value from this book. We will call them Plan A and Plan B.

In Plan A, you go straight to the Practice Tests and complete them according to the instructions. This will be a good indicator of your initial knowledge of the subject and will help you identify specific areas for preparation and review. You can now use the first seven chapters of the book to help you improve your relative weak points.

In Plan B, you go through Chapters 1 through 7 checking off your answers and then comparing your choices with the answers and discussions in the book. Once you have completed this process, you can take the Practice Tests and see how well prepared you are. If you still have a major weakness, it should be apparent in time for you to take remedial action.

In Plan A, by taking the Practice Tests first, you get quick feedback regarding your initial areas of strength and weakness. You may find that you have a good command of the material, indicating that perhaps only a cursory review of the seven chapters is necessary. This, of course, would be good to know early on in your exam preparation.

On the other hand, you may find that you have many areas of weakness. In this case, you could then focus on these areas in your review not just with this book, but also with the cited references and with your current textbooks.

It is, however, unlikely that you will not do some studying prior to taking the USMLE (especially since you have this book). Therefore, it may be more realistic to take the Practice Tests after you have reviewed the first seven chapters (as in Plan B). This will probably give you a more realistic type of testing situation since very few of us just sit down to a test without studying. In this case, you will have done some reviewing (from superficial to in-depth), and your Practice Tests will reflect this studying time. If, after reviewing the first seven chapters and taking the Practice Tests, you still have some weaknesses, you can then go back to the first seven chapters and supplement your review with your texts.

Specific Information on the Step 1 Examination

The official source of all information with respect to the United States Medical Licensing Examination Step 1 is the National Board of Medical Examiners (NBME), 3930 Chestnut Street, Philadelphia, PA 19104 (www.nbme.org). Established in 1915, the NBME is a voluntary, nonprofit, independent organization whose sole function is the design, implementation, distribution, and processing of a vast bank of question items, certifying examinations, and evaluative services in the professional medical field. You should contact the NBME directly for information regarding eligibility to sit for the USMLE, or visit the USMLE web site at www.usmle.org.

Scoring

Because there is no deduction for wrong answers, you should answer every question. Your test is scored in the following way:

1. The number of questions answered correctly is totaled. This is called the raw score.
2. The raw score is converted statistically to a “standard” score on a scale of 200–800, with the mean set at 500. Each 100 points away from 500 is one standard deviation.
3. Your score is compared statistically with the criteria set by the scores of the second-year medical school candidates for certification in the June administration during the prior 4 years. This is what is meant by the term, “criterion referenced test.”
4. A score of 500 places you around the 50th percentile.

A score of 380 is the minimum passing score for Step 1; this probably represents about the 12th to 15th percentile. If you answer 50 percent or so of the questions correctly, you will probably receive a passing score.

Remember: You do not have to pass all seven basic science components, although you will receive
a standard score in each of them. A score of less than 400 (about the 15th percentile) on any particular area is a real cause for concern as it will certainly drag down your overall score. Likewise, a 600 or better (85th percentile) is an area of great relative strength. (You can use the practice test included in this book to help determine your areas of strength and weakness well in advance of the actual examination.)

Physical Conditions

The NBME is very concerned that all their exams be administered under uniform conditions in the numerous centers that are used. Since 1999, the USMLE examination has been administered electronically.

Please visit www.nmbe.org for details, or contact your local Prometric center for scheduling and further information.
### Standard Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACTH</td>
<td>adrenocorticotropic hormone</td>
</tr>
<tr>
<td>ADH</td>
<td>antidiuretic hormone</td>
</tr>
<tr>
<td>ADP</td>
<td>adenosine diphosphate</td>
</tr>
<tr>
<td>AFP</td>
<td>alpha-fetoprotein</td>
</tr>
<tr>
<td>AMP</td>
<td>adenosine monophosphate</td>
</tr>
<tr>
<td>ATP</td>
<td>adenosine triphosphate</td>
</tr>
<tr>
<td>ATPase</td>
<td>adenosine triphosphatase</td>
</tr>
<tr>
<td>bid</td>
<td>two times a day</td>
</tr>
<tr>
<td>BP</td>
<td>blood pressure</td>
</tr>
<tr>
<td>BUN</td>
<td>blood urea nitrogen</td>
</tr>
<tr>
<td>CT</td>
<td>computed tomography</td>
</tr>
<tr>
<td>CBC</td>
<td>complete blood count</td>
</tr>
<tr>
<td>CCU</td>
<td>coronary care unit</td>
</tr>
<tr>
<td>CNS</td>
<td>central nervous system</td>
</tr>
<tr>
<td>CPK</td>
<td>creatine phosphokinase</td>
</tr>
<tr>
<td>CSF</td>
<td>cerebrospinal fluid</td>
</tr>
<tr>
<td>DNA</td>
<td>deoxyribonucleic acid</td>
</tr>
<tr>
<td>DNase</td>
<td>deoxyribonuclease</td>
</tr>
<tr>
<td>ECG</td>
<td>electrocardiogram</td>
</tr>
<tr>
<td>EDTA</td>
<td>ethylenediaminetetraacetate</td>
</tr>
<tr>
<td>EEG</td>
<td>electroencephalogram</td>
</tr>
<tr>
<td>ER</td>
<td>emergency room</td>
</tr>
<tr>
<td>FAD</td>
<td>flavin adenine dinucleotide</td>
</tr>
<tr>
<td>FSH</td>
<td>follicle-stimulating hormone</td>
</tr>
<tr>
<td>GI</td>
<td>gastrointestinal</td>
</tr>
<tr>
<td>GU</td>
<td>genitourinary</td>
</tr>
<tr>
<td>Hb</td>
<td>hemoglobin</td>
</tr>
<tr>
<td>hCG</td>
<td>human chorionic gonadotropin</td>
</tr>
<tr>
<td>HDL</td>
<td>high-density lipoprotein</td>
</tr>
<tr>
<td>Hct</td>
<td>hematocrit</td>
</tr>
<tr>
<td>IgA, etc.</td>
<td>immunoglobulin A, etc.</td>
</tr>
<tr>
<td>IM</td>
<td>intramuscular(ly)</td>
</tr>
<tr>
<td>IQ</td>
<td>intelligence quotient</td>
</tr>
<tr>
<td>IU</td>
<td>international unit</td>
</tr>
<tr>
<td>IV</td>
<td>intravenous(ly)</td>
</tr>
<tr>
<td>KUB</td>
<td>kidney, ureter, and bladder</td>
</tr>
<tr>
<td>LDH</td>
<td>lactic dehydrogenase</td>
</tr>
<tr>
<td>LDL</td>
<td>low-density lipoprotein</td>
</tr>
<tr>
<td>LH</td>
<td>luteinizing hormone</td>
</tr>
<tr>
<td>LSD</td>
<td>lysergic acid diethylamide</td>
</tr>
<tr>
<td>mRNA</td>
<td>messenger RNA</td>
</tr>
<tr>
<td>NAD</td>
<td>nicotinamide adenine dinucleotide</td>
</tr>
<tr>
<td>NADP</td>
<td>nicotinamide adenine dinucleotide phosphate</td>
</tr>
<tr>
<td>PO</td>
<td>oral(ly)</td>
</tr>
<tr>
<td>prn</td>
<td>as needed</td>
</tr>
<tr>
<td>RBC</td>
<td>red blood cell</td>
</tr>
<tr>
<td>RNA</td>
<td>ribonucleic acid</td>
</tr>
<tr>
<td>RNase</td>
<td>ribonuclease</td>
</tr>
<tr>
<td>rRNA</td>
<td>ribosomal RNA</td>
</tr>
<tr>
<td>SC</td>
<td>subcutaneous(ly)</td>
</tr>
<tr>
<td>SGOT</td>
<td>serum glutamic oxaloacetic transaminase</td>
</tr>
<tr>
<td>SGPT</td>
<td>serum glutamic pyruvic transaminase</td>
</tr>
<tr>
<td>TB</td>
<td>Tuberculosis</td>
</tr>
<tr>
<td>tRNA</td>
<td>transfer RNA</td>
</tr>
<tr>
<td>TSH</td>
<td>thyroid-stimulating hormone</td>
</tr>
<tr>
<td>WBC</td>
<td>white blood cell</td>
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<table>
<thead>
<tr>
<th><strong>REFERENCE RANGE</strong></th>
<th><strong>SI REFERENCE INTERVALS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BLOOD, PLASMA, SERUM</strong></td>
<td></td>
</tr>
<tr>
<td>* Alanine aminotransferase (ALT, GPT at 30 EC)</td>
<td>8–20 U/L</td>
</tr>
<tr>
<td>Alpha-fetoprotein</td>
<td>Adult: &lt;40 ng/mL</td>
</tr>
<tr>
<td>Amylase, serum</td>
<td>25–125 U/L</td>
</tr>
<tr>
<td>* Aspartate aminotransferase (AST, GOT at 30 EC)</td>
<td>8–20 U/L</td>
</tr>
<tr>
<td>Bilirubin, serum (adult)</td>
<td>Total // Direct</td>
</tr>
<tr>
<td>* Calcium, serum (Ca(^{2+}))</td>
<td>8.4–10.2 mg/dL</td>
</tr>
<tr>
<td>* Cholesterol, serum</td>
<td>Rec:&lt;200 mg/dL</td>
</tr>
<tr>
<td>* Cortisol, serum</td>
<td>0800 h: 5–23 μg/dL // 1600 h: 3–15 μg/dL</td>
</tr>
<tr>
<td>* Creatine kinase, serum</td>
<td>Male: 25–90 U/L</td>
</tr>
<tr>
<td>* Creatinine, serum</td>
<td>0.6–1.2 mg/dL</td>
</tr>
<tr>
<td>Electrolytes, serum</td>
<td>Sodium (Na(^+))</td>
</tr>
<tr>
<td>Chloride (Cl(^–))</td>
<td>95–105 meq/L</td>
</tr>
<tr>
<td>* Potassium (K(^+))</td>
<td>3.5–5.0 meq/L</td>
</tr>
<tr>
<td>Bicarbonate (HCO(_3)(^–))</td>
<td>22–28 meq/L</td>
</tr>
<tr>
<td>Magnesium (Mg(^{2+}))</td>
<td>1.5–2.0 meq/L</td>
</tr>
<tr>
<td>Estriol, total, serum (in pregnancy)</td>
<td>24–28 weeks // 32–36 weeks</td>
</tr>
<tr>
<td>28–32 weeks // 36–40 weeks</td>
<td>40–220 ng/mL // 80–350 ng/mL</td>
</tr>
<tr>
<td>Ferritin, serum</td>
<td>Male: 15–200 ng/mL</td>
</tr>
<tr>
<td>Female: 12–150 ng/mL</td>
<td>12–150 μg/L</td>
</tr>
<tr>
<td>Follicle-stimulating hormone, serum/plasma</td>
<td>Male: 4–25 mIU/mL</td>
</tr>
<tr>
<td>Female:</td>
<td>Premenopause 4–30 mIU/mL</td>
</tr>
<tr>
<td></td>
<td>Midcycle peak 10–90 mIU/mL</td>
</tr>
<tr>
<td></td>
<td>Postmenopause 40–250 mIU/mL</td>
</tr>
<tr>
<td>Gases, arterial blood (room air)</td>
<td>pH</td>
</tr>
<tr>
<td></td>
<td>PCO(_2)</td>
</tr>
<tr>
<td></td>
<td>PO(_2)</td>
</tr>
<tr>
<td>* Glucose, serum</td>
<td>Fasting: 70–110 mg/dL</td>
</tr>
<tr>
<td></td>
<td>2-h postprandial: &lt;120 mg/dL</td>
</tr>
<tr>
<td>Growth hormone—arginine stimulation</td>
<td>Fasting: &lt;5 ng/mL</td>
</tr>
<tr>
<td></td>
<td>provocative stimuli: &gt;7 ng/mL</td>
</tr>
<tr>
<td>Immunoglobulins, serum</td>
<td>IgA</td>
</tr>
<tr>
<td></td>
<td>IgE</td>
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<tr>
<td></td>
<td>IgG</td>
</tr>
<tr>
<td></td>
<td>IgM</td>
</tr>
<tr>
<td>Lactate dehydrogenase, serum</td>
<td>45–90 U/L</td>
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<tr>
<td>Luteinizing hormone, serum/plasma</td>
<td>Male: 6–23 mIU/mL</td>
</tr>
<tr>
<td>Female:</td>
<td>Follicular phase 5–30 mIU/mL</td>
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<tr>
<td></td>
<td>Midcycle 75–150 mIU/mL</td>
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<tr>
<td></td>
<td>Postmenopause 30–200 mIU/mL</td>
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<tr>
<td>Osmolality, serum</td>
<td>275–295 mOsm/kg</td>
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<tr>
<td>Parathyroid hormone, serum, N-terminal</td>
<td>230–630 pg/mL</td>
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<tr>
<td>* Phosphatase (alkaline), serum (P-NPP at 30 EC)</td>
<td>20–70 U/L</td>
</tr>
<tr>
<td>* Phosphorus (inorganic), serum</td>
<td>3.0–4.5 mg/dL</td>
</tr>
<tr>
<td>Prolactin, serum (hPRL)</td>
<td>&lt;20 ng/mL</td>
</tr>
<tr>
<td>* Proteins, serum</td>
<td>Total (recumbent)</td>
</tr>
<tr>
<td></td>
<td>Albumin</td>
</tr>
<tr>
<td></td>
<td>Globulin</td>
</tr>
<tr>
<td>Thyroid-stimulating hormone, serum or plasma</td>
<td>0.5–5.0 μU/mL</td>
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<tr>
<td>Thyroidal iodine (123I) uptake</td>
<td>8–30% of administered does/24 h</td>
</tr>
<tr>
<td>Thyroxine (T(_4)) serum</td>
<td>5–12 μg/dL</td>
</tr>
<tr>
<td>Triglycerides, serum</td>
<td>35–160 mg/dL</td>
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<th>Measure</th>
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<tbody>
<tr>
<td><strong>Triiodothyroxine (T3), serum (RIA)</strong></td>
<td>115–190 ng/dL</td>
<td>1.8–2.9 nmol/L</td>
</tr>
<tr>
<td><strong>Triiodothyronine (T3) resin uptake</strong></td>
<td>25–35%</td>
<td>0.25–0.35</td>
</tr>
<tr>
<td>* Urea nitrogen, serum (BUN)</td>
<td>7–18 mg/dL</td>
<td>1.2–3.0 mmol urea/L</td>
</tr>
<tr>
<td>* Uric acid, serum</td>
<td>3.0–8.2 mg/dL</td>
<td>0.18–0.48 mmol/L</td>
</tr>
</tbody>
</table>

**BODY MASS INDEX (BMI)**

Body mass index: Adult: 19–25 kg/m²

**CEREBROSPINAL FLUID**

<table>
<thead>
<tr>
<th>Measure</th>
<th>REFERENCE RANGE</th>
<th>SI REFERENCE INTERVALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell count</td>
<td>0–5 cells/mm³</td>
<td>0–5 x 10⁶/L</td>
</tr>
<tr>
<td>Chloride</td>
<td>118–132 meq/L</td>
<td>118–132 mmol/L</td>
</tr>
<tr>
<td>Gamma globulin</td>
<td>3–12% total proteins</td>
<td>0.03–0.12</td>
</tr>
<tr>
<td>Glucose</td>
<td>70–180 mg/dL</td>
<td>0.25–0.35</td>
</tr>
<tr>
<td>Pressure</td>
<td>70–180 mm H₂O</td>
<td>70–180 mm H₂O</td>
</tr>
<tr>
<td>Proteins, total</td>
<td>&lt;40 mg/dL</td>
<td>&lt;0.40 g/L</td>
</tr>
</tbody>
</table>

**HEMATOLOGIC**

<table>
<thead>
<tr>
<th>Measure</th>
<th>REFERENCE RANGE</th>
<th>SI REFERENCE INTERVALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bleeding time (template)</td>
<td>2–7 min</td>
<td>2–7 min</td>
</tr>
<tr>
<td>Erythrocyte count</td>
<td>Male: 4.3–5.9 million/mm³</td>
<td>4.3–5.9 x 10¹²/L</td>
</tr>
<tr>
<td></td>
<td>Female: 3.5–5.6 million/mm³</td>
<td>3.5–5.6 x 10¹²/L</td>
</tr>
<tr>
<td>Erythrocyte sedimentation rate (Westergren)</td>
<td>Male: 0–15 mm/h</td>
<td>0–15 mm/h</td>
</tr>
<tr>
<td></td>
<td>Female: 0–20 mm/h</td>
<td>0–20 mm/h</td>
</tr>
<tr>
<td>Hematocrit</td>
<td>Male: 41–53%</td>
<td>0.41–0.53</td>
</tr>
<tr>
<td></td>
<td>Female: 36–46%</td>
<td>0.36–0.46</td>
</tr>
<tr>
<td>Hemoglobin A₁c</td>
<td>≤6%</td>
<td>≤0.06%</td>
</tr>
<tr>
<td>Hemoglobin, blood</td>
<td>Male: 13.5–17.5 g/dL</td>
<td>2.09–2.71 mmol/L</td>
</tr>
<tr>
<td></td>
<td>Female: 12.0–16.0 g/dL</td>
<td>1.86–2.48 mmol/L</td>
</tr>
<tr>
<td>Hemoglobin, plasma</td>
<td>1–4 mg/dL</td>
<td>0.16–0.62 mmol/L</td>
</tr>
<tr>
<td>Leukocyte count and differential</td>
<td>4500–11,000/mm³</td>
<td>4.5–11.0 x 10⁹/L</td>
</tr>
<tr>
<td>Leukocyte count</td>
<td>54–62%</td>
<td>0.54–0.62</td>
</tr>
<tr>
<td></td>
<td>3–5%</td>
<td>0.03–0.05</td>
</tr>
<tr>
<td>Eosinophils</td>
<td>1–3%</td>
<td>0.01–0.03</td>
</tr>
<tr>
<td>Basophils</td>
<td>0–0.75%</td>
<td>0–0.0075</td>
</tr>
<tr>
<td>Lymphocytes</td>
<td>25–33%</td>
<td>0.25–0.33</td>
</tr>
<tr>
<td>Monocytes</td>
<td>3–7%</td>
<td>0.03–0.07</td>
</tr>
<tr>
<td>Mean corpuscular hemoglobin</td>
<td>25.4–34.6 pg./cell</td>
<td>0.39–0.45 pg/cell</td>
</tr>
<tr>
<td>Mean corpuscular hemoglobin concentration</td>
<td>31–36% Hb/cell</td>
<td>4.81–5.58 mmol Hb/L</td>
</tr>
<tr>
<td>Mean corpuscular volume</td>
<td>80–100 μm³</td>
<td>80–100 fL</td>
</tr>
<tr>
<td>Partial thromboplastin time (activated)</td>
<td>25–40 s</td>
<td>25–40 s</td>
</tr>
<tr>
<td>Platelet count</td>
<td>150,000–400,000/mm³</td>
<td>150–400 x 10⁹/L</td>
</tr>
<tr>
<td>Prothrombin time</td>
<td>11–15 s</td>
<td>11–15 s</td>
</tr>
<tr>
<td>Reticulocyte count</td>
<td>0.5–1.5% of red cells</td>
<td>0.005–0.015</td>
</tr>
<tr>
<td>Thrombin time</td>
<td>&lt;2 s deviation from control</td>
<td>&lt;2 s deviation from control</td>
</tr>
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</table>

**VOLUME**

<table>
<thead>
<tr>
<th>Measure</th>
<th>REFERENCE RANGE</th>
<th>SI REFERENCE INTERVALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasma</td>
<td>Male: 25–43 mL/kg</td>
<td>0.025–0.043 L/kg</td>
</tr>
<tr>
<td></td>
<td>Female: 28–45 mL/kg</td>
<td>0.028–0.045 L/kg</td>
</tr>
<tr>
<td>Red cell</td>
<td>Male: 20–36 mL/kg</td>
<td>0.020–0.036 L/kg</td>
</tr>
<tr>
<td></td>
<td>Female: 19–31 mL/kg</td>
<td>0.019–0.031 L/kg</td>
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</table>

**SWEAT**

<table>
<thead>
<tr>
<th>Measure</th>
<th>REFERENCE RANGE</th>
<th>SI REFERENCE INTERVALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloride</td>
<td>0.35 mmol/L</td>
<td>0–35 mmol/L</td>
</tr>
</tbody>
</table>

**URINE**

<table>
<thead>
<tr>
<th>Measure</th>
<th>REFERENCE RANGE</th>
<th>SI REFERENCE INTERVALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>100–300 mg/24 h</td>
<td>2.5–7.5 mmol/24 h</td>
</tr>
<tr>
<td>Chloride</td>
<td>Varies with intake</td>
<td>Varies with intake</td>
</tr>
<tr>
<td>Creatinine clearance</td>
<td>Male: 97–137 mL/min</td>
<td>Varies with intake</td>
</tr>
<tr>
<td></td>
<td>Female: 88–128 mL/min</td>
<td></td>
</tr>
<tr>
<td>Estriol, total (in pregnancy)</td>
<td>30 weeks: 6–18 mg/24 h</td>
<td>21–62 μmol/24 h</td>
</tr>
<tr>
<td></td>
<td>35 weeks: 9–28 mg/24 h</td>
<td>31–97 μmol/24 h</td>
</tr>
<tr>
<td></td>
<td>40 weeks: 15–42 mg/24 h</td>
<td>45–146 μmol/24 h</td>
</tr>
<tr>
<td>17-Hydroxycorticosteroids</td>
<td>Male: 3.0–10.0 mg/24 h</td>
<td>8.2–27.6 μmol/24 h</td>
</tr>
<tr>
<td></td>
<td>Female: 2.0–8.0 mg/24 h</td>
<td>5.5–22 μmol/24 h</td>
</tr>
<tr>
<td>17-Ketosteroids, total</td>
<td>Male: 8–20 mg/24 h</td>
<td>28–70 μmol/24 h</td>
</tr>
<tr>
<td></td>
<td>Female: 6–15 mg/24 h</td>
<td>21–52 μmol/24 h</td>
</tr>
<tr>
<td>Osmolality</td>
<td>50–1400 mOsm/kg</td>
<td></td>
</tr>
<tr>
<td>Oxalate</td>
<td>8–40 μg/mL</td>
<td>90–445 μg/mL</td>
</tr>
<tr>
<td>Potassium</td>
<td>Varies with diet</td>
<td>Varies with diet</td>
</tr>
<tr>
<td>Proteins, total</td>
<td>&lt;150 mg/24 h</td>
<td>&lt;0.15 g/24 h</td>
</tr>
<tr>
<td>Sodium</td>
<td>Varies with diet</td>
<td>Varies with diet</td>
</tr>
<tr>
<td>Uric acid</td>
<td>Varies with diet</td>
<td>Varies with diet</td>
</tr>
</tbody>
</table>

* Included in the Biochemical Profile (SMA-12)
CHAPTER 1

Anatomy

taihung duong, PhD

Questions

1. A 2-year-old male patient develops progressive generalized weakness and muscle atrophy. The impairment first began with the muscles of the hips, and then progressed to the pelvic area, thigh, and shoulder muscles. The patient is diagnosed with Duchenne’s muscular dystrophy, a congenital disorder where the protein dystrophin is deficient. Which of the following describes the role of dystrophin in muscle tissue?

(A) anchors actin to the sarcolemma
(B) endows the myosin filaments with elastic recoil properties
(C) extends from Z disk to Z disk, forming a supportive network
(D) inhibits the binding of myosin to actin
(E) protects desmin filaments from stress-induced damage

2. An 8-year-old boy is referred to a neurologist by his family physician because he has developed progressive slow and clumsy walking. On examination, the patient has difficulty with standing and running. While standing, he adopts a wide-based gait with constant shifting of position to maintain his balance. Sitting or standing, he also displays a constant tremor of the head and trunk. When asked to walk, his feet strike the ground in an uneven and irregular rhythm; if he attempts to correct his imbalance, he displays wild and abrupt movements. A magnetic resonance image (MRI) reveals demyelination in the dorsal columns, corticospinal and spinocerebellar tracts. The child is diagnosed with Friedreich’s ataxia, an autosomal recessive neurological disorder resulting from mutation of a gene locus on chromosome 9. Second-order neurons of the dorsal (posterior) spinocerebellar tracts are located in which of the following?

(A) deep cerebellar nuclei
(B) dorsal root ganglion
(C) nucleus cuneatus
(D) nucleus dorsalis (Clarke’s column)
(E) Rexed’s lamina IX of the spinal cord

3. The third week of development is characterized by the appearance of the branchial apparatus, the embryonic primordium from which head and neck structures will be derived. The apparatus consists of five branchial arches, numbered 1, 2, 3, 4 and 6. Second arch anomalies represent 95% of all branchial anomalies and are classified into four types with types I-III being the most common. The anomalies manifest as cysts or fistulae in the lateral neck, located anterior and deep to the sternocleidomastoid muscle. Which of the following structures develop from the second branchial arch?

(A) anterior digastric muscle
(B) posterior cricoarytenoid muscle
(C) posterior digastric muscle
(D) stylopharyngeus muscle
(E) superior constrictor muscle
4. A 10-year boy is examined because his parents noticed that “his eyes never seem to look in the right direction.” On examination, the left eye of the child is unable to move laterally (abduction) and when asked to look toward the nose (adduction), the eyeball retracts into the socket and the eye opening narrows. Sometimes, the eye also moves superiorly. The child is diagnosed with Duane syndrome, a congenital ocular motility disorder characterized by limited abduction of the affected eye. This is due to absence of the abducens (fifth cranial) nerve with aberrant innervation by the oculomotor (third cranial) nerve. Which of the following muscles is normally innervated by the abducens nerve?

(A) inferior oblique  
(B) lateral rectus  
(C) medial rectus  
(D) superior oblique  
(E) superior rectus

5. Retinitis pigmentosa is a hereditary disorder, which affects the photoreceptors (the rods and the cones) in the retina. These photoreceptors are located in which of the numbered layers in Fig. 1-1?

(A) 1  
(B) 2  
(C) 3  
(D) 4  
(E) 5

6. The structure indicated by arrow 1 in Fig. 1-2 is which of the following vessels?

(A) brachiocephalic artery  
(B) left brachiocephalic vein  
(C) left common carotid artery  
(D) right brachiocephalic vein  
(E) superior vena cava

7. A 4-month-old male infant is brought to the clinic because of excessive noisy respiration. On examination, the infant is within the normal range of growth, appears healthy, and does not show respiratory distress. Phonation is normal, along with head and neck examination findings. However, the child displays stridor (high-pitched breathing sound) on inspiration, accentuated in the supine position. The parents report that the same stridor is heard during feeding or when the child is agitated. The attending physician places the child in the prone position and the stridor is relieved. To confirm, she holds the child in a neck extended position, which also relieves the stridor. An endoscopic laryngeal examination reveals bulky arytenoids cartilages and the diagnosis of laryngomalacia is established. During development, the arytenoids cartilages arise from which of the following?

(A) first pharyngeal arch  
(B) second pharyngeal arch  
(C) third pharyngeal arch  
(D) fifth pharyngeal arch  
(E) sixth pharyngeal arch
8. An 8-year-old male patient is brought to a rural hospital with a history of recurrent infection. The patient has a characteristic facies with a high, broad nasal bridge, long face, narrow palpebral fissures, and an abnormally small mandible. The patient also has a cleft palate. The patient is diagnosed with DiGeorge syndrome, an inherited immunodeficiency disease due to a chromosome 22q11.2 deletion. In this syndrome, the production of which of the following cells is affected in the thymus?

   (A) B cells
   (B) endothelial cells
   (C) macrophages
   (D) neutrophils
   (E) T cells

9. A newborn infant suffers from cyanotic heart disease caused by transposition of the great arteries (TGA). In this situation, the aorta arises from which of the following structures?

   (A) ductus arteriosus
   (B) left atrium
   (C) left ventricle
   (D) right atrium
   (E) right ventricle

10. About 75% of the blood supply of the spinal cord is derived from the anterior spinal artery. This artery arises from which of the following?

    (A) artery of Adamkiewicz
    (B) basilar artery
    (C) internal carotid artery
    (D) posterior inferior cerebellar artery
    (E) vertebral artery

11. Clinical edema results when lymphatic vessels are blocked or when the volume of extracellular fluid exceeds the drainage capacity of the lymphatic vessels. Which of the following numbered structures in Fig. 1-3 is a lymphatic vessel?

    (A) 1
    (B) 2
    (C) 3
    (D) 4
    (E) 5

12. The histological structure marked by the asterisk in Fig. 1-4 is which of the following structures from the integumentary system?

    (A) aprocrine sweat gland
    (B) dermal papilla
    (C) eccrine sweat gland
    (D) hair follicle
    (E) sebaceous gland
13. Occlusion of which of the following vessels affects the entire dorsolateral part of the rostral medulla (level of the restiform body) and produces the lateral medullary (Wallenberg) syndrome?

(A) anterior inferior cerebellar artery  
(B) anterior spinal artery  
(C) posterior inferior cerebellar artery  
(D) posterior spinal artery  
(E) superior cerebellar artery

14. A third-year medical student is asked to review the computerized tomographic (CT) results of a patient with a possible abdominal aortic aneurysm. Which of the following arrows in Fig. 1-5 points to the abdominal aorta?

(A) 1  
(B) 2  
(C) 3  
(D) 4  
(E) 5

15. The chief or peptic (zymogenic) cells of the gastric glands secrete pepsinogen. The latter is converted to pepsin, a 35-kilodalton (kDa) proteolytic enzyme, when the pH in the stomach falls below 5.0. In Fig. 1-6, which of the following arrows point to the location of chief or peptic (zymogenic) cells?

(A) 1  
(B) 2  
(C) 3  
(D) 4  
(E) 5

16. A 62-year-old patient diagnosed with prostate carcinoma complains of a right-sided headache worsening over 4 days and displays a drooping right upper eyelid. Examination reveals a right third nerve palsy. An MRI reveals a single metastasis of the prostatic carcinoma in the right side of the midbrain, causing Benedikt’s syndrome. Which of the following signs would also be seen in this patient?

(A) complete paralysis of facial expression musculature on the left side  
(B) deviation of the tongue to the right  
(C) intention tremor in the left upper and lower extremity  
(D) ipsilateral hemiplegia  
(E) vertical gaze palsy
17. During a routine physical examination, you notice that your patient, a 35-year-old avid surfer, has spots of abnormal pigmentation on two of her fingers. You explain to your patient that long-term exposure to the sun increases the risk of neoplastic changes and that you would like to perform biopsies to verify the nature of the abnormal pigmentation. Referring to Fig. 1-7, cells from which layer of the epidermis are most vulnerable to neoplastic changes due to long-term exposure to the sun?

(A) 1  
(B) 2  
(C) 3  
(D) 4  
(E) 5

18. A female 44-year-old patient suffers from acute bacterial sinusitis localized to the frontal sinus. The patient displays a mucopurulent greenish discharge from the nose bilaterally, with associated fever and malaise. The patient also complains of pain over the forehead with headache. Which of the following innervates the frontal sinus?

(A) anterior ethmoidal nerve  
(B) lacrimal nerve  
(C) nasociliary nerve  
(D) posterior ethmoidal nerve  
(E) supraorbital nerve

19. In a medial medullary syndrome that involves a left-sided branch of the anterior spinal artery, which of the following deficits is seen?

(A) deviation of the tongue to the left, hemiplegia of arm and leg on the left  
(B) deviation of the tongue to the right, hemiplegia of arm and leg on the right  
(C) loss of conscious proprioception and precise tactile discrimination over the right side of the body exclusive of the face  
(D) only deviation of the tongue to the left  
(E) only hemiplegia on the right

20. A neurologist is performing the neurological examination on a patient who recently suffered a head trauma. You note that, as part of the examination, she uses a cotton swab to touch the upper part of the auricle, the external auditory meatus, and the lobule. The external auditory meatus of the ear is innervated by which of the following?

(A) vagus (tenth cranial) nerve  
(B) great auricular nerve  
(C) auriculotemporal nerve  
(D) greater occipital nerve  
(E) facial (seventh cranial) nerve
21. A 48-year-old male patient is brought to the emergency room because of intense pain of the right face and neck with transient visual loss of the right eye. On examination, the patient has palsy of the oculomotor nerve on the right side with resulting diplopia, along with a right lateralized painful Horner syndrome. This constellation of signs is suggestive of a cervical carotid dissection, which is a separation of the arterial tunical intima from the subjacent tunica media. Which numbered structure in Fig. 1-8 is the tunica intima?

(A) 1  
(B) 2  
(C) 3  
(D) 4  
(E) 5

22. The structure indicated by arrow 2 in Fig. 1-9 is which of the following?

![Fig. 1-9](image)

(A) ethmoidal sinus  
(B) inferior nasal meatus  
(C) infratemporal fossa  
(D) maxillary sinus  
(E) sphenoidal sinus

23. A young resident doing a fellowship in neuropathology is asked to review histological slides from the cerebral cortex of a 79-year-old nursing home resident, who died of multiinfarct dementia. The resident is asked to estimate the density of neurons in the infarcted brain area. To prepare himself for the task, he first reviews slides from the normal areas of the cerebral cortex. Referring to Fig. 1-10, which of the following structures does he correctly identify as neurons?

![Fig. 1-10](image)

(A) 1  
(B) 2  
(C) 3  
(D) 4  
(E) 5
24. A stroke resulting from obstruction of the structure indicated by arrow 1 in Fig. 1-11 may result in ischemia in which of the following brain regions?

(A) Broca’s area in the left frontal lobe  
(B) cerebellum  
(C) medial aspect of the right frontal lobe  
(D) pons  
(E) Wernicke’s area in the left frontal lobe

25. The structure indicated by arrow 2 in Fig. 1-11 terminates by dividing into which of the following?

(A) anterior and middle cerebral arteries  
(B) internal cerebral veins  
(C) posterior cerebral arteries  
(D) superior cerebellar arteries  
(E) vertebral arteries

26. In the brain, the amygdala plays an important role in emotional processing. Patients with lesion of the amygdala display impairment in enhanced perception of emotionally salient events. Which of the following is a major output pathway from the amygdala?

(A) fasciculus arcuatus  
(B) fasciculus cuneatus  
(C) fasciculus of Vicq d’Azyr  
(D) fornix  
(E) stria terminalis

27. An infant is born anencephalic. He presents without both a forebrain and a cerebrum. The remaining brain tissue is exposed, not covered by bone or skin. The infant is blind, deaf, unconscious, and unable to feel pain. Because the infant has a rudimentary brainstem, reflex actions such as respiration (breathing) and responses to sound or touch occur. However, the lack of a functioning cerebrum permanently rules out the possibility of ever gaining consciousness. Anencephaly is the result of a defect in which of the following?

(A) closure of the caudal neuropore  
(B) closure of the rostral neuropore  
(C) formation of the first branchial arch  
(D) formation of the somites  
(E) fusion of the metopon
28. As the consulting physician to the US Open, you are asked to examine a golfer who complains of increased pain with right wrist flexion and pronation activities. The patient also reports discomfort even when simply shaking hands with someone. Examination reveals also decreased sensation in the territory of the ulnar nerve. Your diagnosis is golfer’s elbow, affecting mostly the superficial flexor muscles of the forearm. This group of muscles has a common origin from which of the following bony landmarks?

(A) head of the radius
(B) lateral epicondyle of the humerus
(C) medial epicondyle of the humerus
(D) olecranon process of the ulna
(E) tuberosity of the radius

Questions 29 and 30

A professional football player was diving for a touchdown when his face mask was grabbed and wrenched, causing neck hyperextension and rotation to the right. When brought to the sideline, the player complained of a burning sensation radiating down the right upper extremity and neurological examination revealed right lateral weakness of this limb. Movements affected were arm rotation and flexion, elbow flexion, forearm supination, and thumb flexion. The patient is diagnosed with a brachial plexus injury at the level of C6.

29. Which of the following muscles can perform arm and elbow flexion along with forearm supination?

(A) biceps brachii
(B) brachialis
(C) brachioradialis
(D) coracobrachialis
(E) supinator

30. Which of the following innervates the muscle identified in question 29?

(A) median
(B) musculocutaneous
(C) radial
(D) suprascapular
(E) ulnar

31. In cleaning the teeth in a patient, a dental hygienist accidentally cuts the gums of the posterior two molar teeth in the lower jaw on the lateral side. The pain of this injury is registered by which of the following nerves?

(A) anterior, middle, and posterior superior alveolar nerves
(B) buccal nerve
(C) greater palatine nerve
(D) lingual nerve
(E) nasopalatine nerve

32. Recanalization of the bile duct after the 13th week after fertilization allows for bile produced in the liver to reach the duodenum. However, if recanalization fails to occur and this cannot be corrected surgically, the affected infant will need a liver transplant. During development, the liver arises from which of the following?

(A) foregut
(B) hindgut
(C) midgut
(D) pleuroperitoneal membrane
(E) septum transversum

33. In Fig. 1-12, arrow 2 points to which of the following specific structures?
34. A 48-year-old female patient is brought to the emergency room by her husband. He reports that his wife suffers from hypertension but, as a high-level executive with a lot of pressure at work, she has been neglecting to take her medication. This morning, as he entered the garage to leave for work, he found his wife lying on the ground next to her own car. She was experiencing uncontrolled flailing of the left arm and leg. What is the most likely site of brain lesion in this patient?

(A) anterior limb of the left internal capsule
(B) anterior limb of the right internal capsule
(C) cerebellum
(D) left subththalamic nucleus of Luys
(E) right subththalamic nucleus of Luys

35. During a direct inguinal hernia repair operation, the attending surgeon reminds the first-year surgical resident that an anatomical variation for the origin of the obturator artery exists. This artery normally arises from the internal iliac artery but it may also originate directly from which of the following vessels?

(A) common iliac artery
(B) external iliac artery
(C) inferior epigastric artery
(D) inferior vesical artery
(E) superior vesical artery

36. A 37-year-old rural female patient developed pain in the lower abdomen and pelvic regions. Her physician suspects a ruptured ectopic pregnancy. However, because of the isolation of the rural community, no medical imaging or laboratory procedure is available and the physician decides to perform a culdocentesis. In the latter procedure, the needle will aspirate from which of the following spaces?

(A) ovarian fossa
(B) rectouterine pouch
(C) uterine body
(D) uterine cervix
(E) vesicouterine pouch

37. Arrow 4 in Fig. 1-13 is pointing to which of the following structures?

![Fig. 1-13](image)

(A) abdominal aorta
(B) colon
(C) liver
(D) spleen
(E) stomach

38. A 64-year-old male patient suffering from diabetes has developed a cataract in the left eye. Which of the following is the most likely location of a cataract?

(A) lens anterior epithelium
(B) lens capsule
(C) substance
(D) posterior chamber
(E) vitreous cavity
39. An elderly resident of a nursing home fell down the front steps and subsequently became disoriented and lethargic. He is brought to the emergency room where an emergency MRI reveals that he has developed hydrocephalus due to a small hemorrhage obstructing the foramina of Monro. The foramina of Monro allow for communication between which of the following?

(A) fourth ventricle and cerebral aqueduct
(B) fourth ventricle and subarachnoid space
(C) lateral ventricles and third ventricle
(D) third ventricle and cerebral aqueduct
(E) third ventricle and fourth ventricle

40. Which of the following is the correct sequence of erythroid differentiation?

(A) proerythroblast, basophilic erythroblast, polychromatophilic erythroblast, normoblast, reticulocyte, mature erythrocyte
(B) proerythroblast, normoblast, reticulocyte, polychromatophilic erythroblast, basophilic erythroblast, mature erythrocyte
(C) proerythroblast, polychromatophilic erythroblast, basophilic erythroblast, reticulocyte, normoblast, mature erythrocyte
(D) proerythroblast, reticulocyte, normoblast, polychromatophilic erythroblast, basophilic erythroblast, mature erythrocyte
(E) proerythroblast, reticulocyte, polychromatophilic erythroblast, basophilic erythroblast, mature erythrocyte

41. In emphysema, which of the following components of the bronchioles is affected?

(A) ciliated cuboidal epithelial cells
(B) Clara cells
(C) elastic fibers
(D) goblet cells
(E) squamous type I alveolar epithelial cells

42. During development, the notochord grows in a cranial direction until it reaches the prechordal plate. This plate is the primordium of the oropharyngeal (or buccopharyngeal) membrane, which, in the embryo, will separate the stomodeum from the foregut. At 26 days of gestation, the oropharyngeal membrane will break down, allowing communication of the foregut with the oral cavity. Of the following structures in the adult, which one lies at the same location as the embryonic oropharyngeal membrane?

(A) buccinator
(B) palatoglossus
(C) palatopharyngeus
(D) stylopharyngeus
(E) superior constrictor

43. Referring to Fig. 1-14, arrow 2 indicates which of the following structures?

(A) intercalated disk
(B) motor end-plate
(C) sarcoplasmic reticulum
(D) tendinous junction
(E) transverse tubule or T tubule
44. The most common type of testicular cancer is germ cell carcinoma. However, testicular tumors arising from other cell types in the testis also occur. Arrow 1 in Fig. 1-15 indicates which of the following structures?

(A) Leydig cell  
(B) Sertoli cell  
(C) spermatid  
(D) spermatocyte  
(E) spermatogonia

45. In the skull, a network of thick-walled vessels named dural venous sinuses drains the cerebrospinal fluid and the venous blood from the brain. These vessels are formed by reflections of the dura mater, which also form partitions between major parts of the brain. Which of the following dural venous sinuses is associated with the falx cerebri?

(A) cavernous sinus  
(B) inferior petrosal sinus  
(C) sigmoid sinus  
(D) superior sagittal sinus  
(E) transverse sinus

46. During the first 5–7 days of life, the umbilical vein can be catherized and used for central venous pressure monitoring. The umbilical vein leads to which of the following vessels?

(A) descending aorta  
(B) ductus arteriosus  
(C) ductus venosus  
(D) inferior vena cava  
(E) portal vein

47. A patient was thrown from a tractor, which partially ran over him and caused injury to the base of the skull. The origin of the internal jugular vein at the jugular foramen was compromised. Which of the following cranial nerves courses through the jugular foramen?

(A) abducens (sixth cranial) nerve  
(B) facial (seventh cranial) nerve  
(C) hypoglossal (twelfth cranial) nerve  
(D) spinal accessory nerve (eleventh cranial) nerve  
(E) vestibulocochlear (eighth cranial) nerve

48. Protein zero ($P_0$) is the predominant protein in myelin in the peripheral nervous system and its function is to stabilize adjacent plasma membranes by interaction with similar $P_0$ molecules. Which of the following cells manufacture $P_0$?

(A) fibrous astrocytes  
(B) microglia  
(C) oligodendrocytes  
(D) protoplasmic astrocytes  
(E) Schwann cells

49. A perilunate fracture dislocation is a devastating closed injury of the wrist. It usually results from a fall where the weight of the body is transferred onto the wrist. The hand is caught in the hyperextended and ulnar deviated position. The fracture dislocation involves rupture of intersosseous ligaments, joints, and ultimately dislocation/fracture of the lunate bone. In the anatomical position, which carpal bone lies directly distal to the lunate?

(A) capitate  
(B) hamate  
(C) scaphoid  
(D) trapezoid  
(E) triquetrum
50. A 19-year-old man was in a barroom brawl and was punched squarely in the right eye. He comes to the emergency room the next day and complains of diplopia. An X-ray reveals fracture of the orbital floor. Neurological examination shows loss of sensation of the skin of the right face below the right eye and the upper gums. Which of the following nerves may be injured?

(A) frontal nerve  
(B) infraorbital nerve  
(C) nasociliary nerve  
(D) supraorbital nerve  
(E) trochlear nerve

51. Cells in the pancreas that secrete glucagon and insulin are which of the following?

(A) A and B cells  
(B) acinar cells  
(C) D cells  
(D) pancreatic D1 cells  
(E) pancreatic polypeptide cells

52. Figure 1-16 is a high magnification photomicrograph of the gall bladder. The arrow points to the internal lining that is formed by which of the following?

(A) pseudostratified columnar epithelium  
(B) simple columnar epithelium  
(C) stratified cuboidal epithelium  
(D) stratified squamous epithelium  
(E) transitional epithelium

53. A 30-year-old patient displays ataxia of extremities and asynergy with decomposition of movement. He also has dysmetria (past-pointing phenomenon), dysdiadochokinesia (the inability to perform rapidly alternating movements), and intention tremor. These neurological signs are characteristic of a lesion in the structure indicated by which arrow in Fig. 1-17?

(A) 1  
(B) 2  
(C) 3  
(D) 4  
(E) 5

54. During surgery at the root of the neck, an attending surgeon cautions her resident to locate important structures which need to be protected. One of these is the phrenic nerve, responsible for the innervation of the diaphragm and thus, respiration. The phrenic nerve can be positively identified by which of the following anatomical relationships?
(A) It is found immediately between the common carotid artery and the internal jugular vein.
(B) It lies immediately between the esophagus and the trachea.
(C) It lies on the scalenus medius muscle.
(D) It wraps around the right subclavian artery.
(E) The suprascapular and transverse cervical arteries cross over it anteriorly.

55. A premature female infant is born about 24 weeks after fertilization and develops rapid, labored breathing shortly after birth. She is immediately transferred to intensive care where she is diagnosed with hyaline membrane disease (HMD). Which of the following is most likely deficient in the infant?

(A) alveolar ducts
(B) lung surfactant
(C) terminal sacules
(D) type I alveolar cells
(E) type II alveolar cells

56. Which label in Fig. 1-18 indicates the typical plane of separation at which retinal detachment occurs?

(A) A
(B) B
(C) C
(D) D
(E) E

57. A 28-year-old male patient suffering from head trauma resulting from a car accident is brought unconscious to the emergency room. In performing the pupillary light reflex, you notice that even though the left pupil constricts when you shine a light directly into the left eye, it does not do so when you shine a light into the right eye. This is best explained by a disconnection between which of the following bilateral structures?

(A) Edinger-Westphal nucleus
(B) habenula
(C) inferior colliculus
(D) lateral geniculate nucleus
(E) medial geniculate nucleus

58. A 45-year-old female patient presents to the emergency room with a headache and complains of abnormal sensations on the left side of her body. She claims that the sensory changes came on rapidly in the last few hours. Her laboratory reports come back normal, a spinal tap reveals normal cerebrospinal fluid (CSF), and her mental ability seems good. You perform a neurological examination and find she has greatly reduced sensation on the entire left side of her body, including her face. The sensory loss includes all modalities. The motor examination is normal, as is her visual examination and hearing examination. Based on the neurological findings, which of the following thalamic nuclei would be involved?

(A) lateral and medial geniculate nuclei
(B) lateral dorsal and lateral posterior nuclei
(C) pulvinar
(D) ventral anterior and ventral lateral nuclei
(E) ventral posterior lateral and ventral posterior medial nuclei
59. A patient has been admitted for hematemesis (vomiting of blood). Endoscopic examination reveals bleeding esophageal varices resulting from portal obstruction. These varices represent anastomoses between branches of which of the following?

(A) inferior vena cava with a patent ductus venosus
(B) left gastric, azygos, and hemiazygos veins
(C) right gastric vein and the inferior vena cava
(D) superior, middle, and inferior rectal veins
(E) veins running on the ligamentum teres and the epigastric veins

60. A 15-year-old high school football player is brought to the emergency room. On examination, his right lower limb is deformed and swollen around the knee. At full extension, there is valgus instability, suggestive of knee dislocation. The patient is in great pain and there is a concern for concomitant vascular and nervous injuries. Palpation of the dorsalis pedis artery reveals a normal pulse. However, neurological examination reveals impaired dorsiflexion of the foot with decreased sensation in the space between digits 1 and 2. Which of the following nerves is affected?

(A) deep peroneal (fibular) nerve
(B) femoral nerve
(C) saphenous nerve
(D) superficial peroneal (fibular) nerve
(E) tibial nerve

61. Which structure most effectively prevents toxic molecules from penetrating an epithelium by passing between adjacent epithelial cells?

(A) desmosome
(B) gap junction
(C) hemidesmosome
(D) terminal bar
(E) tight junction

62. In the central auditory pathways, second-order neurons are located in which of the following?

(A) cochlear (spiral) ganglion
(B) cochlear nuclei
(C) inferior colliculi
(D) nuclei of lateral lemniscus
(E) superior olivary nuclei

63. Arrow 2 in Fig. 1-19 points to which of the following structures?

(A) glomerulus
(B) juxtaglomerular cells
(C) lacis cells
(D) macula densa
(E) vascular pole of the renal corpuscle

64. A gang member is rushed to the emergency room suffering from multiple stab wounds made by an ice pick. A third-year medical student rotating through emergency medicine is puzzled by the sight of a milky white substance exuding from a stab wound just superior to the right sternoclavicular joint. Which of the following structures is possibly injured at this location?

(A) the common carotid artery
(B) the cupola of the right lung
(C) the internal jugular vein
(D) the right lymphatic trunk
(E) the thoracic duct
65. A 72-year-old male patient has suffered a cerebral infarct affecting the left cerebral hemisphere. On examination of the patient, it is noticed that his verbal output is fluent and paraphasic. His comprehension of speech is normal but repetition is severely impaired. Naming is also impaired, although when given a list, the patient is able to select the correct name. Special consultation with a neurologist results in a diagnosis of conduction aphasia. Which of the following brain structures is affected?

(A) arcuate fasciculus  
(B) Broca’s area  
(C) nucleus ambiguus  
(D) red nucleus  
(E) Wernicke’s area

66. Which of the following is characterized by an absence of lymphoid follicles and germinal centers?

(A) axillary lymph node  
(B) Peyer’s patches  
(C) pharyngeal tonsil  
(D) spleen  
(E) thymus

67. A 57-year-old female patient has suffered a major stroke and as a result is in a coma. The attending neurologist is very concerned because the patient is developing ataxic breathing. The pneumotaxic center and apneustic centers of the brain are located in which of the following?

(A) diencephalon  
(B) midbrain  
(C) pons  
(D) spinal cord  
(E) telencephalon

Questions 68 and 69

68. A 24-year-old student is brought to the emergency room after being found in a ditch where he had lain overnight after being hit by a car. He complains of severe pain in the left arm and examination reveals a broken humerus. Neurological examination reveals that the patient can extend the elbow but displays inability to supinate the elbow when it is extended. The patient also has wrist drop and very weak hand grasp. The neurological lesion is likely localized at which of the following locations?

(A) posterior cord of the brachial plexus  
(B) posterior divisions of the brachial plexus  
(C) radial nerve at the distal third of the humerus  
(D) radial nerve at the midforearm  
(E) radial nerve at the wrist

69. In the above patient, when the elbow is partially flexed, the patient can supinate the left forearm. This is due to the function of which of the following?

(A) biceps brachii  
(B) brachialis muscle  
(C) brachioradialis  
(D) pronator teres  
(E) anconeus

70. Hormone-secreting chromophils in the pars distalis of the adenohypophysis are classified into acidophils and basophils. Which of the following hormones is secreted by the acidophils?

(A) adrenocorticotropin  
(B) follicle-stimulating hormone  
(C) luteinizing hormone  
(D) prolactin  
(E) thyrotropin (thyroid-stimulating hormone)

71. Production of specific granules occurs mainly during which stage of granulocyte development?

(A) granulocyte colony-forming unit  
(B) metamyelocyte  
(C) myeloblast  
(D) myelocyte  
(E) promyelocyte
72. A 1-year-old infant presents with cardiomegaly and congestive heart failure. She has increased intracranial pressure with hydrocephaly and cranial bruit. A vein of Galen aneurysm, revealed by MRI, is shown to compress the aqueduct of Sylvius, the posterior part of the third ventricle, and the splenium of the corpus callosum. Normally, the cerebral vein of Galen joins with which dural venous sinus?

(A) inferior sagittal sinus  
(B) sigmoid sinus  
(C) superior petrosal sinus  
(D) superior sagittal sinus  
(E) transverse sinus

73. A newborn female infant cannot swallow, exhibits persistent drooling, and aspiration or regurgitation of food after attempted feedings. When the infant strains, coughs, or cries, the stomach inflates, elevating the diaphragm and making respiration more difficult. The patient is diagnosed with congenital esophageal atresia at the cervical levels, necessitating surgical repair. During the surgery, the blood supply of the esophagus must be carefully isolated to protect from injury. Which of the following arteries supplies the esophagus at cervical levels?

(A) bronchial artery  
(B) inferior thyroid artery  
(C) internal thoracic artery  
(D) left inferior gastric artery  
(E) left inferior phrenic artery

74. During development, the upper limb buds appear by day 27 and the lower limb buds by day 29. An apical ectodermal ridge at the tip of each limb bud promotes growth. This multi-layered epithelial structure interacts with which of the following to direct the growth of the limb?

(A) ectoderm  
(B) endoderm  
(C) mesenchyme  
(D) notochord  
(E) sclerotome

75. Serous cells are glandular acinar cells that produce a watery, proteinaceous fluid. This cell type is most predominant in which of the following glands?

(A) esophageal glands  
(B) intestinal glands (of Lieberkün)  
(C) the parotid gland  
(D) the sublingual gland  
(E) the submandibular gland

76. A member of a college fraternity, who had consumed a large amount of alcohol on a dare, is brought to the emergency room with vomiting and severe abdominal pain. Blood tests reveal that he has elevated serum levels of amylase and lipase. A tentative diagnosis of acute hemorrhagic pancreatitis is formulated. Which cells of the pancreas are directly involved in this condition?

(A) alpha cells  
(B) beta cells  
(C) centroacinar cells  
(D) delta cells  
(E) F cells

77. A football player was simultaneously tackled from the front above the knee and from the back below the knee. In the emergency room, he displays a positive anterior drawer test which becomes negative if the knee is internally or externally rotated. Which of the following has ruptured?

(A) anterior cruciate ligament  
(B) fibula  
(C) fibular (lateral) collateral ligament  
(D) posterior cruciate ligament  
(E) tibial (medial) collateral ligament

78. In this same patient, the pectineus muscle is also badly bruised. This muscle is innervated by which of the following?

(A) genitofemoral nerve  
(B) obturator nerve  
(C) peroneal division of the sciatic nerve  
(D) saphenous nerve  
(E) tibial division of the sciatic nerve
79. An overworked surgical resident is resecting an acinic cell carcinoma from the inferior aspect of the parotid gland when he makes a careless incision and nicks a branch of the facial (seventh cranial) nerve. Which of the following muscles may be affected by this injury?

(A) omohyoid
(B) sternohyoid
(C) sternothyroid
(D) stylohyoid
(E) thyrohyoid

80. A 35-year-old male patient suffering from pulmonary hypertension has been diagnosed with ostium secundum atrial septal defect. Abnormal development of which of the following structures is responsible for this developmental defect?

(A) aorticopulmonary septum
(B) endocardial cushion
(C) interventricular septum
(D) septum primum
(E) sinus venosus

81. Desmin is a 53-kDa protein found in skeletal and smooth muscle cells. It plays a role in coordinating muscle cell contraction. Desmin belongs to which type of intermediate filaments?

(A) type I
(B) type III
(C) type IV
(D) type V
(E) type VI

82. Which of the following normally occupy the dark spaces indicated by the arrows in Fig. 1-20?

(A) blood vessels
(B) differentiating blood cell precursors
(C) osteoblasts
(D) osteoclasts
(E) osteocytes

83. A 19-year-old camper fell asleep with the right side of her face against the cold earth on an autumn night. In the morning, she woke up and found that she could not move the right side of the face. She went to the local emergency room in a nearby town and was diagnosed with Bell’s palsy. Which of the following muscles is not affected in her condition?

(A) buccinator
(B) levator labii superioris
(C) levator labii superioris alaeque nasi
(D) levator palpebrae superioris
(E) orbicularis oculi
84. In examining a 30-year-old male patient with multiple sclerosis, you notice that when you ask the patient to look to the left, the right eye fails to adduct and when the patient looks to the right, the left eye fails to adduct. However, both eyes in the patient can adduct during convergence. There is no noticeable strabismus when the eyes are focused on a far point. During abduction, both eyes display nystagmus. You record on the patient’s chart a diagnosis of bilateral internuclear ophthalmoplegia. Which of the following neural structures is affected?

(A) fourth cranial (trochlear) nerve  
(B) medial longitudinal fasciculus (MLF)  
(C) second cranial (optic) nerve  
(D) sixth cranial (abducens) nerve  
(E) third cranial (oculomotor) nerve

85. You are examining a 12-year-old male patient who has a slowly enlarging, painless swelling in the left inferior region of the neck. After careful palpation and consideration of the results of the radioimaging studies, you diagnose a branchial cyst in the left inferior parathyroid gland. This gland arose in development from which of the following pharyngeal pouches?

(A) fifth  
(B) first  
(C) fourth  
(D) second  
(E) third

86. Regarding the axon of the second-order neuron in the pathway for conscious awareness of fine, discriminative touch and vibratory sensation from the upper limb, which of the following is correct?

(A) ascends the brainstem in the medial lemniscus  
(B) decussates in the ventral white commissure of the spinal cord  
(C) has its cell body in the nucleus gracilis  
(D) is found in the dorsal funiculus of the spinal cord  
(E) terminates in the nucleus cuneatus

87. A 60-year-old male patient is brought to the hospital following sudden onset of weakness and sensory loss in the right face and upper limb. The right lower limb is unaffected. An MRI scan would reveal signs of a stroke in which of the following areas?

(A) in the territory of the left anterior cerebral artery  
(B) in the territory of the left middle cerebral artery  
(C) in the territory of the left posterior cerebral artery  
(D) in the territory of the right middle cerebral artery  
(E) in the territory of the right posterior cerebral artery

88. An 18-year-old male patient was thrown from a horse and suffered extensive damage to the back and pelvic region. After 2 weeks of recovery, it is noted that the patient has a spastic neurogenic urinary bladder. Although the patient is unable to initiate micturition, the bladder periodically empties itself. Where is the lesion affecting control of the bladder in this patient located?

(A) cauda equina  
(B) spinal cord, above the level of S2  
(C) spinal cord, at the level of S2  
(D) spinal cord, at the level of S3  
(E) spinal cord, at the level of S4

89. Papez circuit provides the anatomic substrate for the integration of cognitive, emotional, and expressive brain activities. Which of the following brain structures participates in Papez circuit?

(A) amygdala  
(B) caudate nucleus  
(C) mamillary nuclei  
(D) suprachiasmatic nucleus  
(E) ventrolateral thalamic nucleus
90. A urologist is teaching her resident to perform a vasectomy. She explains that he has to inject the anesthetic in the skin of the scrotum, in preparation for incision of its lateral aspect. This surgical location allows for easy access to the spermatic cord. Which of the following nerves innervates the skin of the scrotum?

(A) femoral nerve  
(B) iliohypogastric nerve  
(C) ilioinguinal nerve  
(D) obturator nerve  
(E) subcostal nerve

91. Infiltrating or invasive ductal cancer is the most common breast cancer histological type, comprising 70–80% of all cases. Invasive breast cancers usually are epithelial tumors of ductal or lobular origin. Which of the following epithelia line the lactiferous ducts?

(A) pseudostratified  
(B) simple squamous  
(C) stratified cuboidal  
(D) stratified squamous  
(E) transitional

92. The abdominal aorta provides for the major blood supply in this region and its branches are organized into paired or unpaired and visceral or parietal branches. Which of the following are paired visceral branches of the abdominal aorta?

(A) celiac trunk  
(B) gonadal arteries  
(C) inferior phrenic arteries  
(D) lumbar arteries  
(E) superior mesenteric artery

93. A female patient is diagnosed by sonogram with uterus didelphys (double uterus). The imaging study reveals a bicornuate uterus with a single vagina. During development, the uterus develops from which of the following?

(A) mesonephric ducts  
(B) nephrogenic ridge  
(C) paramesonephric ducts  
(D) urogenital sinus  
(E) yolk sac

94. A newborn infant suffers from a posterolateral defect on the left side of the body. His abdominal contents have herniated through the defect into the thoracic cavity, and as a result, the infant suffers from pulmonary hypoplasia. His breathing difficulty is life threatening because the herniation has inhibited lung development and inflation. This congenital defect is due to a malformation of which of the following?

(A) mesentery of the esophagus  
(B) muscular ingrowth of the body wall  
(C) pleuroperticardial membrane  
(D) pleuropitoneal membrane  
(E) septum transversum

95. A 17-year-old male college student is brought to the emergency room, displaying vomiting, fever, and diarrhea. The patient reports that for a period of 24 hours prior to admission, he suffered from abdominal pain first centered around the navel and then moving inferiorly to the right. As the patient talks, you realize that he is gesturing toward McBurney’s point. You tentatively diagnose acute appendicitis and request emergency surgery. Accurate visual identification of the appendix during surgery can be verified by using which of the following landmarks?

(A) bifurcation of the abdominal aorta  
(B) epiploic appendages  
(C) hastrae  
(D) inferior border of the right kidney  
(E) taeniae coli

96. The efferent limb of the pupillary light reflex is interrupted along with corticospinal and corticobulbar fibers in which of the following clinical entities?

(A) Broca’s aphasia  
(B) inferior alternating hemiplegia  
(C) middle alternating hemiplegia  
(D) superior alternating hemiplegia  
(E) Wallenberg syndrome
97. Horner syndrome is sometimes seen in patients diagnosed with the lateral medullary syndrome. Which of the following is a characteristic feature of Horner syndrome?

(A) atrophy of tongue musculature  
(B) mydriasis  
(C) paralysis of muscles of facial expression  
(D) profuse sweating  
(E) red blushing of the skin in the affected area

98. A 52-year-old male patient with a history of alcoholism is brought to the emergency room because of a sudden onset of right upper quadrant pain, nausea, blood in the vomitus, and fever. Ultrasound diagnosis reveals a portal vein obstruction caused by liver cirrhosis and accompanied by esophageal varices. Proper portal circulation must be reestablished to alleviate the esophageal varices, and the attending surgeon decides on an end-to-side portocaval shunt. Which of the following describes the chosen procedure?

(A) anastomosis by communication between the portal vein and the inferior vena cava  
(B) anastomosis by prosthetic vascular graft between the inferior vena cava and the superior mesenteric vein  
(C) anastomosis by suturing the inferior end of the portal vein to the inferior vena cava  
(D) anastomosis of the splenic vein to the left renal vein  
(E) placement of an expandable stent between a hepatic vein and the portal vein

99. During surgical resection of the gastrointestinal tract for treatment of long-standing irritable bowel syndrome, a surgery resident is asked to select a surgical site coinciding with the termination of the vagal innervation. Which of the following does she select?

(A) duodenojejunal junction  
(B) ileocolic junction

100. The structure indicated by arrow 1 in Fig. 1-21 is innervated by which of the following?

(A) anterior ethmoidal nerve  
(B) greater palatine nerve  
(C) lesser palatine nerve  
(D) middle superior alveolar nerve  
(E) nasopalatine nerve

101. A large vascular infarct involving the posterior limb of the internal capsule on the right side is likely to produce which of the following deficits?

(A) deviation of the protruded tongue to the right  
(B) hypertonia and hyperreflexia in the right upper limb  
(C) paralysis of facial expression muscles on the lower left portion of face  
(D) paraplegia involving the lower extremities  
(E) spastic hemiplegia involving the right side of the body
102. Which of the following thalamic nuclei serves a motor function?
   (A) dorsomedial nucleus
   (B) lateral geniculate nucleus
   (C) medical geniculate nucleus
   (D) ventral lateral nucleus
   (E) ventral posterior medial nucleus

103. A neurology resident is testing the jaw-jerk reflex in a patient by tapping gently on the right masseter muscle and observing elevation of the mandible. What is the location of the neuronal cell bodies of the proprioceptive fibers mediating the jaw-jerk reflex?
   (A) mesencephalic trigeminal nucleus
   (B) motor trigeminal nucleus
   (C) principal (main) trigeminal nucleus
   (D) spinal trigeminal nucleus
   (E) trigeminal (gasserian) ganglion

104. Which of the following statements concerning muscle spindles is correct?
   (A) Activation of type Ia sensory fibers from a given spindle leads to inhibition of the muscle in which that spindle is located.
   (B) Alpha motoneurons synapse directly with intrafusal muscle fibers.
   (C) Each intrafusal fiber is innervated by two different gamma motoneurons.
   (D) Only one type of intrafusal muscle fiber (cell) is present in most muscle spindles.
   (E) Type Ia sensory fibers from a spindle form direct synaptic contact with alpha motoneurons in the spinal cord.

105. Which of the following is characteristic of damage to the corticospinal (pyramidal) system?
   (A) Babinski’s sign
   (B) flaccid paralysis and hypotonia
   (C) immediate muscle degeneration and atrophy
   (D) intention tremor
   (E) loss of deep tendon reflexes

106. Cilia are anchored to the apical portion of certain types of epithelial cells and they are mobile. Which of the following form the motile cytoskeletal component of the cilia?
   (A) intermediate filaments
   (B) microfilament
   (C) microtubule
   (D) neurofilament
   (E) tonofilaments

107. A 79-year-old female patient was admitted to the hospital, presenting with fever, vomiting, dehydration, and distension of the abdomen. An X-ray reveals ileus and exploratory surgery reveals occlusion of vasa recta of the jejunum. Which of the following arteries supply branches to the involved vasa recta?
   (A) ileocolic artery
   (B) inferior pancreaticoduodenal artery
   (C) right colic artery
   (D) right gastroepiploic artery
   (E) superior mesenteric artery

108. Which of the following is directly involved with the descending modulation of pain transmission?
   (A) dopamine
   (B) MLF
   (C) nucleus raphe magnus
   (D) rubrospinal fibers
   (E) ventral lateral thalamic nucleus

109. Which of the following vessels participate in the arterial circulation of the spleen?
   (A) afferent arteriole
   (B) efferent arteriole
   (C) interlobar arteries
   (D) interlobular arteries
   (E) sheathed arteriole
110. A middle-aged, markedly obese male patient presents to the emergency room with pain in the inguinal region. Examination reveals an abnormal bulge which increases in size when the patient performs the Valsava maneuver. The bulge can be reduced manually when the patient is lying supine. However, as soon as the patient stands up and coughs, the bulge reappears. The patient is diagnosed with an inguinal hernia. The chief resident in surgery asks for a determination of whether the hernia is direct or indirect. Which of the following is a useful landmark to distinguish an indirect from a direct inguinal hernia?

(A) anterior superior iliac spine
(B) inferior epigastric vessels
(C) inguinal ligament
(D) pubic tubercle
(E) umbilicus

111. A fourth-year medical student is learning to place a central line. To prepare for this procedure, she reviews X-rays and CT scans in order to gain a proper three-dimensional relationship of the structures involved. In Fig. 1-22, what is the structure pointed to by arrow 1?

(A) Ascending aorta
(B) Azygos vein
(C) Descending aorta

(D) Right bronchus
(E) Superior vena cava

112. Referring to Fig. 1-23, what is the most likely source of this epithelium?

(A) gall bladder
(B) salivary duct
(C) thick skin
(D) trachea
(E) urinary bladder

113. A failure of the truncoconal septum to follow a spiral course results in which of the following conditions?

(A) common atrium
(B) persistent atrioventricular canal
(C) persistent truncus arteriosus
(D) Tetralogy of Fallot
(E) transposition of the great vessels

114. During surgery to repair a strangulated inguinal hernia, it is discovered that the left testicular vein is thrombosed and must be repaired. The left testicular vein normally drains into which of the following?

(A) inferior vena cava
(B) left renal vein
(C) right common iliac vein
(D) right femoral vein
(E) right renal vein
115. The sensory innervation of the posterior one-third of the tongue is performed by cranial nerve IX (glossopharyngeal). During development, this region of the tongue develops from which of the following pharyngeal arches?

(A) first  
(B) fourth  
(C) second  
(D) sixth  
(E) third

116. The sinoatrial (SA) node initiates the heartbeat by giving off an impulse about 80 times per minute. It is located at the junction of the superior vena cava and right atrium. In about 60% of the cases, the SA node derives its vascular supply from which of the following?

(A) anterior interventricular artery  
(B) left circumflex artery  
(C) posterior interventricular artery  
(D) right coronary artery  
(E) right marginal branch

117. In elderly patients (over 60 years of age), fractures of the neck of the femur following a fall are common. Arterial branches supplying the femoral head and neck are vulnerable to injury during these fractures, and the resulting post-traumatic avascular necrosis affects the head of the femur. In the adult, the most important direct vascular source to the femoral head and neck is which of the following?

(A) artery to the head of the femur  
(B) femoral artery  
(C) lateral circumflex femoral artery  
(D) medial circumflex femoral artery  
(E) superior gluteal artery

118. A 38-year-old female patient suffers from pleurisy and requires pleural fluid sampling (thoracentesis). The attending physician asks you to perform the procedure at the midaxillary line on the right side. Which of the following would be the appropriate level to perform the procedure?

(A) above the level of the 7th rib  
(B) at the level of the 10th rib  
(C) at the level of the 5th rib  
(D) below the level of the 10th rib  
(E) between the level of the 8th and 10th ribs

119. A 45-year-old female patient develops Parinaud’s syndrome (vertical gaze palsy) and an MRI shows a large tumor of her pineal gland. The tumor is not only compressing her tectum, causing the vertical gaze palsy, but also obstructing the underlying cerebrospinal fluid pathway causing progressive noncommunicating hydrocephalus. The obstruction causes immediate accumulation of cerebrospinal fluid in which of the following?

(A) cerebral aqueduct of Sylvius  
(B) fourth ventricle  
(C) lateral ventricle  
(D) subarachnoid space  
(E) third ventricle

120. A patient has been severely injured in the back of the head during a mugging attempt and imaging studies reveal possible fracture of the skull along with the C1 (atlas) vertebra. The patient is also hemorrhaging from the vertebral artery in this location, and the attending surgeon will attempt to stop the bleeding by access through the suboccipital triangle. Which of the following muscles attaches from the transverse process of C1 to the occipital bone and forms the lateral border of the suboccipital triangle?

(A) obliquus capitis inferior  
(B) obliquus capitis superior  
(C) rectus capitis posterior major  
(D) rectus capitis posterior minor  
(E) semispinalis cervicis
Questions 121 and 122

Your patient presents in your office complaining of hoarseness. During your examination, you find that one vocal fold has deviated toward the midline and does not abduct during deep inspiration or vocalization. You also observe that touch sensation in the vestibule of the larynx appears to be intact.

121. Which laryngeal muscle is most important in abduction of the vocal folds?
(A) cricothyroid
(B) lateral cricoarytenoid
(C) posterior cricoarytenoid
(D) thyroarytenoid
(E) transverse arytenoid

122. You suspect that a nerve has been damaged, but which nerve is most likely involved?
(A) external laryngeal
(B) glossopharyngeal
(C) inferior laryngeal
(D) internal laryngeal
(E) superior laryngeal

123. During maturation of the oocytes, which of the following structures retain almost all of the cytoplasm after the first meiotic division?
(A) first polar body
(B) ovum
(C) primary oocyte
(D) second polar body
(E) zygote

Questions 124 and 125

Your patient reports that several days earlier he “threw his back out” when he bent from the waist and picked up a very heavy package. The pain was immediate and extended from his hip, down the back of the thigh, and into his leg and foot. As he lies on the examining table, you raise his leg by the foot keeping the knee extended and elicit intense pain over the distribution of the sciatic nerve. An MRI scan confirms your conclusion that your patient has a herniated intervertebral disk between the fourth and fifth lumbar vertebrae.

124. Intervertebral disks may protrude or rupture in any direction, but they most commonly protrude in which direction?
(A) anteriorly
(B) anterolaterally
(C) laterally
(D) posteriorly
(E) posterolaterally

125. Herniation of the intervertebral disk between the fourth and fifth lumbar vertebrae most likely impinges on the roots of which spinal nerve?
(A) L3
(B) L4
(C) L5
(D) S1
(E) S2

126. An opera singer, who has maintained a demanding work schedule, worries about the effect on her vocal cords. The epithelium covering the vocal cords is which of the following?
(A) pseudostratified ciliated
(B) simple columnar
(C) simple cuboidal
(D) simple squamous
(E) stratified squamous

127. A patient suffers from Frey’s syndrome manifested by perspiration of the skin covering the left parotid gland whenever the patient eats. On inquiry, the patient reveals that he suffered deep injuries on that side of his face and neck in an automobile accident. You explain to him that his syndrome results from abnormal connections between the great auricular nerve and parasympathetic secretomotor fibers, which normally innervate only the parotid gland. This abnormal reinnervation occurred during the healing period after the accident. The parasympathetic secretomotor fibers to the parotid gland are carried by which of the following?
(A) auriculotemporal nerve
(B) buccal branch of the facial nerve
(C) buccal nerve
128. Your young female patient has a large bulge on the anterior thigh below the inguinal ligament. You suspect an abdominal hernia that has passed through the femoral ring into the femoral sheath and then through the saphenous hiatus into the subcutaneous layer of the upper thigh. In addition to the hernial sac, you would expect the femoral canal to contain which of the following?

(A) connective tissue and lymph nodes
(B) femoral artery
(C) femoral nerve
(D) femoral vein
(E) great saphenous vein

129. Sensations from the thoracic and abdominal organs are usually difficult to localize. They are conveyed by general visceral afferent (GVA) fibers, which synapse in which of the following nuclei?

(A) ambiguus nucleus
(B) dorsal motor nucleus of the vagus
(C) hypoglossal nucleus
(D) solitary nucleus
(E) spinal (descending) trigeminal nucleus

130. Corneal abrasions produce eye pain and excessive lacrimation. Which cranial nerve innervates the cornea?

(A) fifth (trigeminal)
(B) fourth (trochlea)
(C) second (optic)
(D) sixth (abducens)
(E) third (oculomotor)

131. The anterior two-thirds of the tongue differ from the posterior one-third of the tongue by its special visceral afferent (SVA; taste) innervation. The perikarya of neurons providing the sensation of taste in the anterior two-thirds of the tongue are found in which of the following?

(A) geniculate ganglion
(B) otic ganglion

(C) pterygopalatine (sphenopalatine) ganglion
(D) submandibular ganglion
(E) trigeminal (gasserian) ganglion

132. You are concerned that your patient may have compromised function of the mitral valve. The sound of the mitral valve is best heard at which of the following locations?

(A) at the apex in the left fifth intercostal space in the midclavicular line
(B) at the xiphisternal junction
(C) in the fifth intercostal space to the right of the sternum
(D) in the second intercostal space to the left of the sternum
(E) in the second intercostal space to the right of the sternum

133. A 14-year-old female patient complains of a severe sore throat and you use a cotton swab to obtain specimens for a culture. As you lightly touch the pharyngeal wall with the cotton swab, the patient gags. What is the location of neuronal cell bodies innervating pharyngeal constrictor muscles involved in the gag reflex?

(A) abducens nucleus
(B) ambiguus nucleus
(C) dorsal motor nucleus of the vagus
(D) facial nucleus
(E) hypoglossal nucleus

134. A newborn infant displays wheezing respiration, which is aggravated when she feeds, flexes her neck, and/or cries. Radioimaging studies of her chest reveal a double aortic arch compressing her trachea and esophagus. This rare developmental defect results from persistence of the right dorsal aorta, which normally disappears. The arch of the aorta arises from which of the following structures?

(A) fifth pair of aortic arches
(B) fourth pair of aortic arches
(C) second pair of aortic arches
(D) sixth pair of aortic arches
(E) third pair of aortic arches
135. After recovery from the surgical removal of the thyroid gland, the quality of the voice in a patient changed to a monotone. It was discovered that the cricothyroid muscle in this patient was paralyzed. The cricothyroid muscle is innervated by which of the following?

(A) accessory nerve
(B) ansa cervicalis
(C) external laryngeal nerve
(D) hypoglossal nerve
(E) internal laryngeal nerve

136. Secretion of pulmonary surfactant is a function of which of the following?

(A) alveolar dust cells
(B) endothelial cells of capillaries in the alveolar septum
(C) small granule cells
(D) type I pneumocytes (squamous alveolar cells)
(E) type II pneumocytes (greater alveolar cells)

137. Climbing fibers provide excitation to the deep cerebellar nuclei and the Purkinje neurons. The climbing fibers originate from which of the following structures?

(A) inferior olivary nucleus
(B) pontine nuclei
(C) spinal cord
(D) superior olivary nucleus
(E) vestibular nuclei

138. A newborn infant suffers from epidermolysis bullosa simplex, characterized by skin blistering soon after birth. The blisters appear at sites of pressure or rubbing such as the fingers. You explain to the distressed parents that this condition is a disease of intermediate filaments and results from mutant genes for keratins K5 and K14. Which cells of the skin normally produce keratins K5 and K14?

(A) adipose cells in the hypodermis
(B) basal cells of the epidermis
(C) fibrocytes of the dermis
(D) melanocytes of the epidermis
(E) upper differentiating cells of the epidermis

139. Cell adhesion molecules enable intercellular contacts in epithelial as well as nonepithelial cells. Which of the following cell adhesion molecules are calcium-dependent molecules?

(A) disintegrins
(B) integrins
(C) intercellular adhesion molecules (I-CAM)
(D) neural cell adhesion molecules (N-CAM)
(E) selectins

140. After removal of cancerous lymph nodes from the lateral pelvic wall, a patient develops painful spasms of the adductor muscles and sensory deficits in the medial thigh region. The adductor muscles are innervated by which of the following nerves?

(A) femoral
(B) inferior gluteal
(C) obturator
(D) pudendal
(E) sciatic

141. A renal calculus (kidney stone) passing from the renal pelvis into the ureter causes excessive distention and severe ureteric colic. During development in the embryo, the ureter arose from which of the following?

(A) mesonephric duct
(B) metanephric diverticulum
(C) metanephric mass of intermediate mesoderm
(D) paramesonephric duct
(E) pronephric duct
142. A patient suffering from Charcot-Marie-Tooth disease displays progressive degeneration of peripheral nerves, distal muscle weakness and atrophy, and defects in deep tendon reflexes. This condition is associated with an abnormal mutation in the gene encoding connexin-32. Connexins are normally found in which type of cell junctions?

(A) communicating (gap) junction  
(B) hemidesmosome  
(C) macula adherens (spot desmosome)  
(D) occluding (tight) junction  
(E) zonula adherens (belt desmosome)

143. Calcitonin decreases blood calcium and bone-resorbing activity in which of the following?

(A) osteoblast  
(B) osteoclast  
(C) osteocyte  
(D) osteon  
(E) osteoprogenitor cells

144. During development, which of the following structures act as a temporary set of kidneys in the fetus?

(A) mesonephroi  
(B) metanephroi  
(C) paramesonephric ducts  
(D) pronephroi  
(E) ureteric bud

145. In adults, lack of vitamin D gives rise to the disease osteomalacia characterized by progressive softening and bending of the bones. This is due to a defect in the mineralization of the osteoid. Under normal conditions, the osteoid is found along which of the following locations?

(A) the interface between osteocytes and bones  
(B) the interface between osteoprogenitor cells and bone marrow

(C) the interface between the fibroblasts in the periosteum  
(D) the interface between the osteoblast and bone  
(E) the ruffled border of osteoclasts

146. Lymph nodes are populated by lymphocytes that exit the vascular compartment to gain access to the parenchyma of the node by passing through the walls of which of the following?

(A) afferent lymphatic vessels  
(B) arterioles  
(C) efferent lymphatic vessels  
(D) high endothelial postcapillary venules  
(E) medullary sinuses

147. A 32-year-old female professional gardener complains of increasing muscle weakness and fatigue during the day, requiring her to take frequent rests. She also reports that she cannot enjoy her meals any more because her muscles of mastication quickly weaken and she has to stop chewing. When she watches television at night for a long period of time, her vision becomes blurry and she sees double. Her neurologist makes a preliminary diagnosis of myasthenia gravis. Which of the following is the cause of myasthenia gravis?

(A) Acetylcholine synthesis in motor neurons is impaired.  
(B) Acetylcholinesterase synthesis is inhibited.  
(C) Autoantibodies destroy cholinergic receptors at the postsynaptic membrane preventing binding of acetylcholine.  
(D) Neurotransmitter release is impaired at the presynaptic membrane of the neuromuscular junction.  
(E) Signal transduction within the muscle is impaired.
148. In Fig. 1-24 which labeled bracket spans a sarcomere?

(A) A  
(B) B  
(C) C  
(D) D  
(E) E

149. The great cerebral vein of Galen indicated by arrow 4 in Fig. 1-25 is formed by the union of two internal cerebral veins and drains into which of the following?

(A) confluence of sinuses  
(B) frontal sinus  
(C) sphenoid sinus  
(D) straight sinus  
(E) superior sagittal sinus

150. A 42-year-old female patient has to undergo emergency cholecystectomy due to intense biliary colic. The structure to be removed during the surgery is indicated in Fig. 1-26 by which of the following arrows?

(A) 1  
(B) 2  
(C) 3  
(D) 4  
(E) 5

151. A patient with a developing astrogliaoma in the primary auditory cortex (Brodmann’s area 41) complains of hearing unusual noises. What is the main source of subcortical input to the primary auditory cortex?

(A) inferior colliculus  
(B) lateral geniculate nucleus  
(C) medial geniculate nucleus  
(D) superior colliculus  
(E) superior olivary nucleus
152. A 65-year-old male patient develops neurological symptoms due to an embolus in the left common carotid artery. In the CT scan in Fig. 1-27, the involved vessel is indicated by which of the following arrows?

(A) 1  
(B) 2  
(C) 3  
(D) 4  
(E) 5  

153. A 53-year-old male patient has developed an abnormal hypersensitivity in the face area. He complains that he feels pain when he drives with the window down and from the wind blowing on his face. The pain is exacerbated by direct touch to the left side of his lower jaw. The patient is diagnosed with trigeminal neuralgia (tic douloureux). Where do pain fibers from the left side of his mandible project to?

(A) mesencephalic trigeminal nucleus  
(B) motor trigeminal nucleus  
(C) principal sensory trigeminal nucleus  
(D) spinal (descending) trigeminal nucleus  
(E) trigeminal (gasserian) ganglion

154. A skydiver landing forcefully on his right lower limb suffered a central fracture of the acetabulum with dislocation of the femoral head into the pelvis. The acetabulum is formed by the joining of the ilium, ischium, and pubis. These three bones are completely fused by which of the following periods?

(A) birth  
(B) 6 years  
(C) puberty  
(D) 16 years  
(E) 23 years

155. In the coronal section of the head shown in Fig. 1-28, arrow 2 points to a structure that belongs to which of the following?

(A) ethmoid bone  
(B) inferior nasal concha  
(C) maxillary bone  
(D) nasal septum  
(E) vomer bone
Answers and Explanations

1. (A) Dystrophin anchors actin to the sarcolemma, reinforcing and stabilizing the latter during muscle contraction. Titin is a large protein which associates with myosin filaments and endows them with elastic recoil properties (choice B). Desmin filaments form a supportive network extending from Z disk to Z disk (choice C). Troponin I inhibits the binding of myosin to actin (choice D). AlphaB-crystallin protects desmin filaments from stress-induced damage (choice E).

2. (D) The nucleus dorsalis (Clarke’s column, Rexed’s lamina VII of the spinal cord) contains the cell bodies of the second order neurons of the dorsal (posterior) spinocebellar tract. Axons from these neurons ascend ipsilaterally in the lateral funiculus of the spinal cord, join the restiform body of the inferior cerebellar peduncle, and terminate in the vermis of the cerebellum as mossy fibers. The dorsal (posterior) spinocebellar tract conveys proprioception from muscle spindles and Golgi tendon organs. Collateral branches of this tract also terminate in the deep cerebellar nuclei (choice A). The dorsal root ganglion (choice B) contains the cell bodies of sensory neurons, including the first-order neurons of the dorsal (posterior) spinocebellar tract. The nucleus cuneatus (choice C) contains the second order neurons of the dorsal column pathways, responsible for conveying sensations of fine touch, pressure, and vibration sense. Rexed’s lamina IX of the spinal cord (choice E) contains the spinal cord motorneurons responsible for the innervation of voluntary muscles.

3. (C) The posterior digastric muscle is derived from the second branchial arch and thus is innervated by its nerve, the facial (Seventh cranial) nerve. The anterior digastric muscle (choice A) is derived from the first branchial arch and is innervated by its nerve, the mandibular division of the trigeminal (fifth cranial) nerve. The posterior cricoarytenoideus muscle (choice B) and the superior constrictor muscle (choice E), derived from a combination of the fourth and sixth branchial arches, are innervated by the vagus (tenth cranial) nerve. The stylopharyngeus (choice D) is derived from the third branchial arch and is the only voluntary muscle innervated by the glosopharyngeal (ninth cranial) nerve.

4. (B) The abducens (sixth cranial) nerve normally innervates the lateral rectus muscle. The inferior oblique (choice A), medial rectus (choice C), and superior rectus (choice E) are all innervated by the oculomotor (third cranial) nerve. The superior oblique (choice D) is innervated by the trochlear (fourth cranial) nerve. In Duane syndrome, the absence of lateral rectus innervation by the abducens (sixth cranial) nerve is replaced by an aberrant innervation of the oculomotor (third cranial) nerve. Thus when the patient is asked to adduct the affected eye, there is co-contraction of the lateral and medial recti with globe retraction.

5. (E) The retina contains three layers of cells. They are, from top to bottom, the ganglion cells (choice A), the bipolar cells (choice C), and the photoreceptor cells (rods and cones, choice E). The internal plexiform layer (choice B) contains the synapses between the bipolar cells and the ganglion cells. The external plexiform layer (choice D) contains the synapses between the photoreceptors and the bipolar cells. Remember that light enters from the top and traverses all the layers to reach the photoreceptors in the bottom layer.

6. (D) Remember that in viewing axial or transverse CT scans through the body, the right side of the patient is to your left and the left side to your right. In other words, the feet of the patient are toward you and the head away
from you. The back of the patient is at the bottom of the image and the front of the patient toward the top. Directional terms are always in reference to the patient. The insert at the bottom right indicates the level of the section. Arrow 1 indicates the right brachiocephalic vein. The left brachiocephalic vein (choice B) is seen as the elongated structure immediately posterior to the manubrium of the sternum and to the left of the right brachiocephalic vein. Immediately posterior to the left brachiocephalic vein is the brachiocephalic artery (choice A, arrow 2). To the left of the latter are the left common carotid artery (choice C) and the left subclavian artery (arrow 3). The superior vena cava (choice E) is not seen at this level because the right and left brachiocephalic veins are still separate.

7. (E) The arytenoid cartilages arise as swellings from the sixth pharyngeal (branchial) arch at 32 days of gestation. They are located between the caudal end of the hypobranchial eminence and the cranial end of the laryngotracheal tube. The swellings will grow cranially to form the arytenoids and corniculate cartilages along with the primitive aryepiglottic folds. In laryngomalacia, the bulky arytenoid cartilages prolapse anteromedially on inspiration, resulting in stridor. The first (choice A), second (choice B), and third (choice C) pharyngeal arches do not participate in the development of laryngeal cartilages. The fifth (choice D) pharyngeal arch remains rudimentary and does not give rise to any adult structure.

8. (E) In DiGeorge syndrome, the cortical epithelial cells of the thymus fail to develop and the thymus is hypoplastic. As a result, bone marrow-derived T-cell precursors cannot differentiate and functional T-cell production is markedly reduced. The development of B cells (choice A) is not affected in DiGeorge syndrome. Endothelial cells (choice B) forming the vascular walls are not affected by thymic maldevelopment, nor are the cells of myeloid lineage, the macrophages (choice C), and the neutrophils (choice D).

9. (E) In TGA, the aorta arises from the right ventricle and the pulmonary trunk arises from the left ventricle (choice C). This is the reverse of the normal situation and gives rise to the cyanotic condition in the newborn. The large arteries arise from the truncus arteriosus in the developing heart and thus could not develop from the atria (choices B and D), which are formed from the sinus venosus. The truncus arteriosus and the sinus venosus are at opposite ends of the heart. The ductus arteriosus (choice A) is the vessel that shunts oxygenated blood from the pulmonary trunk to the arch of the aorta in the fetus. It does not give rise to the aorta.

10. (E) At the level of the foramen magnum, the bilateral vertebral arteries supply a medial branch each and they combine to form the anterior spinal artery. As the anterior spinal artery continues caudally, it is supplied by radicular arteries arising from the aorta and its branches. The artery of Adamkiewicz (choice A) is the largest radicular artery (arteria radicularis magna), frequently arising from a segmental branch of the thoracic aorta at the level of T10. The basilar artery (choice B) is formed by the joining of the vertebral arteries superior to the foramen magnum and thus does not provide blood supply to the spinal cord. Its branches supply the brainstem. The internal carotid artery (choice C) supplies the orbit via its ophthalmic branch and the brain by its anterior and middle cerebral branches. The posterior inferior cerebellar artery (choice D) is a branch of the vertebral artery, providing vascular supply to the medulla oblongata and the inferior aspect of the cerebellum.

11. (C) An irregular outline, a thin wall, and the lack of erythrocytes in the lumen characterize lymphatic vessel. Arterioles (choices A and B) have thicker walls and contain erythrocytes. Venules (choice D) are thin-walled but they contain erythrocytes. Capillaries (choice E) are small in diameter and they contain erythrocytes.

12. (C) This is the secretory portion of the eccrine sweat gland, recognizable by its three cell types. The apical dark cells (arrow 1) are closest to the lumen. The clear or basal cells (arrow 2) and the myoepithelial cells (arrow 3) are located against the basal lamina. Characteristically, these cells
are large and the lumen is small. The apocrine sweat gland (choice A) is lined with simple cuboidal epithelium and thus has a large lumen. The dermal papilla (choice B) is formed by fibroblasts, not epithelia. The hair follicle (choice D) is formed by three concentric zones of keratinized cells and does not have a lumen. The sebaceous glands (choice E) are appendages of the hair follicle and their lumen is lined by stratified squamous epithelium.

13. (C) The posterior inferior cerebellar artery supplies the rostral, dorsolateral medulla. The posterior spinal (choice D) and anterior spinal (choice B) arteries supply dorsal and ventral portions, respectively, of the caudal medulla. The anterior inferior cerebellar (choice A) and superior cerebellar (choice E) arteries supply portions of the pons and mesencephalon.

14. (B) Arrow 2 points to the abdominal aorta, located anterior to the lumbar vertebra. Arrows 1 (choice A) and 5 (choice B) indicate the left and right kidneys respectively. Arrow 3 points to the inferior vena cava; the junctions of the left and right renal veins to the inferior vena cava are seen in this CT scan. Arrow 4 points to a loop of the small intestine, filled with contrast-enhancing material.

15. (B) Arrow 2 points to the base of the gastric glands where chief or peptic (zymogenic) cells tend to be clustered. Arrow 1 points to the luminal surface of the stomach where mucus-secreting cells are found. Arrow 3 points to the muscularis mucosae. Arrow 4 points to the middle of the gastric glands where parietal or oxyntic cells tend to be most numerous. Arrow 5 point to the side of a gastric pit where mucus-secreting cells are also found.

16. (C) Benedikt’s syndrome results from a lesion situated in the tegmentum of the midbrain, at the level of the third cranial nerve (oculomotor) nucleus and its associated tracts, as exemplified by ptosis and third nerve palsy in this patient. The red nucleus is also affected at this level giving rise to motor impairment displayed by the intention tremor. Since the rubrospinal tract crosses at the level of the midbrain to project to the opposite side of the body, the tremor will manifest itself contralateral to the side to the lesion. The seventh cranial nerve (facial) nucleus is located in the pons, and the facial musculature (choice A) in this patient would not be affected. Likewise, the twelfth cranial nerve (hypoglossal) nucleus is located in the medulla, and the innervation of the tongue (choice B) would be spared in this patient. A lesion causing a pure Benedikt’s syndrome would be confined to the midbrain tegmentum and not affect the corticospinal tract. Ipsilateral hemiplegia (choice D) would not be present in this patient. Finally, vertical gaze palsy (choice E) results from a lesion or compression of the midbrain tectum and not of the tegmentum.

17. (D) Long-term exposure to the sun increases the risk of alteration of the DNA structure by cleavage, ionizing radiation, or recombination of DNA with highly reactive free radicals. These changes can result in neoplastic changes or death in skin cells. In the skin, mitosis occurs only in the malpighian layer formed by the stratum basale and the stratum spinosum of the epidermis. The DNA of dividing cells is more vulnerable to the harmful effects of the sun, and neoplastic changes are usually observed in the malpighian layer. They are not seen in the stratum corneum (choice A), stratum lucidum (choice B), or stratum granulosum (choice C). Choice E represents the dermis located below the epidermis, which is the only skin layer considered in this question.

18. (E) The frontal sinus is innervated by the supraorbital and supratrochlear branches of the frontal nerve. All nerves mentioned in this question are branches of ophthalmic division (V1) of the trigeminal (fifth cranial) nerve. The anterior (choice A) and the posterior (choice D) ethmoidal nerves arise from the nasociliary nerve (choice C). They innervate the ethmoid and sphenopalatine sinuses. The lacrimal nerve (choice B) carries in its terminal segment the parasympathetic innervation to the lacrimal gland and provides sensory innervation to the upper eyelid.

19. (C) A vascular lesion affecting the left caudal medulla involves the left medial lemniscus, left hypoglossal nerve fibers, and the left medullary
20. (A) The vagus (tenth cranial) nerve innervates the external auditory meatus of the ear. The great auricular nerve (choice B) innervates the lobule of the auricle and the auriculotemporal nerve (choice C), the superior aspect of the auricle. In fact, a sensory test which includes these three parts of the ear tests the integrity of the trigeminal (fifth cranial) nerve by the auriculotemporal nerve, the vagus (tenth cranial) nerve by its branch innervating the auditory meatus, and spinal nerves C2-3 by their great auricular branch. The test thus covers the upper and lower medulla and the upper spinal cord. The greater occipital nerve (choice D) is a branch of the cervical plexus originating from C2 and innervates the scalp of the back of the head. The facial (seventh cranial) nerve provides only motor innervation to the face and scalp areas.

21. (D) Arrow 3 points to the ethmoidal sinus located medial to the orbits. The sinus is divided into compartments by the air cells. The maxillary sinus (choice D) and the inferior nasal meatus (choice B) are located inferior to the level of this scan and are not seen. The sphenoidal sinus (choice E) is indicated by arrow 3 and the infratemporal fossa (choice C) by arrow 1.

22. (A) This axial scan is at the level of the orbits as indicated by the insert at the bottom right and the eyeballs in the orbits. Arrow 2 points to the ethmoidal sinus located medial to the orbits. The sinuses are divided into compartments by the air cells. The maxillary sinus (choice D) and the inferior nasal meatus (choice B) are located inferior to the level of this scan and are not seen. The sphenoidal sinus (choice E) is indicated by arrow 3 and the infratemporal fossa (choice C) by arrow 1.

23. (D) Routine neuropathological identification of cells in the central nervous system is based on nuclear morphology using a stain such as the hematoxylin-eosin (H&E) stain shown in Fig. 1-10. The largest nuclei belong to neurons. Nuclei of glial cells are smaller and decrease in size from astroglia (choice A), to oligodendroglia (choice B), to microglia (choice C). Endothelial cells of the penetrating vasculature of the brain represent choice E.

24. (C) Arrow 1 points to the right internal carotid artery which supplies the anterior and middle cerebral arteries in the brain. The territory of the right anterior cerebral artery includes the right medial aspect of the frontal lobe, which will be affected by obstruction of the internal carotid artery. Broca’s (choice A) and Wernicke’s (choice E) areas are located in the majority of the population in the left cerebral hemisphere and are supplied by the left middle cerebral artery from the left internal carotid artery. They will not be affected in this case. The cerebellum (choice B) and pons (choice D) receive their blood supply from the basilar artery (arrow 2) which is formed from the vertebral arteries.

25. (C) The structure indicated by arrow 2 in Fig. 1–11 is the basilar artery, which terminates by dividing into the posterior cerebral arteries. The anterior and middle cerebral arteries (choice A) are terminal branches of the internal carotid artery. The internal cerebral veins (choice B) drain into the great cerebral vein of Galen. The superior cerebellar arteries (choice D) are branches of the basilar artery. The vertebral arteries (choice E) unite to form the basilar artery.

26. (E) The stria terminalis or fasciculus of Foville is one of the major output pathways from the
amygdala to the septal, hypothalamic, and thalamic nuclei. Another main amygdaloid output pathway is the ventral amygdalofugal pathway. The fasciculus arcuatus (choice A) or superior longitudinal fasciculus is a bundle of fibers in the cerebrum connecting ipsilateral regions of the frontal, temporal, parietal, and occipital lobes. The fasciculus cuneatus (choice B) carries ascending sensory fibers in the dorsal funiculus of the spinal cord and terminates in the nucleus cuneatus of the medulla oblongata. The fasciculus of Vicq d’Azyr (choice C) or mammillothalamic tract connects the mammillary bodies to the anterior nuclei of the thalamus. This bundle of fibers forms part of Papez circuit, which is also involved in emotional processing. Another part of Papez circuit is the fornix (choice D), a large efferent pathway from the hippocampus.

27. (B) Malclosure of the rostral neuropore during the fourth week of development results in anencephaly and is lethal in the affected newborn. The condition is better termed meroanencephaly because of the presence of the rudimentary brainstem with some functioning nervous tissues. Defects in the closure of the caudal neuropore (choice A) result in varying conditions of spina bifida at the lower end of the spinal cord. The first branchial arch (choice C) and the somites (choice D) do not play any role in the formation of the brain. Fusion of the metopon or forehead (choice E) occurs after birth and also does not play a role in brain formation.

28. (C) The superficial layer of flexor muscles of the forearm all originate from the medial epicondyle of the humerus. Thus, this condition is also called medial epicondyritis and is the most common finding is tenderness with palpation over the anterior aspect of the medial epicondyle. The muscles involved are most often the Pronator Teres, Flexor Carpi Radialis, and Palmaris Longus. The Flexor Digitorum Superficialis and Flexor Carpi Ulnaris may also be affected. There is no muscle attachment to the head of the radius (choice A). The lateral epicondyle of the humerus (choice B) is the attachment point of the common extensor tendon. The olecranon process of the ulna (choice D) is the attachment point for the Triceps Brachii, Flexor Carpi Ulnaris, and Anconeus. The tuberosity of the radius (choice E) receives the distal tendon of the biceps brachii.

29. (A) The biceps brachii muscle attaches proximally by its short head to the coracoid process of the scapula and by its long head to the supraglenoid tubercle. Distally it attaches by a strong tendon to the tuberosity of the radius and by an aponeurosis to the ulna. It thus can perform arm and elbow flexion along with forearm supination. The brachialis (choice B) attaches proximally to the anterior aspect of the lower half of the humerus and distally to the coronoid process of the ulna. It can only perform elbow flexion. The brachioradialis (choice C) attaches from the lateral supracondylar ridge of the humerus to the base of the styloid process of the radius. Although innervated by the nerve to the extensor compartment, the radial nerve, it performs elbow flexion and forearm pronation. The coracobrachialis (choice D) attaches from the coracoid process of the scapula to the anterior aspect of the upper half of the humerus. It performs arm flexion and weak adduction. The supinator (choice E) attaches proximally to the lateral epicondyle of the humerus and the annular ligament of the radius. Distally, it covers nearly the upper third of the radius and attaches to its lateral anterior aspect. It supinates the forearm, but is a weaker supinator than the biceps brachii.

30. (B) The musculocutaneous nerve innervates the biceps brachii along with the coracobrachialis and the brachialis. It continues into the forearm as the lateral antebrachial cutaneous nerve. In this brachial plexus injury, the sudden hyperextension and right rotation of the neck narrow the intervertebral foramina through which exit the cervical nerves. Injury at the level of C6 will affect the musculocutaneous nerve along with the suprascapular nerve, resulting in impairment of the movements described. The median nerve (choice A) and ulnar nerve (choice E) innervate muscles not in the arm but in the forearm and hand. In the arm, the radial nerve (choice C) is the nerve to the only muscle in the extensor compartment,
the triceps brachii. The suprascapular nerve (choice D) innervates two muscles of the rotator cuff, the supraspinatus and infraspinatus. It is affected in a brachial plexus injury at the C6 level.

31. (B) The gums on the lateral side of the mandibular molar teeth are innervated by the buccal nerve (long buccal nerve). All three superior alveolar nerves (choice A) supply the gums lateral to all maxillary teeth. The greater palatine nerve (choice C) innervates the gums medial to the maxillary premolar and molar teeth. The lingual nerve (choice D) supplies the gums medial to all mandibular teeth. The nasopalatine nerve (choice E) innervates the gums posterior to the maxillary incisors.

32. (A) The liver arises as a ventral outgrowth from the caudal portion of the foregut. The midgut (choice C) arises past the junction point between the bile duct and the duodenum, distal to the formative outgrowth of the liver. The midgut gives rise to the small intestine and part of the large intestine. The hindgut (choice B) arises further distally and gives rise to the rest of the large intestine, the superior part of the anal canal, the epithelium of the urinary bladder, and most of the urethra. The pleuroperitoneal membrane (choice D) and the septum transversum (choice E) are developmental components of the diaphragm.

33. (A) Arrow 2 points to the central vein which defines the center of each hepatic lobule (choice B). Arrows 1 and 3 point to portal tracts (choice C), which are located at the angles of the margins of the hepatic lobule. The sinusoids (choice D) originate from the margins of the lobules and converge to the central vein by running between the plates of hepatocytes. The space of Disse (choice E) is found between the sinusoid lining cells and the surfaces of the hepatocytes. It is best seen in electron micrographs and not in a photomicrograph.

34. (E) Hemiballismus is a movement disorder characterized by involuntary large amplitude movements of one or both limbs on one side of the body. It results from infarct damage to the contralateral subthalamus nucleus of Luys, in this case the right one. The left subthalamus nucleus (choice D) controls the limbs on the right side of the body, which are not affected in this case. The anterior limbs of the internal capsule (choices A and B) contain mainly thalamocortical and corticothalamic fibers and lesions in these areas do not result in hemiballismus. Lesions in the cerebellum (choice C) also do not result in hemiballismus.

35. (C) The obturator artery can originate from the inferior epigastric artery, a location which renders it vulnerable during inguinal hernia surgical repair. The common iliac artery (choice A) only has two branches, the external and internal iliac arteries. Within the pelvis, the external iliac artery (choice B) gives out two branches, the deep circumflex iliac and inferior epigastric arteries. The superior (choice E) and inferior (choice D) vesical arteries are branches of the internal iliac arteries, supplying the bladder.

36. (B) In culdocentesis, the needle is inserted through the posterior fornix of the vagina and fluid is aspirated from the rectouterine pouch. If nonclotting blood is collected then the likelihood of a ruptured ectopic pregnancy is high. This procedure is rapid and inexpensive, however, serum progesterone level assay or ultrasonography are preferred methods. The ovarian fossa (choice A) or vesicouterine pouch (choice E) are not used in culdocentesis. The uterine body (choice C) and cervix (choice D) would not reveal blood from a ruptured ectopic pregnancy and thus are also not used in culdocentesis.

37. (D) The spleen (arrow 4) lies to the left of the abdominal cavity. It is in contact with the left side of the stomach (arrow 2) and lodges against the left paravertebral gutter. The abdominal aorta (choice A, arrow 5) is seen as the circular structure immediately anterior to the vertebra. The colon (choice B, arrow 3) is the convoluted structure to the left anterior aspect of the abdominal cavity. The large liver (choice C, arrow 1) occupies most of the right side of the abdominal cavity. The stomach (choice E, arrow 2) is located between the colon and the liver, and in this case, contains liquid contrast material.
38. (C) A cataract is an opacification of the lens caused by a change in the solubility of the lens proteins filensin and crystallins (α, β, and γ). These proteins are synthesized by the cortical lens fibers in the lens substance. Their change in solubility and aggregation result in increased light scattering, forming the cataract, which can only occur in the lens substance. The lens anterior epithelium (choice A) consists of a simple cuboidal epithelium. When these cells reach the equatorial region of the lens, they differentiate into the cortical lens fibers, which then synthesize filensin and the crystallins. The lens capsule (choice B) is a thick and transparent membrane enclosing the lens. The posterior chamber (choice D), located anterior to the lens, and the vitreous cavity (choice E), located posterior to the lens, are not involved in cataract formation.

39. (C) The foramina of Monro form the communication between the lateral ventricles and the third ventricle. The cerebral aqueduct of Sylvius flows caudally into the fourth ventricle (choice A). The lateral foramina of Luschka and the median foramen of Magendie allow for communication between the fourth ventricle and the subarachnoid space. The third ventricle communicates posteriorly with the cerebral aqueduct of Sylvius (choice D). Thus, the third and fourth ventricle communicate by way of this cerebral aqueduct.

40. (A) The correct sequence of erythroid differentiation is indicated by choice A. Erythrocyte differentiation in the adult occurs exclusively in the bone marrow and consists of several cellular changes. The cell size decreases: proerythroblast 14–19 μm in diameter; basophilic erythroblast 13–16 μm; polychromatophilic erythroblast 12–15 μm; normoblast, reticulocyte, and mature erythrocyte 8–10 μm. Condensation of the nuclear chromatin and decrease in nuclear diameter occur from the proerythroblast to the normoblast stage with ejection of the nucleus. Subsequent ejection of remaining organelles occurs in the reticulocyte to give rise to the mature erythrocyte. The maturing cells change their staining affinity because the increased hemoglobin in the cytoplasm results in increased acidophilia, whereas the decrease in the ribosome numbers in the cytoplasm results in decreased basophilia. Choices B, C, D, and E are incorrect sequences.

41. (C) Elastic fibers are destroyed in emphysema by elastase. This protease is released by neutrophils recruited by macrophages under abnormal stimulus such as cigarette smoke. The loss of elasticity in the bronchioles and alveolar walls gives rise to emphysema, characterized by chronic airway obstruction. Ciliated cuboidal epithelial (choice A) and Clara (choice B) cells line the terminal bronchioles. Goblet cells (choice D) may be found at the beginning of the bronchioles and squamous type I alveolar epithelial cells line the respiratory bronchioles.

42. (B) The palatoglossus muscle, which can be observed in the oral cavity to form the palatoglossal arch anterior to the palatine tonsil, lies in the same location as the embryonic oropharyngeal membrane. It lies at the junction line between the stomodeum and the foregut. The buccinator (choice A) is a muscle of the cheek and thus is located in the original stomodeum. The palatopharyngeus (choice C) is located posterior to the palatoglossus and palatine tonsil, forming the palatopharyngeal arch. The palatopharyngeus, stylopharyngeus (choice D), and superior constrictor (choice E) muscles are all pharyngeal muscles and thus are located in the original foregut.

43. (A) The intercalated disks are specialized junctional complexes found only in cardiac muscle and they appear as dark lines between the muscle fibers. The motor end-plate (choice B) is a specialized group of synapses between the axon terminals of a motor neuron and the sarcolemma of a skeletal muscle fiber. It is not seen in cardiac muscle. The sarcoplasmic reticulum (choice C) is a specialized modification of the smooth endoplasmic reticulum for sequestering calcium ions. The transverse tubule or T tubule (choice E) is an invagination of the sarcolemma, which penetrates the muscle fiber and overlies the surface of the myofibrils. The sarcoplasmic reticulum and T tubule can only be seen in electron micrographs. There is no tendinous junction (choice D) in cardiac muscle.
44. (A) Arrow 1 indicates an interstitial cell of Leydig. These cells are recognizable by their location in the intertubular space, close to the capillaries and lymph vessels. Sertoli cells (choice B) are columnar cells with a large nucleolus. They span the distance from the seminiferous tubular wall to the lumen. However, their nuclei are located closer to the tubular wall. Spermatids (choice C; arrow 4) have a condensed nucleus, which becomes elongated with further maturation. This cell type is located closest to the lumen of the seminiferous tubule. Spermatocytes (choice D; arrow 2) are seen above the layer spermatogonia (choice E; arrow 3) which are located against the basal lamina.

45. (D) The falx cerebri is the dural partition separating the hemispheres of the brain, above the corpus callosum. It has in its superior edge the superior sagittal sinus and in its inferior border, the inferior sagittal sinus. The cavernous sinus (choice A) is a dural pocket in the middle cranial fossa and is located on either side of the sella turcica. It is unusual because it contains the internal carotid artery and cranial nerves III, IV, V1, V2, and VI. The sigmoid sinus (choice C) is located in the posterior cranial fossa, below the level of the tentorium cerebelli, which contains in its posterior border the transverse sinus (choice E).

46. (C) In the fetus, the umbilical vein connects directly to the ductus venosus, a fetal vessel which bypasses the liver to bring oxygenated blood to the inferior vena cava (choice D). The descending aorta (choice A) distributes blood to the body and, in the fetal circulation, brings blood to the umbilical arteries by way of the iliac arteries for return to the placenta for oxygenation. The ductus arteriosus (choice B) is a fetal vessel which allows bypass of the oxygenated blood from the pulmonary trunk to the arch of the aorta. The portal vein (choice E) is formed by the union of the splenic vein and the superior mesenteric vein; it returns blood from the digestive system to the liver.

47. (D) The spinal accessory (eleventh cranial) nerve takes its origins in the neck, but then runs cranially into the skull through the foramen magnum to join with its cranial component. They exit as one through the jugular foramen, along with the glossopharyngeal (ninth cranial) and vagus (tenth cranial) nerves. The abducens (sixth cranial) nerve (choice A) runs through the superior orbital fissure to reach the orbit. The facial (seventh cranial; choice B) and vestibulocochlear (eighth cranial; choice E) nerves run together through the internal acoustic meatus into the temporal bone. The facial nerve exits the skull through the stylomastoid foramen. The hypoglossal (twelfth cranial; choice C) nerve exits the skull through the hypoglossal canal.

48. (E) Schwann cells produce myelin in the peripheral nervous system whereas oligodendrocytes produce myelin in the central nervous system. Oligodendrocytes manufacture the proteolipid protein, the functional equivalent to P0 in the central nervous system. Fibrous (choice A) and protoplasmic (choice D) astrocytes are supportive cells which play a role in the regulation of brain metabolism. Microglia (choice B) are mesodermal in origin and have phagocytotic activity in the central nervous system.

49. (A) The capitate bone lies directly distal to the lunate. The mechanism of perilunate fracture dislocation involves rupture of the radioscaphocapitate and scapholunate interosseous ligaments, dislocation of the capitulunate joint, rupture of the lunotriquetral interosseous ligament, and finally dislocation/rupture of the lunate. In the anatomical position, the hamate (choice B) is the most medial carpal bone, located just distal to the triquetrum. The scaphoid (choice C) lies lateral to the lunate and proximal to the trapezium (choice D), the carpal bone articulating with the thumb. The trapezoid (choice E) is medial to the trapezoid and distal to the scaphoid. The lunate bone (choice C) lies adjacent to the scaphoid in the proximal row of carpals and with the scaphoid articulates with the radius at the radiocarpal or wrist joint. It is not related to the anatomic snuffbox. The pisiform bone (choice D) is a sesamoid bone in the tendon of the flexor carpi ulnaris on the lateral wrist. It is not related to the anatomic snuffbox.
50. (B) The infraorbital nerve, a branch of the maxillary (V2) division of the trigeminal (fifth cranial) nerve, courses below the orbital floor to reach the area of skin below the eye. It provides superior alveolar branches to supply the upper gums and is vulnerable in fractures involving the floor of the orbit and face area. All the nerves mentioned in the other choices will be spared by this type of injury. The frontal nerve (choice A) and nasociliary nerve (choice C) are branches from the ophthalmic division (V1) of the trigeminal (fifth cranial) nerve and course within the orbit. The supraorbital (fourth cranial) nerve is a continuation branch of the frontal nerve onto the forehead, providing sensory innervation for this area. The trochlear (fourth cranial) nerve is also located within the orbit.

51. (A) In the human pancreas, A and B cells of the islets of Langerhans secrete glucagon and insulin, respectively. Pancreatic D1 cells (choice D) release a product similar to vasoactive intestinal polypeptide. Pancreatic polypeptide cells (choice E) secrete pancreatic polypeptide and D cells (choice C) release somatostatin. All the aforementioned cells belong to the endocrine pancreas. Acinar cells (choice B) are part of the exocrine pancreas and do not secrete glucagon or insulin.

52. (B) The lining of the gallbladder is a simple columnar epithelium identifiable by tall cells with elongated nuclei arranged at the same level. Pseudostratified epithelium (choice A) is distinguishable from the simple columnar epithelium by the cell nuclei being arranged at different levels. Stratified cuboidal epithelium (choice C) is characterized by short cells with nuclei arranged at different levels. Stratified epithelium (choice D) has a characteristic cellular basal layer with flat degenerate cells in its upper layer. Transitional epithelium (choice E) is a type of stratified epithelium exclusively confined to the urinary tract.

53. (D) The collective neurological signs are characteristic of a lesion of the neocerebellum (cerebellar hemispheres). A lesion in the archicerebellum (cerebellar vermis; arrow 5, choice E) results in loss of equilibrium. None of the other choices apply to the collection of neurological signs displayed by this patient: arrow 1 (choice A) points to the temporal lobe, arrow 2 (choice B) to the eyeball, and arrow 3 (choice C) to the pons.

54. (E) At the root of the neck, the phrenic nerve (C3, C4, C5) lies on the scalenus anterior muscle, not the scalenus medius (choice C). The transverse cervical and suprascapular arteries course over it. The vagus (tenth cranial) nerve, not the phrenic nerve is located between the common carotid artery and the internal jugular vein (choice A). The recurrent laryngeal branch from the vagus nerve wraps around the right subclavian artery (choice D), and courses cranially between the esophagus and the trachea (choice B).

55. (B) HMD is also known as respiratory distress syndrome, which is most often caused by the lack of lung surfactant, due to a premature birth. Lung surfactant production begins around 20 weeks after fertilization. But it is present only in small amounts until the last 2 weeks before birth when its amount increases significantly. Alveolar ducts (choice A) branch from the respiratory bronchioles during development. Type I alveolar cells (choice D) or pneumocytes are squamous epithelial cells, which participate in gas exchange. These epithelial cells line the terminal saccules (choice C). Type II alveolar cells (choice E) synthesize surfactant.

56. (D) Retinal separation typically occurs at the interface between the retinal pigment epithelium and the outer limit of the sensory (neural) retina. The weakness of this plane is attributed to the manner in which the retina develops, a process that involves obliteration of the space between two of the layers of the optic cup—an inner layer from which the sensory retina arises and an outer layer from which the retinal pigment epithelium arises. Other retinal layers are bridged by neuronal processes, and Müller cells (the retina’s glial cells) span the entire thickness of the neural retina. Plane A (choice A) marks the boundary between the nerve fiber layer above and the ganglion cell layer below. The nerve fiber layer is composed of axons of the retinal ganglion cells. Plane B (choice B) is
within the inner plexiform layer, the site of synaptic contacts between bipolar neurons, retinal ganglion cells, and amacrine cells. Plane C (choice C) is within the outer plexiform layer, the site of synapses among bipolar cells, rods and cones, and horizontal cells. The boundary between the choroid (of the middle vascular tunic or uvea) and the sclera (of the external, fibrous tunic) is marked by plane E (choice E).

57. (A) The central visual pathway for the pupillary light reflex is organized as follows: fibers from the ganglionic layer of the retina project posteriorly to the pretectum, which in turn innervates the Edinger-Westphal nucleus. Preganglionic parasympathetic neurons in the Edinger-Westphal nucleus project to the ciliary ganglion, which sends postganglionic parasympathetic innervation back to the constrictor pupillae of the eye. The Edinger-Westphal nuclei from each side of the midbrain are also connected to each other by projections running through the posterior commissure. Disconnection of these fibers will result in loss of the consensual pupillary light reflex on the contralateral side, as happens in this case. The habenula (choice B) is a nucleus of the thalamus, which does not participate in the central visual pathways. The lateral geniculate nucleus (choice D) receives fibers from the ganglionic layer of the retina. However, fibers participating in the pupillary light reflex run through this structure without synapsing and terminate in the pretectum. Thus, the lateral geniculate nucleus does not participate in the pupillary light reflex. The inferior colliculus (choice C) and the medial geniculate nucleus (choice E) are components of the auditory system.

58. (E) The ventral posterior lateral (VPL) and ventral posterior medial (VPM) nuclei are sensory relay thalamic nuclei. The lateral and medial geniculate nuclei (choice A) are respectively concerned with visual and auditory sensory information. The lateral dorsal (LD) and lateral posterior (LP) nuclei (choice B), and the pulvinar (choice C) are association or multimodal relay nuclei. The ventral anterior (VA) and ventral lateral (VL) are motor relay nuclei.

59. (B) Obstruction of the portal vein results in an increase in the collateral circulation between veins that normally drain to the portal vein and those that drain to the systemic veins. Choices A, B, D, and E all represent possible collateral venous circulation in case of portal obstruction. Choice A is rare because the ductus venosus closes after birth.

Choice B is correct because varicose veins in this region give rise to esophageal varices. Choice D results in varicose veins in the rectal region. Choice C is incorrect because there is no connection between the right gastric vein and the inferior vena cava. In choice E, enlargement of the epigastric veins results in varicose veins radiating from the umbilicus, the caput medusae.

60. (A) The deep peroneal (fibular) nerve innervates the muscles responsible for dorsiflexion in the anterior compartment of the leg. It also provides for the cutaneous innervation of the space between digits 1 and 2. The femoral nerve (choice B) innervates muscles in the anterior compartment of the thigh and the skin of the medial aspect of the leg by a continuing branch, the saphenous nerve (choice C). The superficial peroneal (fibular) nerve (choice D) innervates the lateral compartment of the leg and muscles responsible for foot eversion. The tibial nerve (choice E) innervates the posterior compartment of the leg and the muscles responsible for plantar flexion.

61. (E) The space between plasmalemmas of adjacent epithelial cells is obliterated at the tight junction (zonula occludens), which forms by fusion of the membranes along narrow anastomosing bands. The tight junction is the apical—most part of the junctional complex, which is typical of epithelia lining tubular and hollow organs. The zonula adherens and desmosome (choice A) also contribute to the junctional complex, but they hold adjacent cells together. The gap junction (choice B) functions to electrically and chemically couple adjacent cells. It consists of direct channels (connexons) between cells, but there is a significant space (about 2 nm) separating the membranes between the channels. The hemidesmosome
(choice C) is a specialization for adhesion of a cell to its basement membrane. The terminal bar (choice D) is not a type of junction, but rather a manifestation of the junctional complex seen with the light microscope.

62. (B) Second-order neurons in the central auditory pathways are located in the dorsal and ventral cochlear nuclei. They receive afferents from the first-order neurons located in the cochlear (spiral) ganglion (choice A). Second-order fibers from the cochlear nuclei project in turn to the inferior colliculi (choice C), nuclei of lateral lemniscus (choice D), and superior olivary nuclei (choice E).

63. (D) The macula densa indicated by arrow 2 is a modified segment of the distal tubule at the site of its passage adjacent to the vascular pole of the renal corpuscle. The name arises from the close spacing of nuclei of the epithelial cells forming this part of the distal tubule. These cells are thought to sense the chloride content in the passing filtrate and generate signals that regulate the caliber of the afferent arteriole. The glomerulus (choice A, arrow 1) is a network of capillaries derived from the afferent arteriole and suspended within Bowman’s capsule by its vascular pole. The juxtaglomerular cells (choice B) form a cuff around the afferent arteriole prior to its entrance into the glomerulus and they secrete renin. Lacis cells (choice C, arrow 4) are extraglomerular mesangial cells with an uncertain function. The vascular pole (choice E, arrow 3) feeds blood to the glomerulus and carries blood away from it. As part of the juxtaglomerular apparatus, it is closely apposed to the macula densa.

64. (D) The right lymphatic trunk is ruptured and chyle is exuding from the wound. Blood would flow from a wound involving the common carotid artery (choice A) or internal jugular vein (choice C). A stabbing lesion of the cupola of the right lung (choice B) would result in pneumothorax. The thoracic duct (choice E) does carry chyle. However, the thoracic duct drains into the bifurcation of the internal jugular and subclavian veins on the left side, above the left sternoclavicular joint.

65. (A) The arcuate fasciculus connects Wernicke’s area to Broca’s area, integrating comprehension of speech with motor speech. A lesion in this connecting bundle results in this unusual condition of conduction aphasia, characterized by impairment of repetition and naming. Broca’s area (choice B) is the motor speech area and lesion in this area will result in motor speech impairment. However, this patient’s verbal output is fluent. A lesion in the nucleus ambiguus (choice C) will result in dysarthria and also loss of a fluent verbal output. The red nucleus (choice D) is a mesencephalic motor nucleus, which does not participate in the central pathways for speech. Wernicke’s area (choice E) is the speech comprehension area, which is intact in this patient because he comprehends spoken language.

66. (E) The thymus provides for development of new T lymphocytes in an environment shielded from foreign antigens. Like bone marrow, the thymus is a primary lymphoid organ, and not a site of reactions to foreign antigens. Lymphoid follicles are sites of B lymphocyte proliferation in response to antigen stimulation. These occur in the lymph nodes (choice A), Peyer’s patches (choice B), tonsils (choice C), and white pulp of the spleen (choice D).

67. (C) The pneumotaxic center is located in the upper one-third of the pons, whereas the apneustic center is in the lower two-thirds. The apneustic center promotes inspiration and the pneumotaxic center, expiration. The telencephalon (choice E), diencephalon (choice A), midbrain (choice B), and spinal cord (choice D) are not known to contain pneumotaxic or apneustic centers.

68. (C) Wrist drop and weak hand grasp indicate that the patient has a lesion of the radial nerve, most likely at the distal third of the humerus, sparing the innervation of the triceps brachii but affecting the supinator. Because the patient can extend the elbow, the integrity of the posterior cord (choice A) and posterior divisions (choice B) of the brachial plexus is preserved. Lesion of the radial nerve at the midforearm
(choice D) and wrist (choice E) would spare the innervation of the supinator.

69. (A) The biceps brachii is a strong supinator of the forearm through its attachment to the radial tuberosity, but it can only function when the elbow is partially flexed. The supinator by itself is a weaker supinator muscle: prove it to yourself by using a screwdriver with your right elbow flexed (biceps brachii and supinator) and your right elbow extended (supinator only). The brachialis (choice B) and brachioradialis (choice C) muscles are flexors of the forearm. The pronator teres (choice D), as its name indicates, pronates the forearm. The anconeus (choice E) helps in extension of the elbow.

70. (D) Prolactin is secreted by one of the two types of hormone-secreting acidophils, the mammotrophs. The other types of acidophils are the somatotrophs, which secrete growth hormone (somatotropin). The hormones listed in all the other choices are secreted by the basophils. Adrenocorticotropicin (choice A) is secreted by the corticotrophs. The gonadotrophs secrete either follicle-stimulating hormone (choice B) or luteinizing hormone (choice C). Thyrotropin (choice E) is secreted by thyrotrophs.

71. (D) Generation of specific granules occurs during the myelocyte stage. Development of all three types of granulocytes follows a similar sequence of stages. The granulocyte colony-forming unit (choice A) is an undifferentiated progenitor cell of the granulocyte line. Buildup of the protein synthesis machinery occurs during the myeloblast (choice C) and promyelocyte (choice E) stages. The promyelocyte stage is also characterized by production of primary (nonspecific) granules. After the myelocyte stage, further condensation and reshaping of the nucleus occurs during the metamyelocyte stage (choice B).

72. (A) The great cerebral vein of Galen joins with the inferior sagittal sinus to form the straight sinus. The latter drains into the transverse sinus (choice E). The superior sagittal sinus (choice D) drains posteriorly into the transverse sinus. The transverse sinus which runs bilaterally on the posterior wall of the posterior cranial fossa becomes the sigmoid sinus (choice B) which flows into the internal jugular vein. The superior petrosal sinus (choice C) extends from the cavernous sinus to the beginning of the sigmoid sinus.

73. (B) The inferior thyroid artery provides for the majority of the blood supply of the esophagus at cervical levels. It can be assisted by branches from the common carotid, subclavian, vertebral, ascending pharyngeal, superficial cervical, and costocervical arteries. The bronchial arteries (choice A) supply the thoracic portion of the esophagus and maybe assisted in the lower part by branches of the internal thoracic artery (choice C). The abdominal portion of the esophagus is vascularized by branches from the left inferior gastric artery and left inferior phrenic artery.

74. (C) The apical ectodermal ridge secretes fibroblast growth factors, which act on mesenchymal cells in the zone of polarizing activity at the posterior margin of the limb bud. Activation of the zone of polarizing activity causes expression of the sonic hedgehog gene. Proteins expressed by the sonic hedgehog gene control the anteroposterior developmental pattern of the limb. The apical ectodermal ridge is contained within the ectoderm (choice A) and has no interaction with the endoderm (choice B). The notochord (choice D) and sclerotome (choice E) are structures involved in the development of the axial skeleton and not the limbs.

75. (C) The parotid gland is the only major salivary gland containing almost exclusively serous secretory cells. Esophageal (choice A) and intestinal glands (choice B) are small mucus-secreting glands. The sublingual (choice D) and submandibular glands (choice E) are mixed glands with differing proportions of serous and mucous cells.

76. (C) Centroacinar cells are components of the exocrine pancreas and they contain zymogen granules, which are released under the action of cholecystokinin from the duodenum. The zymogen granules contain inactive proenzymes.
that normally become activated within the duodenum. Premature activation of the pancreatic enzymes, such as trypsin, leads to autodigestion of the centroacinar cells of the pancreatic acini, which secrete these enzymes. This results in acute hemorrhagic pancreatitis which can be caused by excessive alcohol ingestion. All the other choices are cells of the endocrine pancreas, which secrete hormones. Alpha cells (choice A) secrete glucagon whereas beta cells (choice B) produce insulin. Delta cells (choice C) synthesize gastrin and somatostatin. F cells produce pancreatic polypeptide.

77. (A) In the anterior drawer test, the patient’s tibia is pulled forward and anterior tibial displacement reveals rupture of the anterior cruciate ligament. The drawer test becomes negative when the knee is internally rotated because of the tightening of the posterior cruciate ligament (choice D); in this case, the result reveals that the posterior cruciate ligament is not affected. External rotation is limited by the tibial (medial) collateral ligament (choice E) and since the drawer sign is negative with the knee in this position, this ligament is also intact. The fibula (choice B) and fibular collateral ligament (choice C) do not participate in the knee joint and have no effect on the drawer test.

78. (B) The pectineus muscle is part of the adductor muscles of the thigh, which are innervated as a group by the obturator nerve. The genitofemoral nerve (choice A) provides sensory innervation for a small area of the skin in the medial superior aspect of the thigh, and motor innervation to the cremaster muscle. The peroneal division of the sciatic nerve (choice C) innervates the skin and muscles in the peroneal and anterior compartments of the leg. The saphenous nerve (choice D) is purely a sensory nerve for the medial aspect of the leg and the foot. The tibial division of the sciatic nerve (choice E) provides sensory and motor innervation to the posterior compartment of the leg and the plantar foot.

79. (D) The stylohyoid is innervated by the facial (seventh cranial) nerve. During the embryonic period, the muscles developing from the second pharyngeal arch include the stylohyoid, stapedius, posterior belly of the digastric, auricular muscles, and muscles of facial expression. The nerve supplying the second pharyngeal arch, and thus all these muscles, is the facial (seventh cranial) nerve. All the other muscles, omohyoid (choice A), sternohyoid (choice B), sternothyroid (choice C), and thyrohyoid (choice E) form the infrayoid muscle. They are supplied as a group by branches of the ansa cervicalis derived from C1, C2, and C3.

80. (D) Abnormal development of either the septum primum or septum secundum results in ostium secundum atrial septal defects in the area of the fossa ovalis. This common type of congenital heart defect is manifested by a patent foramen ovale between right and left atria. This is well-tolerated during childhood, but symptoms usually appear after 30 years of age. The aorticopulmonary septum (choice A) divides the truncus arteriosus of the developing heart and gives rise to the ascending aorta and pulmonary trunk. The endocardial cushions (choice B) give rise to the right and left atrioventricular canals. The interventricular septum (choice C) forms between the right and left ventricles. The sinus venosus (choice E) becomes incorporated into the atria, as well as giving rise to the openings of the pulmonary veins and the venae cavae.

81. (B) Desmin belongs to the type III intermediate filaments. Intermediate filament proteins have three domains: a head domain (N-terminal), an alpha-helical rod domain, and a tail domain (C-terminal). The six types of intermediate filament proteins are differentiated by the sequence in the rod domain. Type I (choice A) intermediate filaments include the cytokeratins. Type IV (choice C) intermediate filaments are found in the nervous system and include the neurofilaments and alpha-internexin. Type V (choice D) intermediate filaments are the nuclear lamins. Nestin, expressed in stem cells of the central nervous system, is a type VI (choice E) intermediate filament.

82. (E) The black areas in this section of dried, compact bone are empty spaces normally occupied
by cells and soft tissues. The arrows indicate lacunae interspersed among lamellae of osteons (haversian systems). In life, these are occupied by osteocytes. The fine lines radiating from the lacunae are canaliculi, which contain processes of the osteocytes. Blood vessels (choice A) of compact bone course through Volkmann’s canals (not shown) and haversian canals (seen here at the center of each osteon). Hematopoietic cells (choice B) occur in red marrow located within medullary canals of long bones and the cavities of cancellous bone. Osteoblasts (choice C) are restricted to surfaces of bone at sites of bone apposition. When osteoblasts become entrapped in lacunae as a result of their synthetic activity, they become osteocytes. Osteoclasts (choice D) are large, multinucleated cells found at surfaces of bone that are undergoing absorption.

83. **(D)** The levator palpebrae superioris, which opens the upper eyelid and is located in the orbit, is innervated by the oculomotor (third cranial) nerve. In this case of Bell’s palsy, long-term exposure to the cold has affected the peripheral portion of the facial (seventh cranial) nerve. The buccinator (choice A), levator labii superioris (choice B), levator labii superioris alaque nasi (choice C), and orbicularis oculi (choice E) are all innervated by the facial nerve and will all be impaired.

84. **(B)** Conjugate movement of the eyes depends on the integrity of the MLF, which links the ipsilateral lateral gaze center in the pons with the contralateral oculomotor nucleus in the midbrain. Lesion of the MLF disconnects these brain nuclei resulting in internuclear ophthalmoplegia and the bilateral condition can be seen in patients with multiple sclerosis. A patient with a lesion of the fourth cranial nerve (choice A) cannot look downward and inward; there is a slight convergent strabismus when the patient attempts to do so. Lesion of the second cranial nerve (choice C) will result in blindness. Weakness of eye abduction characterizes lesion of the sixth cranial nerve (choice D), which also displays as a convergent strabismus. In a patient with a third cranial nerve (choice E) lesion, the eye is deviated downward and outward (divergent strabismus); ptosis would also be noticeable.

85. **(E)** The inferior parathyroid glands and the thymus arise from the third pharyngeal pouch. The superior parathyroid glands develop from the fourth pharyngeal pouch (choice C). The fifth pharyngeal pouch (choice A) in the human is rudimentary or absent. The first pharyngeal pouch (choice B) gives rise to the tympanic membrane, tympanic cavity, mastoid antrum, and pharyngotympanic tube. The palatine tonsil along with the tonsillar sinus and crypts develop from the second pharyngeal pouch (choice D).

86. **(A)** The sensations of discriminative touch and vibration are transmitted through the medial lemniscus. Pain and temperature pathways decussate in the ventral white commissure (choice B). The nucleus gracilis (choice C) contains neurons that process sensory signals from the lower extremity. The second-order fibers carrying discriminative touch and vibration from the upper limb originate from neurons in the nucleus cuneatus (choice E). First order fibers are found in the dorsal funiculus (choice D).

87. **(B)** Because the right side of the patient is affected, the stroke is in the territory of the left middle cerebral artery. This artery supplies the lateral aspect of the cerebral hemisphere, including portions of the pre-and postcentral gyri corresponding to the head, upper limb, and trunk on the primary motor (area 4 of Brodmann) and primary sensory (area 3,1,2 of Brodmann) cortical strips. These cortical control areas for the right lower limb are supplied by branches of the left anterior cerebral artery (choice A), which is uninvolved in this case since the lower limb is intact. The left posterior cerebral artery (choice C) supplies the occipital and temporal lobes and is unaffected in this case. Since the right side of the brain controls the left side of the body and the patient is intact on the left side, none of the right side cerebral arteries (choices D and E) are involved.

88. **(B)** Since the patient presents with a spastic neurogenic bladder, the lesion is in the spinal
cord above the level of S2. The micturition reflex works as follows: when the bladder becomes distended, sensory impulses travel back from the bladder to synapse onto preganglionic parasympathetic neurons located at the levels of S2-S4. These neurons, in turn, excite postganglionic parasympathetic neurons which innervate and cause contraction of the detrusor muscle of the urinary bladder, thus emptying the bladder. This primitive reflex loop comes under supraspinal influence in early childhood when the child learns control of the micturition reflex. When the supraspinal influence is removed, as happens with spinal lesions above the level of S2, the primitive reflex loop remains and the neurogenic spastic bladder empties itself reflexively whenever it becomes full. Lesions in the cauda equina (choice A), or in the spinal cord at the level of S2 (choice B), S3 (choice D), or S4 (choice E) will result in a flaccid bladder because of loss of innervation to the detrusor muscle. In this case, the bladder does not contract by itself and the patient will have to be catheterized to prevent cystitis.

89. (C) Papez circuit is formed by efferent fibers of the hippocampus, which project by way of the fornix to the mammillary nuclei in the hypothalamus. Axons from the mammillary nuclei project to the anterior thalamic nucleus, which is connected to the cingulate gyrus. The latter projects back to the hippocampus by way of the parahippocampal gyrus. Papez circuit integrates cortical, hypothalamic, and thalamic functions resulting in the integration of cognitive, emotional, and expressive brain functions. The ventrolateral thalamic nucleus (choice E) is involved in motor pathways, being connected to the deep cerebellar nuclei and the motor cortex. The caudate nucleus (choice B) is a component of the basal ganglia and the extrapyramidal motor control system. Although the amygdala (choice A) is involved in emotional brain functions, it is not part of Papez circuit. The suprachiasmatic nucleus (choice D) is located in the hypothalamus and mediates the circadian rhythm.

90. (C) The anterior aspect of the scrotum is innervated by branches of the ilioinguinal nerve (L1). Other nerves innervating the scrotum are branches of the genitofemoral nerve (L1, L2), pudendal nerve (S2-S4), and posterior femoral cutaneous nerve (S2, S3). The femoral nerve (L2-L4, choice A) supplies sensory innervation to the anteromedial thigh, hip joint, and knee joint. It also innervates muscles of the anterior compartment of the thigh. The iliohypogastric nerve (L1, choice B) provides sensory innervation over the iliac crest and the hypogastric region. The obturator nerve (L2-L4, choice D) supplies motor innervation to the medial compartment of the thigh. The subcostal nerve (T12, choice E) provides motor innervation for the lower part of the external oblique muscle and sensory innervation over the hip and anterior superior iliac spine.

91. (C) The lactiferous duct is lined by a two-cell layered cuboidal epithelium. All other epithelial choices are not found in the breast tissue and are thus incorrect.

92. (B) The gonadal arteries are paired visceral branches of the abdominal aorta. Other branches in this category are the suprarenal and renal arteries. The celiac trunk (choice A) and superior mesenteric artery (choice E) are unpaired visceral branches. The inferior phrenic (choice C) and lumbar (choice D) arteries are paired parietal branches.

93. (C) During development, the uterus develops from fusion of the caudal ends of the para-mesonephric ducts. Failure of fusion results in uterus didelphys. The mesonephric ducts (choice A) give rise to the epididymis, vas deferens, and ejaculatory duct in the male. The nephrogenic ridge (choice B) is the derivative of the urogenital ridge which will give rise to the urinary system. The urogenital sinus (choice D) gives rise to the urinary bladder, urethra, vagina, and associated glands in the female. The yolk sac (choice E) plays a role in transfer of nutrients before uteroplacental circulation is established, in blood development before the liver begins its hemopoietic activity, and is the site of formation of primordial germ cells.

94. (D) Congenital defect of the pleuroperitoneal membrane results in an abnormal opening in
the posterolateral aspects of the diaphragm. This defect occurs more often on the left side of the body. It is due to the failure of the pleuropertoneal membrane to form properly and/or to fuse with the other parts of the diaphragm: the mesentery of the esophagus (choice A), the muscular ingrowth of the body wall (choice B), and the septum transversum (choice E). The pleuropertoneal membranes (choice C) participate in the formation of the mediastinum and do not contribute to the formation of the diaphragm.

95.  (E) The position of the appendix varies depending on the patient. The taeniae coli are three longitudinal bands of smooth muscle running the length of the colon. Since the appendix is part of the colon, the taeniae coli can be accurately followed to this structure. The bifurcation of the abdominal aorta (choice A) and inferior border of the right kidney (choice D) are retroperitoneal and would not be of value in identification of the appendix. The epiploic appendages (choice B) are small pockets of fatty tissue along the length of the colon, but they are not found on the appendix. The haustra (choice C) are sacculations of the large intestine resulting from contractions of the taeniae coli.

96.  (D) Compression of cranial nerve III, in combination with descending corticospinal and corticobulbar fibers, occurs as part of superior alternating hemiplegia. Patients with Broca’s aphasia (choice A) typically do not exhibit involvement of the pupillary light reflexes. Inferior alternating hemiplegia (choice B) and middle alternating hemiplegia (choice C) involve cranial nerves XII and VI, respectively, in combination with corticospinal fibers. Wallenberg syndrome (lateral medullary syndrome) (choice E) typically does not include damage to the corticospinal tract.

97.  (E) The skin in the affected area is red and dry (not moist as in choice D) due to diminished sympathetic activity. The pupil on the affected side is constricted (myosis) (not dilated as in choice B) due to unopposed activity of the sphincter pupillae muscle. Motor deficits such as atrophy of tongue musculature (choice A) or paralysis of facial expression muscles (choice C) are typically not part of Horner syndrome.

98.  (C) Suturing the inferior end of the portal vein to the inferior vena cava is termed end-to-side portocaval shunt, whereas establishing a communication between the portal vein and the inferior vena cava (choice A) is a side-to-side portocaval shunt. Placing a prosthetic vascular graft between the inferior vena cava and the superior mesenteric vein (choice B) is termed a mesocaval shunt. Anastomosis of the splenic vein to the left renal vein (choice D) is a splenorenal or Warren shunt. Placement of an expandable stent between the hepatic vein and portal vein (choice E) is called a transjugular intrahepatic portosystemic shunt or TIPS.

99.  (D) The left colic (splenic) flexure represents the junction of the midgut to the hindgut during embryonic development. The vagus (tenth cranial) nerve provides the parasympathetic innervation of the digestive tract up to this flexure, whereas the pelvic parasympathetic fibers from S2-S4 innervate the rest of the tract. The duodenaljejunal junction (choice A), ileocolic junction (choice B), and right colic (hepatic) flexure (choice E) are anatomical landmarks along the digestive tract without change in parasympathetic innervation. The junction of the second part and third part of the duodenum (choice C) represents the embryonic junction between the foregut and the midgut, but both receive vagal innervation.

100. (D) Arrow 1 points to the maxillary sinus, which is innervated by the posterior, middle, and anterior superior alveolar nerves. The latter are branches from the infraorbital nerve arising from the maxillary division (V2) of the trigeminal (fifth cranial) nerve. The anterior ethmoidal nerve (choice A) is a branch of the nasociliary nerve from the ophthalmic division (V1) of the trigeminal nerve. The greater palatine nerve (choice B) and lesser palatine nerve (choice C) are branches of the maxillary division of the trigeminal nerve supplying the hard and soft palate, respectively. The nasopalatine nerve (choice E) is derived from the maxillary division of the trigeminal nerve and supplies the nasal septum.
101. (C) Capsular lesions of the corticobulbar system produce the “central seven” symptoms. Loss of the descending cortical fibers to the contralateral facial nucleus (cranial nerve VII) primarily affects the muscles of facial expression in the lower portion of the face, particularly those around the angle of the mouth and the nasolabial fold. Deviation of the protruded tongue (choice A), hypertonia/hyperreflexia (choice B), and spastic hemiplegia (choice E) are symptoms that result from a capsular lesion, but they would be seen contralateral to the affected capsule, and in this case would involve the left side of the body. Paraplegia (choice D) is not typically seen following a unilateral capsular lesion.

102. (D) The ventral lateral nucleus of the thalamus receives projections from the deep cerebellar nuclei and, in turn, sends projections to the motor cortex. It is thus functionally defined as a thalamic motor nucleus. The dorsomedial nucleus (choice A) is considered a limbic nucleus of the thalamus as it receives projections from the amygdala and olfactory cortex, and projects to the prefrontal cortex and hypothalamus. The lateral (choice B) and medial geniculate (choice C) nuclei and the ventral posterior medial nucleus (choice D) are considered sensory nuclei as they receive information mediating vision, audition, and somatosensory signals from the face, respectively. In turn, these three brain areas project to the somatosensory cortex.

103. (A) The jaw-jerk reflex is a monosynaptic (stretch) reflex for the masseter muscle. Proprioceptive fibers from the muscle travel by way of the trigeminal nerve back to their cell bodies in the mesencephalic trigeminal nucleus. Projections from this nucleus synapse on motor neurons of the motor trigeminal nucleus (choice B) which elicits contraction of the masseter muscle. The principal (main) trigeminal nucleus (choice C) receives light touch sensory information from the face, whereas the spinal trigeminal nucleus (choice D) receives pain and temperature sensations. The trigeminal (gasserian) ganglion (choice E) contains the cell bodies of all sensory neurons projecting to the principal (main) and spinal trigeminal nuclei.

104. (E) The type Ia sensory fibers from a spindle form direct excitatory synapses with alpha motoneurons. Activation of type Ia sensory fibers (choice A) leads to excitation of the muscle in which that spindle is located. Alpha motoneurons (choice B) synapse with extrafusal muscle fibers, whereas gamma motoneurons synapse with intrafusal muscle fibers. Each intrafusal muscle fiber (choice C) is innervated by only one gamma motoneuron. Each muscle spindle contains a mixture of both nuclear bag and nuclear chain intrafusal fibers, not just one type as indicated in choice D.

105. (A) The Babinski sign—dorsiflexion of the great toe in response to stroking the plantar aspect of the foot—is a characteristic sign of pyramidal tract involvement. Signs and symptoms of corticospinal tract injury that are nearly always apparent to some degree include spastic paralysis, hypertonia, loss of deep tendon reflexes, and hyperactive abdominal and cremasteric reflexes. Flaccid paralysis and hypotonia (choice B) are commonly seen following lower motoneuron injury, as is loss of deep tendon reflexes (choice E). Muscle degeneration and atrophy (choice C) are not characteristic symptoms of corticospinal tract damage. The presence of an intention tremor (choice D) is a sign of cerebellar damage, and is not seen with corticospinal tract lesions.

106. (C) A cilium is formed by a concentric array of nine microtubule doublets surrounding a central pair of microtubules (9 + 2 organization). Intermediate filaments (choice A) are intermediate in diameter size (10 nm) between the microtubules (25 nm) and the microfilaments (7 nm). They do not confer motility to the cilia. They instead participate in the cytoskeletal integrity of nerve cells, neurofilaments (choice D) or hemidesmosomes, tonofilaments (choice E). Microfilaments (choice B) are found in microvilli and stereocilia.

107. (E) Ileus is obstruction of the intestine, in this case due to paralysis resulting from ischemia. The jejunum receives its vascular supply from jejunal branches arising from the superior mesenteric artery. The ileocolic artery (choice A)
supplies the ileum, ileocolic junction, and the appendix. The inferior pancreaticoduodenal artery (choice B) provides vascular innervation to the pancreas and duodenum, and forms the anastomosis between the foregut and midgut. The right colic artery (choice C) supplies the ascending colon and the right gastroepiploic artery (choice D) the greater curvature of the stomach and greater omentum.

108. (C) The nucleus raphe magnus receives input from the periaqueductal gray and gives rise to descending serotonergic fibers of the raphe spinal projection. The latter fibers activate enkephalinergic spinal cord interneurons that presynaptically inhibit incoming pain fibers at their initial synapse in the spinal cord dorsal horn. The neurotransmitter dopamine (choice A) has not been shown to be involved in the descending systems that modulate pain transmission. The MLF (choice B) is an ascending fiber system in the brainstem that is primarily involved in the control of eye movements. The rubrospinal system (choice D) is a descending fiber tract involved with the control of limb musculature. The ventral lateral nucleus of the thalamus (choice E) is primarily involved with motor function and does not contribute to descending pathways that influence pain transmission.

109. (E) The spleen receives its blood supply from the splenic artery, which branches off from the celiac trunk from the abdominal aorta. At the hilum of the spleen, the splenic artery branches off into trabecular arteries, which enter the spleen along the trabeculae and branch in the parenchyma as central arteries running in the white pulp. The central arteries branch into penicillar arterioles, which give rise to capillaries and sheathed arterioles. The capillaries feed the marginal sinuses as well as the red pulp sinuses. Afferent (choice A) and efferent (choice B) arterioles, and interlobar (choice C) and interlobular (choice D) arteries are vessels found in the kidney.

110. (B) The inferior epigastric vessels lie medial to the deep inguinal ring. An indirect inguinal hernia leaves the abdominal cavity through the deep inguinal ring and is thus always localized lateral to the inferior epigastric vessels. A direct inguinal hernia results from weakness in the posterior wall of the inguinal canal and pushes through the conjoint tendon to reach the superficial inguinal ring. The direct inguinal hernia is thus always located medial to the inferior epigastric vessels. The anterior superior iliac spine (choice A) and pubic tubercle (choice D) are respectively located too far laterally or medially to be of use in distinguishing indirect from direct hernias. The inguinal ligament (choice C) is used to distinguish a femoral hernia which is always located inferior to this structure. The umbilicus (choice E) is the site for an umbilical hernia and not inguinal hernias.

111. (E) Arrow 1 points to the superior vena cava. The central venous catheter is inserted into the subclavian vein and threaded into the superior vena cava. The ascending aorta (choice A) is labeled by arrow 4 and its counterpart, the descending aorta (choice C) by arrow 5. The azygos vein (choice B) is indicated by arrow 1. Arrow 2 indicates the right bronchus (choice D) just as it leaves the carina.

112. (E) The appearance of this epithelium reveals it to be transitional epithelium. It is stratified with a scalloped surface outline. The cells at the bottom layer are cuboidal in appearance and stained darkly; cells in the intermediate layer are polygonal. Cells at the surface of the epithelium are pale-stained, rounded, and large. Transitional epithelium is characteristic of organs of the urinary system, such as the urinary bladder. The gall bladder (choice A) is characterized by simple columnar epithelium. The epithelium of the salivary gland (choice B) is simple cuboidal epithelium. Thick skin (choice C) is made up of stratified squamous epithelium and the trachea (choice D) is lined with pseudostratified columnar epithelium.

113. (E) Transposition of the great vessels occurs when the truncoconal ridges fail to spiral as they divide the outflow tract into two channels. This produces two totally independent circulatory loops with the right ventricle feeding into the aorta and the left ventricle feeding
into the pulmonary artery. Common atrium (choice A) results from a complete failure of the septum primum and septum secundum to form. Persistent atrioventricular canal (choice B) results from a failure of the endocardial cushions to fuse and partition the atrioventricular canal into a right and left component. It is accompanied by defects of the atrial and ventricular septa. Persistent truncus arteriosus (choice C) results from a total failure of the truncal conal ridges to develop and partition the outflow tract of the developing heart. Tetralogy of Fallot (choice D) is a related group of defects with the primary malformation being an unequal division of the outflow tract, resulting in pulmonary stenosis. The other features of tetralogy are an interventricular septal defect, an overriding aorta, and right ventricular hypertrophy. Survival of the infant depends on the maintenance of a patent ductus arteriosus.

114. (B) The left testicular vein drains into the left renal vein. The inferior vena cava (choice A) receives the right testicular vein. The equivalent relationship holds true in the female where the left ovarian vein drains into the left renal vein and the right ovarian vein into the inferior vena cava. The right common iliac vein (choice C), right femoral vein (choice D), and right renal vein (choice E) do not receive gonadal veins.

115. (E) The posterior one-third of the tongue is derived from the third pharyngeal arch and is thus innervated by cranial nerve IX (glossopharyngeal). The first pharyngeal arch (choice A) and second pharyngeal arch (choice C) give rise to the anterior two-thirds of the tongue. The mandibular division of cranial nerve V (trigeminal) provides general sensation to the anterior two-thirds of the tongue, and cranial nerve VII via the chorda tympani provides special sensation (taste). The fourth pharyngeal arch (choice B) gives rise to the epiglottis and, along with the sixth pharyngeal arch (choice D), to the laryngeal cartilages. The nerve to the fourth pharyngeal arch is cranial nerve X (vagus).

116. (D) In 60% of patients, the right coronary artery supplies the SA node. In a third of the population, the SA node is supplied by the left coronary artery and in some patients it receives branches from both the right and the left. The anterior interventricular (choice A) and left circumflex (choice B) arteries are distal branches of the left coronary artery, too distant to supply the SA node. The right coronary artery normally gives out its SA nodal branch in its proximal portion and then distally gives rise to the right marginal (choice E) and posterior interventricular (choice C) arteries. These are also too distant to supply the SA node.

117. (D) The medial circumflex femoral artery supplies the most important source of blood to the femoral head and neck. This artery anastomoses with the artery to the head of the femur (choice A), which arises from the obturator artery. However, if the medial circumflex femoral artery is injured, the blood flow in the small artery to the head of the femur may not be sufficient to prevent posttraumatic avascular necrosis of the femoral head. Normally, the medial and lateral circumflex femoral arteries arise from the deep artery of the thigh but occasionally they arise from the femoral artery (choice B). However, the femoral artery is not a direct vascular source to the head of the femur. The lateral circumflex femoral artery (choice C) and superior gluteal artery (choice E) also supply the hip joint, but their contribution to the head and neck of the femur is less than that of the medial femoral circumflex artery.

118. (E) The needle for thoracentesis should be inserted in the intercostals spaces between the 8th and 10th ribs. Remember that the parietal pleura extends approximately two ribs inferior to the lung: at the midaxillary line, the inferior surface at the lung is at the level of the 8th rib and the parietal pleura at the 10th rib. Above the level of the 7th (choice A) and 5th (choice C) ribs, the needle will injure the lung. At (choice B) or below the level of the 10th rib (choice D), it will injure the liver or other abdominal organs.

119. (E) In this situation, the cerebrospinal fluid will accumulate immediately in the third ventricle and cause hydrocephalus. The flow of cerebrospinal fluid is normally from the lateral ventricles (choice C) to the third ventricle and then
by way of the cerebral aqueduct of Sylvius (choice A) to the fourth ventricle (choice B). From there the cerebrospinal fluid flows out of the brain into the subarachnoid space (choice D). A blockage of the cerebral aqueduct will result in immediate accumulation of cerebrospinal fluid in the third ventricle. Because the cerebrospinal fluid no longer flows from the ventricular system to the subarachnoid space, the resulting hydrocephalus is termed noncommunicating.

120. (B) The obliquus capitis superior, attached between the transverse process of C1 and the suboccipital bone between the nuchal lines. It forms the lateral border of the suboccipital triangle. The obliquus capitis inferior (choice A) is the inferior border of the triangle, attaching from the spinous process of C2 to the transverse process of C1. The rectus capitis posterior major (choice C) inserts from the spinous process of C2 into the inferior nuchal line on the occipital bone; it forms the medial border of the suboccipital triangle. The rectus capitis posterior minor (choice D) lies medial to the rectus capitis posterior major. The semispinalis cervicis (choice E) does not participate in the formation of the suboccipital triangle.

121. (C) The vocal folds are abducted and the rima glottidis is widened by the posterior cricoarytenoid muscles that rotate the arytenoid cartilages laterally. The cricothyroid muscles (choice A) tense and lengthen the vocal ligament by tilting the thyroid cartilage forward. The lateral cricoarytenoid muscles (choice B) adduct the vocal folds by medially rotating the arytenoid cartilages. The thyroarytenoid muscles (choice D) decrease the tension and length of the vocal ligaments by tilting the thyroid cartilages posteriorly. The transverse arytenoid muscle (choice E) adducts the vocal folds by pulling the arytenoid cartilages together.

122. (C) The inferior laryngeal nerve is motor to the intrinsic muscles of the larynx except the cricothyroid muscle, and is sensory to the larynx below the level of the vocal fold. The external laryngeal nerve (choice A) is the branch of the superior laryngeal nerve that contains the motor fibers to the cricothyroid muscle and to the cricopharyngeus muscle.

The glossopharyngeal nerve (choice B) does not supply either motor or sensory fibers to the larynx. The internal laryngeal nerve (choice D) is the branch of the superior laryngeal nerve that contains the sensory fibers to the laryngeal mucosa above the vocal fold.

The superior laryngeal nerve (choice E) is sensory to the laryngeal mucosa above the vocal fold and also includes motor fibers to the cricothyroid muscle.

123. (B) The first meiotic division results in two secondary oocytes: the ovum retains almost all of the cytoplasm whereas the first polar body (choice A) does not. Primary oocytes (choice C) are the cells undergoing the first meiotic division. The second polar body (choice D) is formed after the second meiotic division. The zygote (choice E) is the fertilized ovum.

124. (E) Intervertebral disks may protrude or rupture in any direction but do so most commonly in a posterolateral direction, just lateral to the strong central portion of the posterior longitudinal ligament. This is usually the weakest part of the disk, because the annulus is thinner here and is not supported by other ligaments. Anteriorly (choice A) the intervertebral disks are supported by the broad and strong anterior ligament. Herniation is less common in this direction. Anterolaterally (choice B) the intervertebral disk is supported by the broad anterior longitudinal ligament. The nucleus pulposus is also situated posteriorly in the disk, making herniation here less likely. Herniation of the intervertebral disk laterally (choice C) is not particularly common. Posteriorly (choice D) the intervertebral disks are supported by the posterior longitudinal ligament. Herniation is less common in this direction.

125. (C) A bulging or protruded disk typically affects the traversing nerve root; that is, the nerve affected is one number greater than the number of the disk. The L3 spinal nerve (choice A) would be affected by protrusion of the L2 intervertebral disk. The L4 spinal nerve (choice B) would be affected by protrusion of
the L3 intervertebral disk. The S1 spinal nerve (choice D) would be affected by protrusion of the L5 intervertebral disk. The S2 spinal nerve (choice E) exits through the foramina of the fused sacrum and, therefore, is not subject to compression by herniated intervertebral disks.

126. (E) A stratified squamous epithelium covers the vocal cords or folds. This epithelium protects the underlying tissue from the mechanical stress acting on the surface of the vocal cords. A simple squamous epithelium (choice D) is not suitable for protection. The rest of the larynx is covered with a pseudostratified ciliated epithelium (ie, a respiratory epithelium [choice A]). Simple columnar (choice B) and simple cuboidal (choice C) epithelia are found more commonly in organs with secretory or absorptive functions.

127. (A) The auriculotemporal nerve is a branch of the mandibular division of the trigeminal nerve. It carries postganglionic parasympathetic fibers from the otic ganglion to the parotid gland. The buccal nerve (choice C) is a sensory branch of the mandibular division of the trigeminal nerve. It innervates the gingiva adjacent to the two posterior molar teeth, the mucosa, and skin of the cheek. The buccal branch of the facial nerve (choice B) provides motor innervation to the muscles around the mouth. The greater petrosal nerve (choice D) is a branch of the facial nerve from the geniculate ganglion. It carries preganglionic parasympathetic fibers to the pterygopalatine ganglion. The lesser petrosal nerve (choice E) is a continuation of the tympanic branch of the glossoharyngeal nerve and carries preganglionic parasympathetic fibers to the otic ganglion.

128. (A) The femoral canal, the medial compartment of the femoral sheath, contains only a slight amount of loose connective tissue and one or two lymphatic vessels and nodes. The femoral artery (choice B) is found in the lateral compartment of the femoral sheath with the genital branch of the genitofemoral nerve. The femoral nerve (choice C) is the most lateral structure in the femoral triangle, but it does not lie within the femoral sheath. The femoral vein (choice D) occupies the intermediate compartment of the femoral sheath. The saphenous vein (choice E) is a superficial vein that passes through the saphenous hiatus to end in the femoral vein. It does not lie within the femoral canal.

129. (D) GVA fibers from the thoracic and abdominal organs have their perikarya in the inferior vagal (nodose) ganglion and project to the solitary nucleus. The ambiguous nucleus (choice A) provides branchial efferent (motor) fibers to the stylopharyngeus, soft palate, pharyngeal, and laryngeal muscles. The dorsal motor nucleus of the vagus (choice B) sends parasympathetic preganglionic fibers to the thoracic and abdominal viscera. The hypoglossal nucleus (choice C) provides motor innervation for the muscles of the tongue. The spinal (descending) trigeminal nucleus (choice E) receives pain and temperature fibers from the face area.

130. (A) The ophthalmic division of cranial nerve V (trigeminal) provides general sensory innervation to the eyeball, including the cornea. Cranial nerve II (optic, choice C) carries the visual function of the retina of the eye. Cranial nerves IV (trochlea, choice B) and VI (abducens, choice D) innervate the superior oblique and lateral rectus muscles, respectively. The innervation of all other extraocular muscles is performed by cranial nerve III (oculomotor, choice E).

131. (A) SVA (taste) fibers have their perikarya in the geniculate ganglion located in the petrous portion of the temporal bone. These neurons project their axons to the gustatory nucleus in the brainstem. The otic ganglion (choice B) receives preganglionic parasympathetic fibers originating from the inferior salivatory nucleus by way of the ninth cranial (glossopharyngeal) nerve. In turn, it projects postganglionic parasympathetic fibers to the parotid salivary gland. The pterygopalatine (sphenopalatine) ganglion (choice C) is also a parasympathetic ganglion, which receives preganglionic fibers from the superior salivatory nucleus by way of the ninth cranial (glossopharyngeal) nerve. In turn, it sends postganglionic parasympathetic fibers to the lacrimal gland and mucous glands.
in the nose. The submandibular ganglion (choice D) receives preganglionic parasympathetic fibers from the chorda tympani, a branch of the nervus intermedius which runs with the seventh cranial nerve. It innervates the submandibular and sublingual salivary glands. The trigeminal (gasserian) ganglion (choice E) receives sensations from the face, mucosa, cornea, teeth, gum, palate, and the anterior two-thirds of the tongue. It sends projections to the principal sensory and spinal trigeminal nuclei in the brainstem.

132. (A) There is only one point of the heart that can be directly identified on the precordium: the apex. A cardiac impulse may be visible at the apex, and palpation over it confirms the presence of the apex beat. The apex is located in the left fifth intercostal space just medial to the midclavicular line, and is the point where the mitral valve is best heard. None of the heart sounds are best heard at the xiphisternal junction (choice B). The tricuspid valve is best heard in the fifth intercostal space to the right of the sternum (choice C). The pulmonary valve is best heard in the second intercostal space to the left of the sternum (choice D). The aortic valve is best heard in the second intercostal space to the right of the sternum (choice E).

133. (B) Motor innervation of the pharyngeal constrictor muscles is derived from the ambiguus nucleus in the medulla oblongata. These motor fibers reach the constrictor muscles via the vagus nerve. The abducens nucleus (choice A) provides motor innervation to the lateral rectus muscle of the eye. The dorsal motor nucleus of the vagus (choice C) provides preganglionic parasympathetic innervation for the organs of the thorax and abdomen. The facial nucleus (choice D) sends motor innervation to the muscles of facial expression and the stapedius. The hypoglossal nucleus (choice E) innervates the muscles of the tongue.

134. (B) The arch of the aorta is formed from the left fourth aortic arch. Part of the right fourth aortic arch becomes the proximal portion of the right subclavian artery, whereas the rest of the fourth arch disappears. However, if it persists, a right aortic arch is formed passing posterior to the trachea and esophagus. With the formation of the normally occurring left aortic arch, which runs anterior to the trachea and esophagus, a double aortic arch is created. This defect clamps the trachea and esophagus resulting in the respiratory symptoms. The second pair of aortic arches (choice C) partially form the stapedial arteries in the middle ear of the embryo. The third pair of aortic arches (choice E) form the common carotid arteries and contribute to the internal carotid arteries. The fifth pair of aortic arches (choice A) either does not develop or form primitive vessels, which disappear eventually. The sixth pair of aortic arches (choice D) contribute to the formation of the pulmonary arteries and ductus arteriosus.

135. (C) The external laryngeal nerve, a branch of the superior laryngeal nerve from the vagus, innervates the cricothyroid muscle. Normally, the cricothyroid muscle varies the length and tension of the vocal cord, and in its absence, the voice acquires a monotonous quality. The accessory nerve (XI, choice A) only innervates the sternocleidomastoid and the trapezius muscles in the neck. The ansa cervicalis (choice B) supplies motor branches to the infrahyoid muscles. The hypoglossal nerve (XII, choice D) innervates intrinsic and extrinsic muscle fibers of the tongue. The internal laryngeal nerve (choice E) provides sensory innervation to the interior of the larynx.

136. (E) All the listed cell types are components of the respiratory system. Type II pneumocytes are the source of pulmonary surfactant. Alveolar dust cells (choice A) are macrophages. Endothelial cells (choice B) and type I pneumocytes (choice D) are components of the blood-air barrier. Small granule cells (choice C), which are members of the diffuse neuroendocrine system, function in paracrine and endocrine signaling.

137. (A) The inferior olivary nucleus in the medulla oblongata is the sole source of climbing fibers to the cerebellum. All other sources of fibers to the cerebellum such as the pontine nuclei (choice B), spinal cord (choice C), or vestibular nuclei (choice E) provide mossy fibers to the
cerebellum. The superior olivary nucleus (choice D) receives auditory fibers from the cochlear nuclei and projects back to the cochlea by way of the olivocochlear bundle. It modifies the sensory input from the organ of Corti in the cochlea and is not involved with cerebellar circuitry.

138. (B) Basal cells of the epidermis produce keratins K5 and K14. Adipose cells in the hypodermis (choice A), fibrocytes of the dermis (choice C), and melanocytes of the epidermis (choice D) do not synthesize keratins. Upper differentiating cells of the epidermis (choice E) produce keratins K1 and K10. A keratin K9 is also found in the palmar or plantar regions of the epidermis.

139. (E) Cell adhesion molecules are divided into two major classes on the basis of their dependence on calcium. Calcium-dependent cell adhesion molecules are the cadherins and the selectins. Calcium-independent cell adhesion molecules include members of the immunoglobulin superfamily, the I-CAM (choice C), and the N-CAM, as well as the integrins (choice B). Disintegrins (choice A) are found in snake venom and disrupt the integrin-mediated cell binding to extracellular matrix proteins such as laminin or fibronectin.

140. (C) The obturator nerve innervates the adductor muscles and the medial region of the thigh. The nerve originates from the lumbar plexus, runs on the lateral aspect of the pelvic wall, and exits through the obturator canal to reach the medial aspect of the thigh. Lying on the lateral pelvic wall, it may be injured by surgical mishap. The femoral nerve (choice A) innervates the anterior aspect of the thigh and the muscles contained within the sartorius and the quadriceps femoris. The inferior gluteal nerve (choice B) innervates the gluteus maximus muscle and is confined to the gluteal region. The pudendal nerve (choice D) is sensory to the genitalia, motor to the perineal muscles, the external urethral sphincter, and the external anal sphincter. The sciatic nerve (choice E) innervates the hamstring muscles in the posterior aspect of the thigh.

141. (B) The metanephric diverticulum or ureteric bud gives rise to the ureter, renal pelvis, calices, and collecting tubules. The metanephric mass of intermediate mesoderm (choice C) gives rise to the nephrons in the kidney. The mesonephric and paramesonephric ducts (choices A and D) play essential roles in the development of the male and female reproductive system, respectively. The pronephric duct (choice E) is derived from the transitory, nonfunctional first set of kidneys or pronephroi and does not contribute to the development of the ureter.

142. (A) Communicating (gap) junctions are formed by connexins, which associate together in groups of six to form connexons. The alignment of connexions between two cells allows for direct channels of communication between their cytoplasms, facilitating the transfer of molecules such as calcium or cyclic adenosine monophosphate (cAMP). Hemidesmosome (choice B), macula adherens (spot desmosome; choice C), and zonula adherens (belt desmosome; choice E) are classified as anchoring junctions. They are associated with intermediate filaments (hemidesmosome and macula adherens) or with actin microfilaments (zonula adherens), but not connexins. Occluding (tight) junctions (choice D) contain the proteins occludin and claudin but not connexin.

143. (B) Calcitonin reduces the surface ruffling of osteoclasts and their activity. Osteoclasts are formed by fusion of blood monocyte derivatives and are components of the mononuclear phagocyte system. Under the influence of parathyroid hormone, osteoclasts enlarge their ruffled borders and increase their bone-resorbing activity. Osteoprogenitor cells (choice E), osteoblast (choice A), and osteocyte (choice C) are bone-forming cells. Osteon (choice D) is another name for the haversian system which is the haversian canal, its contents, surrounding lamellae, and osteocytes.

144. (A) The second set or mesonephroi appear late in the fourth week and are functional until the permanent kidneys or metanephroi are fully developed. During development, three sets of kidneys are formed in the embryo. The first set
or pronephroi (choice D) are transitional, non-functional structures that appear around the fourth week of development. Next come the mesonephroi, then the permanent set of kidneys develops from the metanephroi. The paramesonephric ducts (choice C) are structures developing lateral to the gonads and mesonephric ducts. They play an essential role in the female reproductive system, but are not involved in the formation of the kidneys. The ureteric bud (choice E) is an outgrowth from the mesonephric duct that gives rise to the ureter, renal pelvis, calices, and collecting tubules.

145. (D) Osteoid is the unmineralized organic matrix formed by osteoblasts and found at the interface between these cells and bone. Osteocytes (choice A) are surrounded by bone and no longer manufacture osteoid. Osteoprogenitor cells (choice B) are similar to stem cells and do not manufacture bone material. Fibroblasts (choice C) are cells of connective tissue forming the periosteum and not bone. Osteoclasts (choice E) are bone-resorbing cells.

146. (D) High endothelial venules (HEV), located primarily in the deep cortex, are specialized to recruit circulating lymphocytes from the blood. Lymphocytes in the circulating blood adhere to the lining endothelial cells of HEV by way of an integrin-based recognition. Lymphocytes then gain access to the lymph node tissue by actively migrating (a process called diapedesis) between or through endothelial cells. Afferent lymphatic vessels (choice A) conduct lymph, not blood, into the lymph node. The source of the lymph is either upstream lymph nodes or tissue fluid from the region supplied by the node. This component of the system serves as a filter and as a mechanism for antigen-presenting cells to enter the node. Arterioles (choice B) are a component of the circulation of the lymph node, but they are not permeable to cell traffic. Efferent lymphatic vessels (choice C) conduct lymph and cells from the lymph node to either the blood circulation or downstream lymph nodes. Lymph in efferent lymphatic vessels conveys immunoglobulins and recirculating lymphocytes to the bloodstream. Medullary sinuses (choice E) are part of a system of passages that filter lymph and direct it from the afferent lymphatic vessels to the efferent lymphatic vessels. Medullary sinuses occupy spaces between medullary cords, which are occupied by large numbers of plasma cells, the cells that secrete immunoglobulins.

147. (C) Myasthenia gravis is an autoimmune disorder where autoantibodies target the postsynaptic cholinergic receptors and destroy them. Acetylcholine released from motor neurons is thus unable to bind and the muscle contraction weakens due to decreased neurotransmitter communication. Acetylcholine synthesis in motor neurons (choice A) remains normal. Acetylcholinesterase (choice B) is the enzyme which degrades acetylcholine and its synthesis is not affected in myasthenia gravis. The cholinergic neurotransmitter release mechanism (choice D) at the presynaptic membrane, as well as the signal transduction mechanism (choice E) within the muscle, remain normal.

148. (A) An individual sarcomere, the unit of contraction in striated muscle, spans the interval between successive Z lines. Each sarcomere encompasses an A-band (choice B) and half of each of two I bands (choice D). Each myofibril (choice C) of a striated muscle fiber is composed of a tandem series of sarcomeres. Coupling of excitation and contraction is a critical function of the triad (choice E), which is composed of a T tubule interposed between two cisternae of the sarcoplasmic reticulum.

149. (D) The great cerebral vein of Galen (arrow 4) drains posteriorly into the straight sinus (arrow 5). The union of the superior sagittal sinus (choice E; arrow 3) and the straight sinus forms the confluence of sinuses (choice A). The straight sinus and superior sagittal sinus are dural venous sinuses: they contain venous blood draining form the brain, skull, and scalp. The frontal sinus (choice B) and the sphenoid sinus (choice C) are bony sinuses: they are hollow, air-filled structures and do not drain venous blood.

150. (B) Arrow 2 points to the gallbladder, which will be removed during the cholecystectomy.
(surgical removal of the gallbladder). Biliary colic may be due to impaction of a gallstone in the cystic duct, resulting in cholecystitis (inflammation of the gallbladder). Arrow 1 (choice A) points to the liver. Arrow 3 (choice C) points to the transverse colon. Arrow 4 (choice D) points to the spleen and arrow 5 (choice E) indicates the stomach, recognizable by its internal rugae.

151. (C) The main subcortical afferents to the primary auditory cortex (Brodmann’s area 41) arise from the medial geniculate nucleus of the thalamus. The inferior colliculus (choice A) is a midbrain auditory relay nucleus, which sends projections to the medial geniculate nucleus. The lateral geniculate nucleus (choice B) is a visual relay nucleus in the thalamus and it projects to the primary visual cortex (Brodmann’s area 17). The superior colliculus (choice D) is a midbrain visual relay nucleus, which provides fibers to the tectospinal tract. The superior olivary nucleus (choice E) is a medullary auditory relay nucleus, which sends projections to the cochlea.

152. (D) Arrow 4 points to the left common carotid artery. The three arteries arising from the arch of the aorta are lined anteriorly to posteriorly on a slanted line: arrow 3 (choice C) shows the brachiocephalic artery, arrow 4 (choice D) points to the left common carotid artery, and arrow 5 (choice E) indicates the left subclavian artery. Arrow 2 (choice B) points to the right brachiocephalic vein, which is joined here by the left brachiocephalic vein. Arrow 1 (choice A) points to the trachea, which is filled with air and thus is not radiopaque.

153. (D) Fibers from pain and temperature receptors in the face area all project to the spinal (descending) trigeminal nucleus. The mesencephalic trigeminal nucleus (choice A) contains the perikarya of the proprioceptive fibers of the muscles of mastication. The motor trigeminal nucleus (choice B) receives innervation from the mesencephalic trigeminal nucleus. The principal sensory trigeminal nucleus (choice C) receives somatosensory fibers from the face, gums, teeth, and anterior two-thirds of the tongue. The trigeminal (gasserian) ganglion (choice E) contains the sensory perikarya of all three subdivisions of the trigeminal nerve.

154. (E) Fusion of the ilium, ischium, and pubis at the acetabulum is usually complete by age 23. From birth to the early 20s (choices A–D), the three bones are held together by a Y-shaped cartilage.

155. (A) Arrow 2 points to the middle nasal concha, which is part of the ethmoid bone. Arrow 3 points to the ethmoid sinus, which also belongs to the ethmoid bone. The inferior nasal concha (arrow 1) is a separate bone (choice B). The maxillary bone (choice C) is located more laterally and does not contribute to the nasal conchae. The maxillary sinus, a part of the maxillary bone, is indicated by arrow 4. The vomer bone (choice E) forms part of the nasal septum (choice D), which can be seen here as the thin line between the nasal conchae. The nasal conchae have no attachment to the septum.


Questions

1. The hands and nails of a 45-year-old woman show the discolorations indicated in Figure 2-1. The woman states that she had pulmonary tuberculosis about 10 years ago. The clinician prescribes cortisol, but counsels her that as a side effect it might lead to thin skin and thinning of her limbs because of an increase in which of the following?

(A) adrenocorticotropic hormone (ACTH) secretion
(B) corticotrophin-releasing hormone (CRH) secretion
(C) insulin sensitivity in muscle
(D) protein degradation
(E) wound healing

2. A healthy 17-year-old male tells his doctor during a normal check-up visit that “his muscles gave out” when he recently attempted to lift a heavy load. On questioning, he answers that he did not experience any other neuromuscular problems after this experience. What is the most likely mechanism responsible for the abrupt cessation of skeletal muscle contraction?

(A) activation of alpha motor neurons
(B) activation of gamma motor neurons
(C) activation of Golgi tendon organs
(D) activation of muscle spindles
(E) skeletal muscle ischemia

3. A 34-year-old male is brought into the emergency room, having been found unconscious in his apartment. Apparently, he has been in this state for 2 days. The laboratory values for the patient’s blood and urine are consistent with elevated circulating antidiuretic hormone (ADH). Which one of the following will directly stimulate ADH in this patient?

(A) angiotensinogen
(B) extracellular fluid osmolality increase
(C) temperature decrease
(D) thyroid hormone
(E) volume increase

4. End-stage chronic renal disease is associated with a glomerular filtration rate (GFR) of less than 15 mL/min and an increase in which of the following blood values?

(A) calcium
(B) erythropoietin (EPO)
(C) hematocrit
(D) phosphate
(E) 1,25-(OH)₂ vitamin D₃
5. A very thin 15-year-old female presents with headache, polyuria, and grand mal seizures. She answers the question, if she has had to vomit recently, with “frequently” but that these symptoms “are under control now.” Her body mass index is 14.1. Serum glucose, calcium, and potassium are normal. Serum sodium, chloride, and osmolarity are low. As a working diagnosis, which of the following is most likely?

(A) Addison disease  
(B) central diabetes insipidus  
(C) diabetes mellitus  
(D) nephrogenic diabetes insipidus  
(E) water intoxication

6. The ventricular action potential labeled N in Figure 2-2 represents a normal ventricular action potential. Which of the other action potentials (labeled A–E) would be most characteristic of the ventricular cell after administration of a drug that partially blocks slow calcium channels?

(A) A  
(B) B  
(C) C  
(D) D  
(E) E

7. Pupil size is an important indicator of brain-stem function. Which of the following results in pupillary constriction?

(A) atropine, a blocker of muscarinic receptors  
(B) decreased parasympathetic activity of inner eye muscle fibers during darkness  
(C) general increased sympathetic tone during emotional excitement

8. For the bithermal caloric test, a measure of vestibular sensitivity, warm or cold water is introduced into the ear. This often causes vertigo and nausea as a side effect as a result of which of the following?

(A) convection currents in endolymph  
(B) especially fast flow of endolymph  
(C) temporary immobilization of cristae ampullares  
(D) temporary immobilization of otolith organs  
(E) temporary inhibition of cochlear hair cells

9. Figure 2-3 shows a lead II electrocardiogram from a normal 30-year-old female at rest. If a beta-adrenergic agonist such as isoproterenol is administered intravenously to this woman, what will be her resulting heart rate in beats per minute?

(A) 40  
(B) 55  
(C) 65  
(D) 70  
(E) 90
10. With increasing age, it is quite common for adults to have very low sensitivity for high-pitch sounds. Which of the following physiologic responses occur as the pitch of a sound is increased at constant sound pressure?

(A) a greater number of hair cells become activated
(B) the amplitude of maximal basilar membrane displacement increases
(C) the frequency of action potentials in auditory nerve fibers increases
(D) the location of maximal basilar membrane displacement moves toward the cochlear base
(E) units in the auditory nerve become responsive to a wider range of sound frequencies

11. A 20-year-old woman admits herself to the emergency room with a yellow discoloration of the whites of her eyes. She says that she does not drink and that she has not experienced any changes in her stool. Her liver enzyme profile and direct serum bilirubin levels are normal, while total bilirubin is elevated. What is the most likely cause for her jaundice?

(A) defect in hepatocytes
(B) defect in Kupffer cells
(C) gallstones
(D) hemolysis
(E) tumor obstructing bile duct

12. A 54-year-old insulin-dependent diabetic notes that her insulin requirements have gone up dramatically in the past year (from 50 U to nearly 200 U of recombinant human insulin) and her blood glucose is still poorly controlled. A possible explanation for the worsening of her diabetes includes which of the following?

(A) a high titer of anti-insulin antibodies
(B) an improved diet
(C) an improved exercise program
(D) progression of macrovascular disease
(E) weight loss

13. A 55-year-old male diabetic has an accommodative power of the lens of 10 dioptres. His near point is located 5 cm (2 in), his far point 10 cm (3.9 in) in front of the eye. Which of the following statements are correct?

(A) his corrective lenses are convex
(B) his corrective lenses have a positive dioptic value
(C) the patient has hyperopia
(D) the patient is capable of driving a car without corrective glasses
(E) the patient is functionally blind

14. An advertisement promotes energy bars containing fructose as an ideal food to take on extreme mountain-climbing expeditions. Which of the following statements concerning fructose absorption is true?

(A) absorption of fructose into an intestinal epithelial cell is by facilitated transport and thus does not require energy
(B) metabolism of fructose generates more energy than glucose
(C) some fructose is already absorbed in the mouth and hence is the fastest way to get energy
(D) the presence of fructose aids in absorption of vitamin A, C, and D
(E) the presence of fructose inhibits reabsorption of glucose, which is then more readily available for muscle activity

15. Patients with functional dyspepsia (disturbed indigestion) and prominent nausea frequently experience spurts of excessive acid exposure to the upper duodenum. This results in pancreatic secretion, mainly through the action of which of the following substances?

(A) cholecystokinin
(B) gastrin
(C) glucagon
(D) secretin
(E) vasoactive intestinal polypeptide (VIP)
16. A 41-year-old male suffering from unstable angina is undergoing cardiac testing. At rest, his heart rate is 70 beats per minute. His left ventricular end-diastolic volume is estimated to be 150 mL, while his end systolic volume is 80 mL. What is his estimated cardiac output?

(A) 3900 mL/min
(B) 4400 mL/min
(C) 4900 mL/min
(D) 5400 mL/min
(E) 5900 mL/min

17. A dislocated shoulder of a middle-aged man was corrected under conscious sedation with etomidate. Since etomidate has been reported to affect adrenocortical function as a side effect, the patient’s ACTH and cortisol were measured in blood samples taken at the indicated times on the following day. What do the ACTH results indicate?

(A) inverted circadian pulsatile release
(B) normal circadian pulsatile release
(C) normal circadian non-pulsatile release
(D) primary adrenal insufficiency
(E) secondary adrenal insufficiency

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<th>ACTH (pg/mL)</th>
<th>Normal values 50–250</th>
<th>Patient 7 a.m. 110</th>
<th>Patient 7:30 a.m. 90</th>
<th>Patient 7 p.m. 120</th>
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<td>Cortisol (ug/dL)</td>
<td>6–23</td>
<td>10</td>
<td>8</td>
<td>20</td>
<td>24</td>
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18. A biopsy from a 55-year-old woman with breast cancer was submitted to an estrogen receptor assay. The binding of estrogen to the cancer cells (Figure 2-4, solid line) was plotted in the form of a Scatchard plot and compared to control cells (Figure 2-4, dotted line). Which of the following would you conclude for the patient’s estrogen receptors?

(A) they are equal in number and have a higher affinity
(B) they are equal in number and have a lower affinity
(C) they are fewer in number and have a higher affinity
(D) they are fewer in number and have a lower affinity
(E) they are higher in number and have an equal affinity

19. A 71-year-old man was admitted to the hospital after getting very dizzy upon rising from the toilet seat. At that time his pulse was racing and he remembers that his stool looked very different than usual. Over the last 4 or 5 weeks before the incident, the patient self-medicated with high-dose ibuprofen three times a day to control some pain in his hips. What is the mechanism of action for nonsteroidal anti-inflammatory drugs (NSAIDs) to cause gastrointestinal (GI) bleeding?

(A) they inhibit arachidonic acid synthesis
(B) they inhibit bradykinin synthesis
(C) they inhibit cyclooxygenase
(D) they inhibit histamine synthesis
(E) they promote prostaglandin synthesis

20. A 52-year-old man has a history of anginal pain that until recently was responsive to nitrates. He is now evaluated for possible angioplasty. The graph in Figure 2-5 shows the ECG of this patient. Blood flow across the mitral valve is largest around which indicated point in this ECG tracing?
21. The graph in Figure 2-6 shows the pressure–volume curve of the left ventricle of this patient (shaded area). The pressure–volume curve of a normal subject is shown for comparison (broken lines). Compared to normal, which term best describes this patient’s heart?

(A) decreased afterload  
(B) decreased preload  
(C) decreased stroke volume  
(D) increased force of contraction  
(E) increased preload

22. The graph in Figure 2-7 shows the jugular vein pressure curve of this patient. If the first heart sound occurs between letters C and D, which part of the curve represents the atrial contraction?

(A) peak A  
(B) peak C  
(C) peak D  
(D) trough B  
(E) trough E

23. A 14-year-old boy presents with weight loss and diarrhea. His tongue becomes sore and blistered after eating oatmeal or rye bread, which leads to the diagnosis of celiac disease. The boy and his parents are advised to be sensitive to symptoms of tetany and paresthesias, since they can occur as a consequence of malabsorption of which of the following?

(A) calcium  
(B) carbohydrates  
(C) fat  
(D) iron  
(E) water

24. An adult male becomes hypotensive during surgery because of blood loss. Intravenous administration of 500 ml of which of the following solutions will have the greatest effect in restoring blood volume, and thus blood pressure to normal?

(A) blood plasma  
(B) distilled water  
(C) hypoosmotic NaCl  
(D) isotonic dextrose solution  
(E) isotonic saline solution
25. Using laboratory micropuncture technique, blood plasma is collected from both the afferent arteriole and efferent arteriole of a renal cortical glomerulus. Which of the following has the lowest afferent/efferent arteriole concentration ratio?

(A) albumin  
(B) chloride  
(C) glucose  
(D) potassium  
(E) sodium

26. It is known that stretch receptors contained in the walls of the atria convey nerve impulses to the brainstem via the vagus nerve. Under normal conditions, these nerve impulses are most likely to occur during ventricular systole. What information is communicated to the brain by these nerve impulses?

(A) arterial muscle contraction  
(B) diastolic arterial pressure  
(C) filling of the atrium by venous pressure  
(D) filling of the ventricle  
(E) systolic arterial pressure

27. High-dose glucocorticoid therapy for treatment of rheumatoid arthritis remains highly controversial. It is widely agreed that it is highly effective in controlling acute rheumatoid inflammation, but it may also result in significant adverse effects. Complications of high-dose glucocorticoid therapy include which of the following?

(A) excessive growth in children and acromegaly in adults  
(B) hyperkalemia  
(C) hyponatremia  
(D) suppression of the hypothalamic-pituitary-adrenal axis  
(E) volume depletion

28. A 53-year-old healthy male undergoes an exercise stress test, running on a treadmill until a maximum exertion is obtained. Which of the following statements correctly describes effects of autonomic nerve activity on the cardiovascular system in such a healthy subject?

(A) inhibition of parasympathetic nerves decreases total peripheral resistance  
(B) inhibition of parasympathetic nerves increases heart rate  
(C) inhibition of parasympathetic nerves increases total peripheral resistance  
(D) stimulation of parasympathetic nerves decreases the strength of cardiac ventricular contractions  
(E) stimulation of sympathetic nerves decreases the strength of cardiac ventricular contractions

29. The majority of CO$_2$ in the blood is carried in which of the following forms?

(A) carbamino compounds  
(B) CO$_2$ dissolved in solution  
(C) CO$_3$$^{-2}$  
(D) HCO$_3$$^{-}$  
(E) H$_2$CO$_3$

30. A patient with acute glomerulonephritis has a total plasma Ca$^{2+}$ of 2.5 mmol/L and a GFR of 160 L/day. What is the estimated daily filtered load of calcium?

(A) 64 mmol/day  
(B) 120 mmol/day  
(C) 240 mmol/day  
(D) 400 mmol/day  
(E) 800 mmol/day

31. Lack of oxygen (hypoxia) will cause reflex vasoconstriction in the circulation supplying which of the following organs?

(A) brain  
(B) heart muscle  
(C) kidney  
(D) lungs  
(E) skeletal muscle

32. Lipoxigenase converts arachidonic acid to biologically active compounds called leukotrienes. Leukotrienes have been implicated in several disease entities, including allergic asthma, where they are presumed to mediate bronchoconstriction. Introducing leukotrienes into
an airway would be expected to cause which of
the following responses?

(A) decreased airway resistance
(B) decreased dead space volume
(C) increased functional residual capacity
   (FRC)
(D) increased lung compliance
(E) increased total lung capacity

33. Figure 2-8 shows the amounts of water
ingested and secreted daily into the GI tract by
a healthy individual. Since about 100 mL of
water is excreted daily in the stool, which of the
following volumes (in milliliter) best reflects
the daily absorbed water in the indicated areas
x, y, and z of the GI tract?

(A) 0 400 8500
(B) 0 8500 400
(C) 450 450 8000
(D) 450 8000 450
(E) 8000 450 450

34. The action potentials shown in Figure 2-9 rep-
resent those of which kind of cells?

(A) cardiac nodal cells
(B) myelinated motor axons
(C) sensory neurons
(D) skeletal muscle cells
(E) ventricular Purkinje cells

35. A patient is admitted to the hospital following
a knife wound to the abdomen which results in
extensive bleeding into the abdomen. The arte-
rial pressure at admission is 65/30 mm Hg with
a rapid, weak pulse. Compared to normal, the
nerve impulses in the carotid sinus nerves
and in the sympathetic nerves are changed
in what way?

(A) both show decreased nerve impulse
   rates
(B) both show increased nerve impulse
   rates
(C) carotid sinus nerve impulses are
decreased, sympathetic are increased
(D) carotid sinus nerve impulses are
increased, sympathetic are decreased
(E) the patient is unconscious so there are
no changes in nerve impulse rates
36. A 66-year-old woman is undergoing surgery to repair an abdominal aortic aneurism. During the procedure the abdominal aorta is momentarily clamped below the renal arteries. Figure 2-10 shows the left ventricular pressure/volume relationship immediately before (curve 1) and during (curve 2) the aortic occlusion. The change in curve 2 represents an increase in which of the following?

(A) afterload  
(B) cardiac output  
(C) ejection fraction  
(D) preload  
(E) stroke volume

37. In Figure 2-11, which point depicts the excreted glucose in a 31-year-old woman with untreated nephrogenic diabetes insipidus?

(A) A  
(B) B  
(C) C  
(D) D  
(E) E

38. In Figure 2-11, which point depicts the renal filtered glucose in an 11-year-old male with untreated Type I diabetes mellitus?

(A) A  
(B) B  
(C) C  
(D) D  
(E) E

39. A 57-year-old woman presents with an arterial pressure of 180/115 mm Hg, and blood creatinine levels are elevated. Renal angiography reveals a severe bilateral stenosis of the renal arteries. Which of the following are elevated also?

(A) ADH secretion  
(B) GFR  
(C) para-aminohippurate (PAH) clearance  
(D) renin secretion  
(E) urine output
40. A patient with untreated diabetes mellitus is admitted to the hospital for treatment. Laboratory findings include a blood pH below 7.2. Which of the following is likely to directly result from this level of acidemia?

(A) arteriolar constriction  
(B) decreased catabolism  
(C) hyperkalemia  
(D) hypoventilation  
(E) insulin sensitivity

41. During a routine preschool examination, a 5-year-old boy is found to have difficulty focusing on distant objects. Which of the following is true during far accommodation of the eyes?

(A) ciliary muscles are relaxed  
(B) pupils are constricted  
(C) the focal length of the lens is short  
(D) the lens is rounded  
(E) zonula fibers are relaxed

42. Although most cases of hypertension are “essential,” meaning the underlying disorder is unknown, about 10% of cases are “secondary hypertension” due to a specific, usually treatable cause. Which of the following alternatives can lead to secondary hypertension?

(A) adrenal insufficiency  
(B) estrogen deficiency  
(C) hyperparathyroidism  
(D) renal artery stenosis  
(E) volume depletion

43. Which of the following compounds directly functions in excitation contraction coupling in smooth but not skeletal muscle?

(A) actin  
(B) calcium  
(C) myosin  
(D) myosin light chain kinase  
(E) troponin

44. In which of the following conditions would the gas composition of both end pulmonary capillary blood and alveolar air approximate that of mixed venous blood?

(A) airway obstruction  
(B) breathing 100% oxygen  
(C) hyperventilation  
(D) normal breathing  
(E) pulmonary capillary embolus

45. Figure 2-12 shows pulmonary function test tracings from a healthy person and a patient with pulmonary fibrosis. Of the following measures which would you expect to be increased in this patient, as compared to the expected norms?

(A) Forced expiratory volume (FEV)/forced vital capacity (FVC)  
(B) FRC  
(C) FVC  
(D) tidal volume  
(E) vital capacity

46. A patient with chronic renal insufficiency due to renal vascular disease has a net functional loss of nephrons. If we assume that production of urea and creatinine is constant and that the patient is in a steady state, a 50% decrease in the normal GFR will cause which of the following to occur?

(A) decrease plasma urea concentration  
(B) greatly increase plasma Na⁺  
(C) increase the percent of filtered Na⁺ excreted  
(D) not affect plasma creatinine  
(E) significantly decrease plasma K⁺
47. A 53-year-old man is being treated for hypertension and diabetes. His medications include insulin and propranolol. He presents at his physician’s office complaining of muscle weakness. Blood tests reveal hyperkalemia (elevated serum potassium) as well as elevated BUN (blood urea nitrogen). Propranolol is gradually eliminated and his insulin dosage is adjusted. His serum potassium normalizes and his muscle weakness is alleviated. What probably caused his muscle weakness?

(A) high potassium-mediated block of acetylcholine receptors
(B) high potassium-mediated block of skeletal muscle calcium channels
(C) motor neuron hyperpolarization
(D) skeletal muscle depolarization with resultant Na-channel inactivation
(E) skeletal muscle hyperpolarization with resultant Na-channel blockade

48. A 30-year-old male seeks help because he lost weight and feels full after eating only a small amount of food. He is diagnosed with a delay in gastric emptying. Which of the following hormones has at physiological levels the strongest effect in inhibiting gastric emptying?

(A) cholecystokinin
(B) gastrin
(C) glucose-dependent insulinotropic peptide
(D) motilin
(E) pancreatic polypeptide

49. A 4-year-old child with signs of precocious (early onset) puberty is brought to a clinic for evaluation and found to have a congenital deficiency of 21-β-hydroxylase. Feedback inhibition of the pituitary gland is lost and excess ACTH is secreted. As a result, which of the following happens?

(A) adrenal cortical atrophy occurs
(B) adrenal medullary hypertrophy occurs
(C) excess cortisol is released
(D) precursors to cortisol synthesis increase
(E) serum cholesterol falls dramatically

50. A 59-year-old Caucasian female is self-donating blood in preparation for a hip replacement surgery in the near future. Shortly after her third session of donating a unit (pint) of whole blood, her mean arterial pressure remains unchanged, even though the venous return of blood to her heart is diminished. Which of the following is the most likely reason for the preservation of arterial pressure?

(A) cardiac output rises to compensate for the reduced venous return
(B) end-diastolic ventricular filling pressure rises during hemorrhage
(C) fall in venous return is offset by an increase in total peripheral resistance
(D) heart rate rises to compensate for a reduced venous return
(E) venous return and blood pressure are unrelated

51. A 35-year-old weight lifter, who has been injecting testosterone for muscle mass augmentation, is evaluated for sterility and found to have an extremely low sperm count. Which of the following is an effect of testosterone and contributes to the mentioned sterility?

(A) activation of inhibin
(B) feedback activation of leptin
(C) feedback inhibition of GnRH
(D) inhibition of seminal prostaglandins
(E) lowered core temperature

52. Evaluating the cause for a coma can be challenging. As a first step, the causes can be divided into two broad categories, structural/surgical and metabolic/medical reasons. Which of the following findings suggests a metabolic cause in a comatose patient?

(A) failure to withdraw from painful stimuli
(B) gross blood in the cerebrospinal fluid
(C) impaired pupillary light responses
(D) posturing of limbs
(E) serum sodium of 115 meq/L

53. Exogenous peripherally injected insulin differs from endogenously secreted insulin in a number of aspects, including which of the following?
54. A 23-year-old Caucasian male is admitted to the hospital following a motorcycle accident. On examination, no bones appear to be broken, but there is extensive muscle bruising resulting in tissue swelling from increased capillary permeability. His arterial blood pressure is 80/40. He is awake and able to walk with assistance. Based on this information, it is likely that which of the following will be decreased from normal?

(A) circulating levels of catecholamines
(B) left atrial pressure
(C) plasma aldosterone concentration
(D) plasma lactate concentration
(E) plasma renin activity

55. The terminal ileum was removed from a 50-year-old woman during excision of a tumor. About 3 years later, the patient was admitted to the hospital. She is very pale. Hemoglobin is 9 g/dL, MCV (mean corpuscular volume) has increased to 110 μm³ (110 fL). The provisional diagnosis is a vitamin deficiency. Which of the following vitamins is the most likely one causing the symptoms?

(A) A
(B) B₁
(C) B₉
(D) B₁₂
(E) K

56. Figure 2-13 illustrates uptake of two gases (nitrous oxide and carbon monoxide) from alveolar air to pulmonary capillary blood. Based on this information what can we conclude about carbon monoxide?

(A) it does not dissolve in blood
(B) it does not interact with hemoglobin
(C) it has equilibrated with pulmonary capillary blood
(D) it is a diffusion-limited gas
(E) it is a perfusion-limited gas

57. Which of the following is likely to cause a negative free-water clearance by the kidney?

(A) central diabetes insipidus
(B) demeclocycline, an inhibitor of the renal tubular actions of ADH
(C) nephrogenic diabetes insipidus
(D) water deprivation
(E) water drinking

58. An 18-year-old woman presented with 1 week of history of fever and malaise. She had mild jaundice and elevated temperature. Hemoglobin was 13.8 g/dL, leukocyte count 13 × 10⁹ per liter. Serum bilirubin was elevated (42 mmol/L) and contained 95% unconjugated bilirubin. Liver enzyme tests were normal. Which of the following is the most likely cause of these signs and symptoms?

(A) alcohol poisoning
(B) decreased glucuronyl transferase
(C) increased lactate dehydrogenase (LDH)
(D) excessive hemolysis
(E) obstruction of bile flow
59. A 25-year-old male athlete has just completed a long distance bicycle race during a hot, humid day. At the conclusion of the race, he provides a urine sample for testing. Assuming that his fluid intake during the race was zero, in what portion of the nephron shown in Figure 2-14 is the tubular fluid osmolality the lowest?

![FIG. 2-14]

- (A) A
- (B) B
- (C) C
- (D) D
- (E) E

60. A motor vehicle accident caused complete pituitary stalk transection. Secretion of all pituitary hormones is lost except for one, the blood level of which actually increases. Which one of the following pituitary hormones is distinctive in that its primary control is by inhibition rather than stimulation by the hypothalamus?

- (A) gonadotropin-releasing hormone
- (B) growth hormone
- (C) prolactin
- (D) proopiomelanocortin
- (E) thyroid-stimulating hormone

61. The parents bring a 5-month-old baby to the emergency room. It is their first child and they are insecure. The boy vomits frequently, seems to be constantly constipated, and has difficulties in defecation. A barium enema study reveals a region in the bowel that is collapsed and an enlarged colon above this area. A biopsy from the part of the bowel 1 in above the anus is sent to the laboratory and histological analysis reveals the absence of ganglia in this tissue. What is the most likely diagnosis?

- (A) cholecystitis
- (B) gastroesophageal reflux disease
- (C) hirschsprung disease
- (D) polymyositis
- (E) temporary problem with no treatment required

Use the following Table to answer Questions 62 and 63:

A healthy 27-year-old male is given a treadmill stress test. His cardiovascular values at rest and during exercise were:

<table>
<thead>
<tr>
<th></th>
<th>Rest</th>
<th>Exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Systolic Blood Pressure (mm Hg)</td>
<td>105</td>
<td>140</td>
</tr>
<tr>
<td>Minimum Diastolic Blood Pressure (mm Hg)</td>
<td>75</td>
<td>65</td>
</tr>
<tr>
<td>Heart Rate (beats/min)</td>
<td>68</td>
<td>140</td>
</tr>
</tbody>
</table>

62. When compared to rest, what was the change in his arterial pulse pressure?

- (A) decreased from 140 to 65
- (B) increased from 30 to 75
- (C) increased from 68 to 140
- (D) increased from 115 to 140
- (E) remained unchanged since heart rate and systolic pressure both increased

63. When compared to rest, what was the change in his estimated mean arterial pressure?

- (A) decreased by 10 mm Hg
- (B) increased by 5 mm Hg
64. Normal metabolism by the body generates large quantities of acid. In spite of this, normal blood pH is a slightly alkaline 7.4. This extracellular fluid alkalinity is maintained primarily by the body’s removal of which of these?

(A) ammonia
(B) carbon dioxide
(C) keto acids such as acetoacetic acid
(D) lactic acid
(E) titratable acids such as phosphoric acid

65. Which of the following persons will have a negative free-water clearance?

(A) one who begins excreting large volumes of urine with an osmolality of 100 mosm/kg H₂O after severe head injury
(B) one who drinks 2 L of distilled water in 30 minutes
(C) one who is receiving lithium treatment for depression, and who develops polyuria that is unresponsive to administration ADH
(D) one with an oat cell carcinoma of the lung, who excretes urine with an osmolality of 1000 mosm/kg H₂O
(E) one with neurogenic diabetes insipidus

66. A 55-year-old male presents with headache and visual field changes. He is six-and-a-half feet tall and has a puffy face. His skin on hands and feet is thickened, and compared to a picture of him at age 30, his nose, ears, and jaw seem larger. His teeth are separated (diastema). He seems to sweat more and complains of bad sleep. Which of the following would provide the greatest therapeutic benefit to this patient?

(A) GHRH
(B) growth hormone
(C) insulin
(D) somatostatin
(E) thyroid hormones

67. A 40-year-old woman complains of chronic fatigue, aching muscles, and general weakness. Physical examination reveals a modest weight gain, dry skin, and slow reflexes. Laboratory findings include TSH: >10 mU/L (normal range 0.5–5 mU/L), free T₄: low to normal. With of the following is the most likely explanation?

(A) hyperthyroidism due to autoimmune thyroid disease
(B) hyperthyroidism due to iodine excess
(C) hyperthyroidism secondary to a hypothalamic-pituitary defect
(D) hypothyroidism due to autoimmune thyroid disease
(E) hypothyroidism secondary to a hypothalamic-pituitary defect

68. A patient presents with long-standing emphysema. Which of the following would you expect to see in this individual?

(A) decreased physiological dead space
(B) increased FEV₁/FVC
(C) increased FRC
(D) increased FVC
(E) increased lung elastic recoil

69. A patient with newly diagnosed schizophrenia is given chlorpromazine. It is a drug that has amongst other effects moderate anti-cholinergic activity. As a consequence, which of the following is an expected side effect of this medication?

(A) bradycardia
(B) decreased GI sphincter tone
(C) dry mouth
(D) emptying of urinary bladder
(E) increased GI motility
70. A patient presents with fever (her core temperature equals 39°C, with normal core temperature equaling 36–37.5°C) as well as an elevated white cell count. Which of the following statements is true regarding the patient’s elevated core body temperature?

(A) Bacterial toxins act directly on skeletal muscle to increase muscle contractile activity, thereby generating heat and elevating core temperature.

(B) Core body temperature now exceeds the hypothalamic set point temperature.

(C) Increased core body temperature is due to increased heat production by leukocytes.

(D) Increased prostaglandins have raised the hypothalamic set point temperature.

(E) The patient will be sweating in an effort to further elevate core temperature.

71. Which of the following statements concerning skeletal muscle is correct?

(A) active tension depends on the extent of overlap between thick and thin filaments

(B) during contraction, thin filaments shorten and thick filaments maintain constant length

(C) significant passive tension is generated at normal rest fiber length

(D) tension generation depends on myosin attachment to the z line

(E) velocity of shortening is independent of fiber load

72. A 55-year-old male with a history of smoking presents with a chronic cough with expectoration. He exhibits dyspnea on exertion, has a stocky build, and shows some cyanosis. Which of the following receptors is involved in the cough reflex?

(A) carotid body chemoreceptors

(B) central chemoreceptors

(C) irritant receptors

(D) lung stretch receptors

(E) muscle spindles

73. Which of the following is an adaptive response to moving from sea level to higher elevation?

(A) bronchial relaxation

(B) decreased cardiac output

(C) decreased circulating levels of EPO

(D) decreased levels of 2,3-diphosphoglycerate (2,3-DPG) in erythrocytes

(E) hyperventilation

74. A 20-year-old female tennis player has just won a tennis match on a warm summer day. Her blood pressure at this time is 135/70 with a heart rate of 140 beats per minute and a respiratory rate of 25 per minute. She is flushed and sweating profusely. Compared to the resting state, what can be said about the level of activity of sympathetic nerves to her heart and to her cutaneous vasculature?

(A) both are increased

(B) both are decreased

(C) neither is different from at rest

(D) sympathetic activity to the heart is decreased while that to the cutaneous vasculature is increased

(E) sympathetic activity to the heart is increased while that to the cutaneous vasculature is decreased

75. The eye examination of a patient with diabetes mellitus reveals no cataract or glaucoma. The patient’s ophthalmoscopic picture of his left eye is shown in the Figure 2-15. Which of the following is most likely affected?
76. You are the primary care physician for a young female college student. She has been engaged over the past 3 months in a vigorous aerobic exercise training regime that includes a significant amount of running in a hot environment. You measure her hematocrit as part of a general physical examination. Her hematocrit could well be abnormal even though she is not anemic. Which of the following choices best fits this profile?

(A) color vision
(B) high acuity vision
(C) near point vision
(D) scotopic vision
(E) spatial vision

77. A 66-year-old male presents with angina and dyspnea on exertion. Auscultation of the chest reveals a loud systolic murmur. He is diagnosed with aortic valvular sclerosis. This stenosis of the aortic valve will cause a murmur that can be heard loudest at which interval shown in Figure 2-16?

(A) between A and B
(B) between B and C
(C) between C and D
(D) between D and A
(E) between D and B

78. A patient is found to be deficient in folate. This patient is anemic, and a complete blood count indicates that the MCV is 105 fL (normal range: 80–96) and the MCHC is 34 g/dL (normal range: 32–36). The anemia is thus macrocytic, normochromic. In this patient how would you predict that the MCH (mean corpuscular hemoglobin) would compare with the normal range?

(A) MCH would be elevated with respect to the normal range
(B) MCH would be depressed with respect to the normal range
(C) MCH would be within the normal range
(D) this cannot be determined based on the information provided
79. Multiple sclerosis is a relatively common nervous system demyelinating disease. It is autoimmune and restricted to the central nervous system. Nerve conduction velocity is depressed in almost all affected individuals. Manipulations which prolong action potential duration seem to mitigate symptoms, possibly by facilitating conduction through sections of membrane which are no longer myelinated. Application of which type of drug might be expected to prolong action potential duration and thus be a potential therapeutic tool?

(A) activates potassium channels  
(B) blocks L-type calcium channels  
(C) blocks potassium channels  
(D) blocks sodium channels  
(E) increases sodium channel inactivation

80. Which of the following conditions would likely be associated with decreased levels of circulating EPO?

(A) chronic alkalosis  
(B) chronic renal failure  
(C) emphysema  
(D) pernicious anemia  
(E) pulmonary fibrosis

81. The graph in Figure 2-17 shows the static pressure–volume curve of a patient’s lung (solid line). The broken line indicates the pressure–volume curve of a normal person for comparison. What is the approximate lung compliance of this patient over the volume range from 1 to 7 L?

(A) 0.5 cm H₂O/L  
(B) 1 cm H₂O/L  
(C) 400 mL/cm H₂O  
(D) 800 mL/cm H₂O  
(E) 1000 mL/cm H₂O

82. The data in Figure 2-17 indicate that the lung compliance in this patient (solid line) is altered relative to the norm. This patient is most likely suffering from which of the following conditions?

(A) acute obstruction of the glottis  
(B) α₁-antitrypsin deficiency  
(C) asbestosis  
(D) idiopathic pulmonary fibrosis  
(E) sarcoidosis

83. Lambert-Eaton myasthenic syndrome (LEMS) is an autoimmune disorder in which autoantibodies attack voltage-gated calcium channels in the presynaptic nerve terminal. A characteristic manifestation of LEMS is limb muscle weakness. A decrease in which of the following would you expect to see in LEMS?

(A) activation threshold for the action potential  
(B) amplitude of the action potential  
(C) amplitude of the miniature end-plate potential (MEPP)  
(D) magnitude of the end-plate potential (EPP)  
(E) quantal content

84. A newlywed 23-year-old woman and her 28-year-old husband are evaluated for infertility. They have been unable to conceive a child despite regular intercourse for the past 12 months. The first step of this couple’s infertility workup is to determine whether ovulation occurs regularly. Which of the following hormones is directly responsible for ovulation?

(A) estradiol  
(B) estriol  
(C) follicle-stimulating hormone (FSH)  
(D) inhibin  
(E) luteinizing hormone (LH)
85. The electrocardiogram of a 66-year-old male with a history of atherosclerotic heart disease reveals an irregular, but rapid heart rate. The QRS complexes are normal but no P-waves can be seen. What is the most likely reason for these findings?

(A) atrial fibrillation  
(B) Paroxysmal ventricular tachycardia  
(C) Right bundle branch block  
(D) Sinus tachycardia  
(E) Wolff-Parkinson-White syndrome

86. Which of the following diseases will result in left ventricular hypertrophy?

(A) Aortic valve stenosis  
(B) mitral valve stenosis  
(C) pulmonary valve regurgitation  
(D) tricuspid valve regurgitation  
(E) tricuspid valve stenosis

87. A 28-year-old, 166 cm (5.45 ft) tall woman, weighing 170 kg (375 lbs) successfully underwent biliopancreatic diversion surgery, in which a portion of her stomach was removed and the remaining portion of the stomach was connected to the lower portion of the small intestine (see Figure 2-18). What is her prevalence for peptic ulcer disease and for what reason?

(A) it is higher due to inflammation caused by the surgical staples  
(B) it is higher due to the loss of secretin release  
(C) it is lower since chief cells were surgically resected  
(D) it is lower since G cells were surgically resected  
(E) it is unchanged since the surgery was successful

88. In patients with type 4 renal tubular acidosis (RTA) aldosterone deficiency is often a prominent finding. Distal tubular transport of which of the following ions will be affected in these patients?

(A) hydrogen and potassium in exchange for sodium  
(B) hydrogen only  
(C) potassium only  
(D) sodium and bicarbonate  
(E) sodium only

89. During a marathon attempt a runner collapses and is admitted with severe acute dehydration. Which of the following is most likely to occur in this patient?

(A) decreased baroreceptor firing rate  
(B) decreased plasma osmolarity  
(C) high renal water excretion  
(D) low plasma ADH levels  
(E) low water permeability of collecting duct tubular cells

90. When glucose is chronically elevated in poorly controlled diabetes mellitus, nonenzymatic glycosylation of various proteins occurs. The change of which of the following substances is most commonly monitored as indicator for the efficiency of blood glucose control?

(A) hemoglobin A1c (HbA1c)  
(B) lipoprotein (a)  
(C) modified albumin  
(D) myoinositol  
(E) sorbitol

FIG. 2-18
91. A patient on intensive care is ventilated with a frequency of 12 per minute and a tidal volume of 0.6 L. His arterial pH increases to >7.5. What is the most reasonable action to correct this respiratory alkalosis?

(A) decrease dead space  
(B) decrease tidal volume  
(C) increase minute ventilation  
(D) increase oxygen fraction  
(E) use positive end-expiratory pressure (PEEP)

92. Figure 2-19 illustrates the extracellular and intracellular volume–osmolarity status of a patient (broken lines) and that of a normal subject (solid lines) for comparison. This patient most likely suffers from which of the following conditions?

(A) adrenal insufficiency  
(B) chronic vomiting  
(C) iatrogenic fluid overload with 0.9% NaCl  
(D) iatrogenic fluid overload with hypertonic solution  
(E) syndrome of inappropriate hypersecretion of antidiuretic hormone (SIADH)

93. Gamma-aminobutyric acid (GABA) is an amino acid that functions as a neurotransmitter in the central nervous system. GABA typically causes increased chloride conductance and functions as an inhibitory transmitter. Assume that the equilibrium potential for chloride (ECl) in a particular cell is −80 mV and that application of GABA inhibits the cell without any change in resting membrane potential. What is the resting membrane potential of the cell?

(A) +80 mV  
(B) 0 mV  
(C) −70 mV  
(D) −80 mV  
(E) −90 mV

94. The striped area in Figure 2-20 indicates a red light on the receptive fields of a red on-center, green off-center surround retina ganglion cell. How will the light spot be perceived?

(A) brown (red + green)  
(B) green  
(C) no color  
(D) red  
(E) reddish green

95. Creatinine clearance is often used to evaluate glomerular function. Which of the curves in Figure 2-21 best represents the relationship between plasma creatinine concentration and creatinine clearance in a normal healthy person?
96. The patient is a 43-year-old male. He is anemic, with a hemoglobin level of 12.2 g/dL (normal is 15.5 g/dL). The erythrocytes are microcytic (MCV = 70 fL, with normal MCV = 80–100 fL). Which of the following would most likely be present in this patient?

(A) acute bleeding  
(B) folate deficiency  
(C) iron deficiency  
(D) vitamin B₁₂ deficiency  
(E) vitamin K deficiency

97. Which of the following statements concerning total body energy storage is correct?

(A) Most of the body’s energy store is held as carbohydrate.  
(B) Most of the body’s energy store is held as lipid.  
(C) Most of the body’s energy store is held as plasma glucose.  
(D) Most of the body’s energy store is held as protein.  
(E) Total body’s energy storage approximately equals resting metabolic rate.

98. During a brain surgery, during which the patient remained conscious, a part of the DC/ML (dorsal column, medial lemniscal) system was exposed and stimulated. Which of the following sensations might the patient most likely experience?

(A) a feeling as if his fingers are warming up  
(B) a feeling as if something were touching his index finger  
(C) a tingling sensation  
(D) mild pain but he is unable to explain exactly where it hurts

99. A patient presented with an acute abdomen including fever, marked abdominal distension, acidosis, and leukocytosis. Laparoscopy revealed that large parts of the small intestine were necrotic and as a consequence, the entire ileum of the patient was resected. It is expected that very soon after the surgery the patient will have considerable problems resulting from the malabsorption of which of the following?

(A) iron  
(B) bile acids  
(C) sodium  
(D) vitamin B₁₂  
(E) protein

100. Figure 2-22 shows a gastric parietal cell with selected membrane transporters and channels. What do X, Y, and Z represent in the figure?

(Figure 2-22: Diagram showing membrane transporters and channels with X, Y, and Z labeled.)

\[
\begin{array}{ccc}
X & Y & Z \\
\text{(A)} & \text{Cl}^- & \text{H}^+ & \text{K}^+ \\
\text{(B)} & \text{Cl}^- & \text{K}^+ & \text{H}^+ \\
\text{(C)} & \text{H}^+ & \text{Cl}^- & \text{HCO}_3^- \\
\text{(D)} & \text{K}^+ & \text{Na}^+ & \text{H}^+ \\
\text{(E)} & \text{Na}^+ & \text{H}^+ & \text{K}^+ \\
\end{array}
\]
101. Altered plasma renin levels can occur in both normal and pathologic conditions. Which of the following states is associated with a decrease in plasma renin levels?

(A) heart failure  
(B) primary aldosteronism  
(C) renal artery stenosis  
(D) salt restriction  
(E) upright posture

102. Figure 2-23 shows the change in the membrane potential of a postsynaptic neuron caused by addition, at the arrow, of a neurotransmitter. The resting membrane potential of this cell is $-80 \text{ mV}$. Relevant equilibrium potentials for $\text{Ca}^{2+}$, $\text{Na}^+$, $\text{Mg}^{2+}$, $\text{Cl}^-$, and $\text{K}^+$ are, respectively, $+120 \text{ mV}$, $+60 \text{ mV}$, $0 \text{ mV}$, $-80 \text{ mV}$, and $-90 \text{ mV}$. This neurotransmitter likely increases the conductance of which of the following ions?

(A) calcium conductance is higher than its normal resting level  
(B) chloride conductance is higher than its normal resting level  
(C) potassium conductance is higher than its normal resting level  
(D) sodium conductance is higher than its normal resting level  
(E) sodium-potassium ATPase activity is depressed

103. Figure 2-24 shows an intracellularly recorded action potential from a mammalian neuron. Which of the following statements is correct concerning events taking place at the point in time indicated by the arrow?

(A) calcium conductance is higher than its normal resting level  
(B) chloride conductance is higher than its normal resting level  
(C) potassium conductance is higher than its normal resting level  
(D) sodium conductance is higher than its normal resting level  
(E) sodium-potassium ATPase activity is depressed

104. Heparin is a rapidly acting, potent anticoagulant that has many important clinical uses. Which of the following is an action of heparin?

(A) activates prothrombin  
(B) acts with antithrombin to inhibit thrombin activity  
(C) decreases prothrombin time  
(D) inhibits calcium action  
(E) promotes vitamin K activity

105. Which of the following is a true statement regarding renal clearance of a substance?

(A) is measured in milligram per minute  
(B) glucose is greater than that of insulin in the normal kidney  
(C) insulin is zero  
(D) PAH remains constant regardless of the plasma level  
(E) potassium clearance will increase after an injection of aldosterone
106. As part of a neurological examination, a patient is placed in a chair that rotates to the right under the control of a computer so that the patient’s head and body move in unison with the chair. How would a healthy person react immediately upon getting off the chair that turned for 1 minute?

(A) behave the same as before the rotation  
(B) display post-rotational eye nystagmus to the right  
(C) experience a vertigo that would be diminished if he immediately got back in the rotating chair  
(D) experience “past pointing” to the left when asked to reach a target  
(E) fall to the left when asked to walk on a straight line

107. One of your diabetic patients has a blood glucose level of 200 mg/dL. Surprisingly, a dipstick test is negative for urinary glucose. How could this finding be explained?

(A) dipstick tests are more sensitive for reducing sugars other than glucose  
(B) the patient has defective tubular glucose transporters  
(C) the patient has diabetes insipidus  
(D) the patient has significantly reduced GFR  
(E) the patient is in a state of antidiuresis

108. Which of the following is a feature of the principal cell in the cortical collecting duct?

(A) normally generates a lumen-positive transepithelial potential difference  
(B) normally reabsorbs potassium and secretes sodium  
(C) responds to aldosterone with increased water permeability via aquaporins  
(D) utilizes a Na⁺/K⁺-ATPase in the basolateral cell membrane  
(E) utilizes a Na⁺/K⁺/2Cl⁻ cotransport protein in the luminal cell membrane

109. Which of the following shows the correct effects of hormones, when increased in serum, on liver glycogen content?

<table>
<thead>
<tr>
<th>Catecholamines</th>
<th>Glucocorticoids</th>
<th>Glucagon</th>
</tr>
</thead>
</table>
| (A) Decreased  | Decreased      | Decreased  
| (B) Decreased  | Decreased      | Increased |
| (C) Decreased  | Increased      | Decreased |
| (D) Increased  | Decreased      | Increased |
| (E) Increased  | Increased      | Decreased |

110. Opioid peptides are an important physiological mechanism of the body for relief from painful stimuli. Used as pharmacologic agents, they are highly valuable tools for pain management, although side effects are usually inevitable. Which of the following problems are most likely during opiate treatments?

(A) difficulty sleeping  
(B) hypermotility of the GI tract  
(C) placebo effects  
(D) respiratory alkalosis  
(E) tolerance (need for higher dosage to achieve the same therapeutic effect)

111. Following an automobile accident a patient suffers a pelvic fracture and significant internal blood loss resulting in hemorrhagic shock. Which of the following organs has the largest specific blood flow (blood flow per gram of tissue) under resting conditions and is especially vulnerable during the shock phase?

(A) brain  
(B) heart muscle  
(C) kidneys  
(D) skeletal muscle  
(E) skin
112. A 75-year-old male presented with a 6-month history of early satiety and with upper abdominal discomfort for many years. Physical examination revealed mild epigastric tenderness. Esophago-gastro-duodenoscopy showed a large, ulcerated mass in the upper stomach, which was found to be cancerous. Surgery resulting in the removal of the gastric fundus was performed. After successful surgery, the patient was advised to eat small portions and to drink small volumes because of which of the following?

(A) almost complete absence of gastric motility
(B) distorted emptying of liquids
(C) inadequate mixing of large food boluses
(D) lack of receptive relaxation in the stomach
(E) weaker and slower propulsion of food toward the pylorus

113. A 68-year-old woman presents with sleep disturbances and memory loss. After careful analysis, she is diagnosed with early stages of Alzheimer's disease. Her pharmacological treatment plan includes acetylcholine esterase inhibitors. One week after starting treatment, the woman's daughter calls in, reporting that her mom has developed new symptoms that might be related to her new medicine. Which of the following is a likely side effect of the drug?

(A) dry mouth
(B) forgetting to urinate
(C) muscle weakness
(D) nausea and diarrhea
(E) vertigo

114. A 14-year-old female presenting with polyuria is subsequently diagnosed with Type I diabetes mellitus. The polyuria results from an osmotic diuresis that involves primarily which part of the renal tubule?

(A) collecting duct
(B) glomerulus
(C) juxtaglomerular apparatus
(D) proximal tubule
(E) thick ascending limb of the loop of Henle

115. A person has an elevated plasma osmolality and reduced plasma ADH level and excretes a large volume of osmotically dilute urine. The urine contains no glucose. What is the most likely explanation for this situation?

(A) congestive heart failure
(B) nephrogenic diabetes insipidus
(C) neurogenic diabetes insipidus
(D) primary polydipsia
(E) uncontrolled diabetes mellitus

116. A 58-year-old male visits your office and complains about impotence. Upon questioning you learn that he is capable of erections, but that they do not last as long and that they are of lesser strength than the previous ones. Which of the following neurotransmitters is primarily responsible for dilation of the penile artery during erections?

(A) acetylcholine
(B) epinephrine
(C) GABA
(D) nitric oxide
(E) norepinephrine

117. Cardioactive steroids, like digoxin, exert a positive inotropic effect on heart muscle cells. Because of this activity, they can be used clinically to increase contraction of a failing heart. Which of the following proteins is important in the mechanism of action of digoxin on the cardiac muscle cell?

(A) N-type calcium channels
(B) Na⁺ : Ca²⁺ exchange protein (NCX)
(C) plasma membrane calcium ATPase (PMCA)
(D) potassium channels
(E) sodium channels

118. A 68-year-old postmenopausal female with a history of osteoporosis and essential hypertension is placed on the thiazide diuretic chlorothiazide, which has a beneficial action toward both conditions. Which letter in Figure 2-25 depicts the tubular location of epithelial cells containing a Na⁺/Cl⁻ cotransport protein inhibited by thiazide diuretics?
Worldwide, one of the most common parasitic infections is schistosomiasis. Assume a complete blood cell count is performed in a patient with this condition. Which of the following blood cells would most likely be present in elevated amounts?

(A) eosinophils  
(B) erythrocytes  
(C) monocytes  
(D) neutrophils  
(E) platelets

120. After total thyroidectomy as a result of a car accident, a 47-year-old woman is positive for Trousseau sign. It is manifested as carpopedal spasm occurring after an inflated blood pressure cuff is held above systolic blood pressure for a few minutes. Which of the following would best describe her postoperative condition when compared to preoperative?

(A) decreased deep tendon reflexes  
(B) higher serum calcitonin levels  
(C) lower serum calcium levels  
(D) lower serum phosphate levels  
(E) shorter Q-T interval of her ECG

121. A 60-year-old woman is admitted to the hospital with a fever and severe diarrhea for the last 24 hours. Cultures of blood, cerebrospinal fluid, urine, and stool are all negative for pathogens. The profile of gut hormones reveals elevated levels of VIP. An analogue of which of the following would most likely lower her VIP levels?

(A) erythromycin  
(B) histamine  
(C) motilin  
(D) somatostatin  
(E) trypsin

122. Malignant hyperthermia is a relatively rare genetic disorder, found in approximately one in 10,000 individuals. Affected individuals can exhibit a life-threatening response to inhalation anesthetics, which entails elevated core body temperature, skeletal muscle rigidity, and elevated blood carbon dioxide levels. Based on these observed symptoms, which of the following is most likely present in malignant hyperthermia?

(A) decreased release of acetylcholine at the neuromuscular junction  
(B) increased activation of myosin light chain kinase  
(C) increased activation of skeletal muscle potassium channels  
(D) increased activation of the calcium release channels of the sarcoplasmic reticulum  
(E) inhibition of skeletal muscle sodium channels
123. Figure 2-26 shows the conversions of cholesterol into the hormones C and D within follicular cells of the ovary (large arrows) and the regulation of these processes (small arrows) by pituitary hormones (A, B, E), when binding to their receptors on the cell surfaces (dark squares). Which of the letters in the figure best represents the hormone the concentration of which in serum changes in the following way?

<table>
<thead>
<tr>
<th>Concentration during follicular phase of the menstrual cycle:</th>
<th>70 pg/mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentration during preovulatory period of the menstrual cycle:</td>
<td>320 pg/mL</td>
</tr>
<tr>
<td>Concentration during luteal phase of the menstrual cycle:</td>
<td>130 pg/mL</td>
</tr>
<tr>
<td>Postmenopausal concentration:</td>
<td>10 pg/mL</td>
</tr>
</tbody>
</table>

(A) A  
(B) B  
(C) C  
(D) D  
(E) E

124. With respect to Figure 2-27, which of the following will decrease the GFR?

(A) decreased hydrostatic pressure in V  
(B) decreased plasma protein concentration in W  
(C) dilation of X  
(D) dilation of Z  
(E) increased aldosterone secretion by Y

125. Which of the following proteins uses the sodium electrochemical gradient to actively transport a solute into the cell?

(A) calcium-ATPase  
(B) GLUT2  
(C) Na⁺, K⁺-ATPase  
(D) Na⁺: Ca²⁺ countertransport protein  
(E) SGLT-1
126. A 23-year-old female has serum electrolytes tested as part of a routine physical. The laboratory results reveal a mild degree of hypokalemia. Which of the following will promote movement of extracellular potassium into the intracellular fluid compartment and cause hypokalemia?

(A) extracellular fluid hyperosmolality  
(B) intravenous administration of a beta-adrenergic blocker  
(C) intravenous administration of insulin  
(D) metabolic acidosis  
(E) physical exercise

127. Figure 2-28 shows blood glucose levels after ingestion, at the arrow of 100 grams of glucose in a patient newly diagnosed with Type II diabetes. The curve labeled R is the patient’s reference response. After curve R was obtained, the patient commenced a daily exercise regime. After several weeks of exercise a second curve was obtained. Which of the following best describes the response to glucose after exercise training?

(A) curve 1  
(B) curve 2  
(C) curve 3  
(D) curve 4
1. (D) Tuberculosis is known to increase the susceptibility of developing chronic adrenal insufficiency, also known as hypocortisolism, or Addison disease. It leads to hyperpigmentation as seen in the palmar skin creases and nails of the woman. Administration of cortisol replaces the inadequate release of glandular cortisol. Cortisol decreases protein synthesis and increases protein degradation. The newly available amino acids are then used for gluconeogenesis, which lead to the name “glucocorticoid” for cortisol. Increasing serum cortisol levels will decrease, not increase, secretion of ACTH (choice A) and CRH (choice B) by feedback inhibition. Cortisol decreases, not increases, the sensitivity of cells to insulin (choice C) by decreasing the translocation of glucose transporters to the cell membrane. Because cortisol decreases utilization of glucose by muscle and adipose tissue, blood glucose rises. This provides a stimulus to release insulin. Thus, prolonged exposure to high levels of cortisol can lead to diabetes mellitus due to exhaustion of pancreatic beta cells. Although cortisol acts as an anti-inflammatory agent, it has a negative, not a positive, effect on wound healing (choice E). Cortisol suppresses the activity of leukocytes which are important for debriding the wound. Cortisol increases catabolism, which leads to the breakdown of nutrients that are needed for generating new tissue. Cortisol stimulates catecholamines leading to vasoconstriction and consequent reduction of oxygen, nutrient, and white blood cell delivery. Cortisol may also inhibit collagen production.

2. (C) When there is danger of damage to the tendons or bones to which the muscles are attached, Golgi tendon organs are activated and elicit rapid responses through neural connections located within the spinal cord that result in muscle relaxation. Golgi tendon organs are muscle proprioceptors that are found close to the junction between tendon and muscle fibers. They are in series with the muscle fibers and respond to the stretch of tendons which accompanies muscle tension. The threshold for activating them in this manner is high and it is therefore believed that they play an important role in the reflex response of a muscle after excessive force (“muscles give out”). In the spinal reflex pathways, the Ib afferent axons from the Golgi tendon organ synapse on inhibitory spinal cord interneurons, which then inhibit, not activate, alpha motor neuron activity serving the same muscles (choice A). Gamma motor neurons (choice B) innervate muscle spindles. These neurons control the sensitivity of the spindle by maintaining the proportions between spindle and muscle length and by dampening the function of the spindle, regardless of change in muscle length. This is important for normal movements. Muscle spindles (choice D) continuously signal information about the length of a muscle and the rate of change in length. They are important for conscious appreciation of the body’s position, for planning and execution of controlled movements. Low oxygenation of the muscle or ischemia (choice E) is not the primary trigger for spinal reflexes, and will occur gradually, not suddenly as described in the question.

3. (B) ADH acts to increase renal water conservation secondary to dehydration. Choice B, which can result from dehydration, is the logical trigger for ADH secretion. Angiotensinogen (choice A) is inactive and will not directly stimulate ADH, but its active metabolite angiotensin II or III will increase ADH secretion. Choices C, D, and E will either inhibit, or have minimal effects on ADH secretion.

4. (D) Chronic renal failure reduces phosphate excretion and thus phosphate accumulates in the blood. The renal peritubular cells are the
major source of circulating EPO, which stimulates red blood cell production. Hence renal failure will decrease EPO levels (choice C) and will decrease hematocrit (choice E) as well. The kidney is responsible for production of 1,25-(OH)₂ vitamin D₃, the active form of vitamin D, and renal failure also results in decreased active vitamin D (choice E). Secondary to this, the circulating levels of calcium will decrease (choice A).

5. (E) Excessive vomiting can lead to large losses in fluid and electrolytes. Dehydration triggers the sense of thirst. Her age, her extremely low body mass index (normal 18.5–24.9), and her frequent vomiting all point toward anorexia nervosa. Anorexic people might drink large amounts of water to reach target weight. By drinking a lot of water without adequately replacing electrolyte imbalances, water intoxication can result. Diluted serum sodium levels can lead to headaches and seizures. Although vomiting, weight loss, and fainting due to low blood pressure could point toward Addison disease, the typical symptoms of hypocortisolism, which include hyperkalemia, hyperosmolality, and hyperpigmentation, are not mentioned and hence make choice A not the best one. In patients with diabetes insipidus, whether caused by a lack of ADH (choice B) or by failure of the kidney to adequately respond to ADH (choice D), serum osmolality is expected to be high. Normal glucose values make uncontrolled diabetes mellitus not the best working diagnosis (choice C).

6. (D) The slow calcium channels function in the ventricular myocardial cell to allow the influx of calcium into the cell, which has the dual role of triggering the calcium-mediated contractile mechanism and maintaining the depolarized state after the voltage-gated sodium channels close, soon after the rapid upstroke. Hence, blocking these channels will shorten the plateau phase of the action potential as seen in choice D, while also decreasing the contractile force of the heart. In choice A action potential duration is also shortened, but in a manner that would reflect blockade of the rapid voltage-gated sodium channels, not the slow calcium channels. Choice B represents no change in the action potential. Choice C would occur if the drug prolonged the open state of the slow calcium channels. The hyperpolarization of choice E is more likely the result of increased potassium channel currents.

7. (E) Pupil diameter is determined by the balance between sympathetic tone to the radial fibers of the iris and parasympathetic tone to the circular pupillary sphincter muscle. Sympathetic activation will result in pupillary dilation via activation of alpha-adrenergic receptors. Hence, an alpha-adrenergic blocker leads to constriction of the pupil. Parasympathetic activation on the other hand will result in pupil constriction via activation of muscarinic acetylcholine receptors, so that pupil dilation occurs as a result of a muscarinic acetylcholine receptor block (choice A). The same is true for decreased parasympathetic activity during darkness (choice B), or increased sympathetic activity, independent if the initial stimulus is due to emotional excitement or darkness (choices C and D).

8. (A) Water that is either warmer or cooler than body temperature when introduced into the external auditory meatus sets up convection currents within the endolymph of the inner ear. These currents may result in the movement of the cupula, the gelatinous matrix, which sits atop the crista ampullaris and occludes the lumen of the semicircular canal. Displacement of the cupula results in activation of the vestibular hair cells of the ampullar crista. This inappropriate stimulation of the vestibular system conflicts with sensory information from other sensor organs, including vestibular sensors on the contralateral side, vision, and proprioception, and may in turn result in vertigo and nausea. The existence of the many ducts within the inner ear might imply that the fluids that fill them are flowing through the ear. However, neither endolymph nor perilymph “flow” along their respective compartments in the normal or stimulated vestibular system (choice B). Neither hair cells of cristae ampullares (choice C) nor of otholith organs (choice D) nor of the cochlea (choice E) are temporarily immobilized or inhibited by temperature changes.
9. (E) From inspection of the figure, the R-R interval (time between heart beats) at rest is 0.83 seconds; 60 seconds/minute divided by 0.83 yields a resting heart rate of 72 beats/minute. Since activation of $\beta_1$ receptors in the sinoatrial node will result in increased heart rate, the only alternative larger than 72 beats/minute is (E), 90 beats/minute.

10. (D) The primary change in the cochlea due to an increase in the frequency of a sound wave is a change in the position of maximal displacement of the basilar membrane. A low-pitched sound produces the greatest displacement toward the apex of the cochlea, which results in activation of hair cells at that location. As pitch increases, the position of greatest displacement moves closer to the base of the cochlea. Increases in the number of hair cells that are activated (choice A), increased amplitude of basilar membrane displacement (choice B), increases in the frequency of discharge of units in the auditory nerve fibers (choice C), and an increase in range of frequencies to which such units respond (choice E), are all more likely to be observed in response to increases in the intensity of the sound stimulus (sound pressure) rather than to increases in pitch.

11. (D) Rupture of large numbers of red blood cells can result in jaundice in the absence of any liver disease. The capacity of the liver to clear released heme metabolites such as bilirubin is temporarily exceeded. Since the liver will not perform its normal function to conjugate bilirubin before excretion in bile and urine, unconjugated bilirubin backs up in serum. This is the reason for the increase in total bilirubin, while conjugated bilirubin, also called direct bilirubin, is not affected. Direct bilirubin would be elevated with most defects of liver cells (choice A) and with obstruction of bile flow by gallstones (choice C) or by a tumor (choice E). All these would most likely also affect bile formation and consequently absorption of dietary fat and fat-soluble vitamins, with the consequence of developing oily, fatty stool. Kupffer cells (choice B) are macrophages within the liver and don’t play a role in the production of bilirubin.

12. (A) The patient clearly has an increase in her state of insulin resistance. Given the magnitude of her increased insulin requirements, she most likely developed a high titer of anti-insulin antibodies that are preventing the injected insulin from lowering blood glucose effectively. A good choice of lifestyle, including an improved diet (choice B), an improved exercise program (choice C), or weight loss (choice E) each are shown to beneficially affect her insulin requirements. Progression of macrovascular disease (choice D) is largely irrelevant to her insulin requirements, except to the extent that it might decrease her ability to exercise.

13. (E) Functionally blind means that a person has a visual impairment, that does not qualify as “legally blind” but results in substantial impediment. With a near point of 5 cm and a far point of 10 cm, the man has a severe case of myopia, not hyperopia as stated in choice C. The total convergence power of the relaxed eye with normal vision is approximately 60 dioptres, and the cornea accounts for more than two-thirds of that (40 dioptres). The accommodative power of the lens is about 20 dioptres in the very young, about 10 dioptres at age 25, and would be around 1 dioptre at the patient’s age, if he had normal vision. For young adults with normal vision, the near point is about 10 cm from the eye; the far point is at infinity. The corrective lenses for the myopic eye are concave, not convex (choice A). Concave lenses compensate for the excessive positive dioptres of the myopic eye. These lenses are thin in the middle and wide at the edges and have negative dioptric values, not positive ones (choice B). The patient definitely won’t be able to drive a car or perform other activities that require fast accommodation without corrective glasses (choice D).

14. (A) Carbohydrate absorption occurs at enterocytes of the upper region of small intestinal villi. Fructose absorption is via the facilitated transporters GLUT5 across the apical enterocyte membrane and GLUT2 across the basolateral enterocyte. Glucose and galactose on the other hand are transported into enterocytes on carriers in combination with a sodium ion. The energy for this secondary active transport is provided by
the electrochemical sodium gradient that is created by Na/K-ATPases. Experimental conditions that collapse the sodium electrochemical gradient, hypoxia, or poisoning of the Na-K-ATPase by ouabain inhibit glucose, but not fructose absorption. Nevertheless, the physiological importance of “saving energy” under extreme conditions such as mountain climbing through the use of fructose as energy source is questionable. For instance, fructose absorption is much slower than absorption of glucose and galactose. The statements in choices B, C, D, and E are incorrect.

15. (D) The strongest stimulator for the release of secretin from cells in the upper small-intestinal mucosa is the contact with acidic chyme. Increased serum secretin levels stimulate water and alkali secretions from the pancreas and the hepatic ducts and inhibit gastrin release. The release of pancreatic enzymes is stimulated by cholecystokinin (choice A). The most potent stimulators for the release of cholecystokinin are not acid, but digestion products of fat and protein. Strong stimulators for gastrin secretion (choice B) are vagus nerve excitation, distention of the stomach, and protein digestion products. Gastrin then stimulates acid secretion and mucosal growth. The major effect of glucagon (choice C) is to increase blood glucose levels. Hence, it is secreted in response to hypoglycemia and protein digestion products, which are then used for gluconeogenesis. VIP (choice E) indeed stimulates intestinal and pancreatic secretion. However, it acts as neurotransmitter in the enteric nervous system and is mainly released by mechanical and neuronal stimulation.

16. (C) Cardiac output is calculated by multiplying heart rate by stroke volume. Stroke volume is the difference between end-diastolic ventricular volume and end-systolic volume. Hence 150 – 80 = 70 mL stroke volume. 70 mL × 70 beats/min = 4900 mL/min.

17. (A) The differences in the hormone concentrations of blood samples taken half-an-hour apart indicate pulsatile release. Hence, non-pulsatile release (choice C) is excluded. However, the normal circadian rhythm for ACTH (choice B) is likely to be highest early in the morning, with cortisol production following ACTH by a short delay, opposite to the patient’s values. Such a reversed pattern could, for instance, be observed for night workers and is not likely to be caused by etomidate. Etomidate has been associated with suppression of glucocorticoid and mineralcorticoid synthesis in the adrenal cortex. Substantial damage to the adrenal gland might indeed lead to adrenocortical hypofunction, called Addison disease. However, primary adrenal insufficiency (disorder of the gland, choice D), and secondary adrenal insufficiency (inadequate ACTH secretion, choice E) both present with low levels of cortisol.

18. (B) The slope of the patient’s line is decreased compared to normal. This indicates a low affinity of estrogen for the estrogen receptor, which makes choice B correct and choice A incorrect. The x-intercept is called Bmax and represents the total number of estrogen receptors. This is unchanged in the patient compared to normal so that choices C, D, and E are excluded. The information about the numbers and status of estrogen and progesterone receptors on cancer cells is of high clinical value to determine the efficiency of consequent hormonal therapy.

19. (C) NSAIDs inhibit cyclooxygenase and consequently inhibit (not promote, choice E) synthesis of prostaglandins. In the stomach, prostaglandins have a cytoprotective effect through inhibition of acid secretion, enhancement of mucosal blood flow, and stimulation of bicarbonate and mucus secretion. Inhibiting these processes can cause stomach ulcers and bleeding such as described in the case. Arachidonic acid (choice A) is not directly affected by NSAIDs—it is turned into prostaglandin H2 by the action of cyclooxygenases. NSAIDs do not regulate bradykinin and histamine synthesis (choices B and D).

20. (E) The most rapid filling of the ventricles occurs in early diastole, immediately after opening of the atroventricular valves. This happens after the repolarization phase (T wave) and resulting relaxation of the cardiac
ventricular muscle. Excitation of the atria (choice A) also results in increased blood flow into the ventricles, occurring around choice B. However, the flow at that time is less than during early diastole. Ventricular contraction begins with the QRS complex (choice C) and lasts until the end of the T wave (choice D). During this time, the mitral and tricuspid valves are closed.

21. **(D)** Note that the end-diastolic volume of this patient is the same as that of a normal subject. Because the patient’s stroke volume is larger than that of a normal subject, the force of contraction must also be larger. This could be due to increased sympathetic tone or to the fact that the patient took inotropic medications. The volume remaining after the ventricular contraction is correspondingly smaller compared to normal. Preload (choices B and E) equals end-diastolic volume and is the same in the patient and normal subjects. Afterload (choice A) is equal to arterial pressure. Both afterload and stroke volume (choice C) are larger in this patient compared to normal.

22. **(B)** Figure 2-7 shows the jugular vein pressure curve. Pressure in the jugular vein reflects atrial pressure and is highest during the atrial contraction (named the “a wave”). The “v wave” (choice A) represents the rise in atrial pressure before the tricuspid valve opens during diastole. The “y notch” (choice D) is due to the fall in atrial pressure during the ventricular filling phase. The “c wave” (choice C) is due to the rise in atrial pressure produced by the bulging of the tricuspid valve during isovolumetric contraction of the right ventricle. The “x notch” (choice E) coincides with the ventricular ejection phase.

23. **(A)** In patients with celiac disease the protein gluten, which is found in bread, oats, and many other foods containing wheat, barley, or rye, triggers an autoimmune response that causes damage to the small intestine leading to widespread manifestations of malabsorption. Calcium is difficult to absorb, so patients frequently experience symptoms of hypocalcemia such as muscle cramping, tetanic contractions, numbness, and tingling sensations. For sensory and motor nerves, calcium is a critical second messenger involved in normal cell function, neural transmission, and cell membrane stability. The nerves respond to a lack of calcium with hyperexcitability. The inability to absorb nutrients such as carbohydrates (choice B) leads to weight loss as experienced by the boy. Fat malabsorption (choice C) is not uncommon in patients with celiac disease as a consequence of greatly diminished absorptive surface. It would manifest in steatorrhea. Iron (choice D), like calcium, is difficult to absorb and may lead to anemia. The general decrease in electrolyte absorption leads to decreased water absorption (choice E). The increased osmotic load in the GI lumen accounts for the boy’s diarrhea.

24. **(A)** Intravenous solutions are distributed in the various body fluid compartments based on osmolality and their ability to penetrate the vascular wall and the cell membrane. The proteins in blood plasma will remain within the vascular compartment because of their low permeability across the vessel wall. Thus, 500 mL of blood plasma will remain in the vascular compartment. Water (choice B) passes across the cell membrane and the vascular wall easily. Hence distilled water will distribute itself between cellular and extracellular spaces, meaning only a small portion will actually contribute to blood volume, the other choices (C, D, and E) cross the vascular barrier and distribute partially to the extravascular space and thus are less effective intravascular volume expanders.

25. **(A)** The process of glomerular ultrafiltration creates a tubular fluid that is essentially protein free. Hence, as plasma passes from the afferent arteriole, through the glomerular capillaries to the efferent arteriole, the protein albumin concentration rises as approximately 20% of the fluid is filtered out, leaving the albumin behind, giving an afferent/efferent arteriole concentration ratio of approximately 0.8. By contrast, the glomerular capillary membrane is freely permeable to water and other small particles such as glucose (choice A), chloride (choice B), potassium (choice D), and sodium (choice E), so their concentrations do not change
as approximately 20% of water and solute are filtered into Bowman’s capsule, giving afferent/efferent arteriole concentration ratios of 1.0.

26. (C) The atrial stretch receptors are depolarized by stretch of the atria proportional to the magnitude of venous-filling pressure. The frequency of action potentials rises to a maximum at the peak of the atrial “v” wave, which signals maximum atrial filling during ventricular contraction. Although the remaining choices (A, B, D, and E) may be influenced by the filling of the heart by venous pressure, the information conveyed to the brain via the atrial stretch receptors relates directly to the filling pressure of the atria themselves.

27. (D) High-dose exogenous glucocorticoids suppress the adrenal neuroendocrine axis. Patients treated for longer than 2 weeks need to be tapered off glucocorticoids slowly to avoid adrenal insufficiency. Other complications of high-dose glucocorticoids include growth suppression, not excessive growth (choice A) in children and volume overload, not volume depletion (choice E). Hyperkalemia (choice B) and hyponatremia (choice C) are observed in adrenal insufficiency due to loss of mineralocorticoid effects and are not relevant to glucocorticoid therapy.

28. (B) Since cardiac SA nodal cells receive tonic input from both sympathetic and parasympathetic nerves, heart rate increases whenever sympathetic firing rate increases or parasympathetic firing rate decreases. In humans, the parasympathetic innervation of ventricular muscle is negligible (choice D), and the strength of contraction increases with increasing preload and with increasing sympathetic firing rate (choice E). With few exceptions, blood vessels are not innervated by parasympathetic nerves, and there is little effect of changes in parasympathetic tone on total peripheral resistance (choices A and C).

29. (D) CO₂ reacts with H₂O to form H₂CO₃ (carbonic acid), in a reaction catalyzed by carbonic anhydrase. Carbonic acid then dissociates to form HCO₃⁻. Approximately 90% of the total CO₂ in the blood is carried as HCO₃⁻. H₂CO₃ rapidly dissociates after being formed and a negligible fraction of blood CO₂ is carried in this form (choice D). Some CO₂ is carried bound to hemoglobin, as carbamino compounds (choice A). This is a small fraction of the total CO₂ (5%). A similar small fraction (5%) of total CO₂ remains dissolved in solution (choice B). Given that normal blood pH is near 7, essentially no HCO₃⁻ dissociates to form CO₃²⁻ (choice C).

30. (C) About 40% of total plasma Ca²⁺ is bound to proteins and not filtered at the glomerular basement membrane. Therefore, the estimated daily filtered load is 1.5 mmol/L × 160 L/day = 240 mmol/day. The exact amount of free versus total Ca²⁺ depends on the blood pH: free Ca²⁺ increases during acidosis and decreases during alkalosis. None of the other choices (A, B, D, and E) reflect the correct renal calcium filtration load.

31. (D) Local hypoxia causes vasoconstriction in vessels of the pulmonary circulation. This is an adaptive response, since it will shunt blood away from poorly ventilated alveoli. This response differentiates the pulmonary circulation from the vasculature of other organs. In heart muscle, skeletal muscle, kidney, and brain (choices A, B, C, and E) vasodilation occurs in response to local hypoxia.

32. (B) Bronchiol volume contributes to dead space volume, so increasing bronchoconstriction would decrease bronchiolar volume and thus decrease dead space volume. Bronchoconstriction is a major determinant of airway resistance to air flow. Leukotrienes, by increasing airway constriction, would increase resistance to air flow (choice A). Lung elastic tissue and alveolar surface tension determine lung compliance (choice D), which should not be affected by airway leukotrienes exposure. FRC (choice C), the point of mechanical balance between chest wall and lung, is dependent on lung compliance and, similarly, would not be affected by leukotrienes exposure. Any bronchoconstriction would slightly decrease total lung capacity (choice E).
33. (B) The small intestine absorbs massive quantities of water. A normal person takes in about 2 L of fluid every day. Another 7 L of fluid are received by the small intestine daily as secretions from salivary glands (1.5 L), stomach (2 L), pancreas (1.5 L), liver (0.5 L), and the small intestine itself (1.5 L). That results in a total of about 9 L of fluid entering the GI tract daily. In a healthy person the duodenum, jejunum, and ileum absorb the bulk of the water that enters the GI tract, here 8500 mL. The colon absorbs most of the remaining fluid (400 mL), not the bulk of it (choice A) and excretes about 100 mL daily. There is generally no water absorption in the esophagus and stomach. Therefore, choices C, D, and E are incorrect.

34. (A) The action potentials illustrated must be those of cardiac nodal cells (SA node or AV node). The duration of these action potentials is too long for motor axons, (choice B), sensory neurons (choice C), or skeletal muscle fibers (choice D). Also, the configuration is different and a pacemaker potential is clearly present. They cannot be ventricular Purkinje action potentials (choice E) because these have a more negative diastolic component that does not gradually depolarize, a longer duration (200 msec) and a plateau region.

35. (C) The carotid sinus baroreceptors signal the magnitude of arterial pressure to the brainstem which then causes reflex inhibition of sympathetic nerves to the body. Thus, a decrease in arterial pressure will cause a reduced carotid sinus nerve impulse rate, which reflexly increases sympathetic nerve impulse rates. Hence, choices A, B, and D are directionally incorrect. Choice E is incorrect because the arterial baroreflexes function at the level of the brainstem, which does not require the conscious mind for its action.

36. (A) Clamping of the abdominal aorta suddenly increases peripheral vascular resistance to blood flow. Hence aortic pressure suddenly rises to a high level. This represents an increased afterload, that is, an increased ventricular pressure is required to eject blood into the aorta. Figure 2-10 shows that momentary clamping of the aorta does not alter the preload, that is, the filling of the ventricle during diastole (choice D). Figure 2-10 shows that the inverse relationship between afterload and stroke volume causes a reduced stroke volume (choice E) immediately after aortic clamping. Since end-diastolic volume (preload) is unchanged, while stroke volume is decreased, this represents a decreased ejection fraction (choice C). Cardiac output is calculated as stroke volume X heart rate. Since heart rate is not given, the cardiac output cannot be determined (choice B). However, it is likely, by Ohm’s law that a momentary rise in peripheral vascular resistance will decrease cardiac output.

37. (E) Nephrogenic diabetes insipidus is a condition in which the kidney is insensitive to the normal action of ADH, which is to cause a concentrated urine by promoting water reabsorption in the collecting duct. In such a person, plasma glucose will be normal—around 80 mg/100 mL and excreted glucose will be zero, since the tubular maximum for glucose has not been exceeded and all the filtered glucose is normally reabsorbed. Choices A, B, and C depict the filtered, reabsorbed, and excreted glucose in a hyperglycemic state which might occur during diabetes mellitus. Choice D depicts the filtered and reabsorbed glucose in a fasting, normoglycemic state.

38. (A) Type I diabetes mellitus is a condition in which the pancreas secretes inadequate quantities of insulin, causing a fasting hyperglycemia. Choice A depicts the filtered glucose in such a hyperglycemic state. Choices B and C depict the reabsorbed and excreted glucose which would also occur in a hyperglycemic state. Choice D depicts the filtered and reabsorbed glucose in a fasting, normoglycemic state. Choice E depicts the zero excreted glucose that would occur in a fasting nondiabetic individual since the tubular maximum for glucose has not been exceeded.

39. (D) The bilateral renal artery stenosis will reduce renal perfusion pressure. Hence the juxtaglomerular apparatus will greatly increase renin secretion which causes the large rise in
arterial pressure because of the vasoconstrictor action of angiotensin II. A reduced renal perfusion pressure will decrease PAH clearance (choice C), which estimates renal blood flow and will reduce GFR (choice B). The decreased formation of tubular fluid will result in reduced urine output (choice E) and the large rise in arterial pressure will activate arterial baroreceptors and suppress ADH secretion from the posterior pituitary (choice A).

40. (C) Acidemia is the presence of excess H+ ions in blood, which tends to create a rise in the extracellular potassium concentration. The rule of thumb for an inorganic acid that causes the acidity is that a decrease in pH of 0.1 unit leads to a rise in plasma potassium of 0.6 milliequivalents per liter. The effect of an organic acid is a lot less. The mechanism responsible for the relationship between pH and extracellular potassium concentration is not completely understood. One effect is that the intracellular acidosis inhibits K+ influx by reducing the activity of the Na-K-pump. An exchange of extracellular H+ for intracellular K+ might also contribute. Choices A, B, D, and E are the opposite of what is observed in acidemia.

41. (A) This patient probably suffers from myopia (nearsightedness). Myopia is either due to eyeballs that are too long or a lens that is too strong. To focus a distant object onto the retina (far accommodation), the lens has to decrease its refractive power (i.e., increase its focal length). This is accomplished through relaxation of the ciliary muscles that oppose the pull of the sclera, resulting in a tightening of the zonula fibers and a flattening of the lens. Shortening of the focal length (choice C), rounding of the lens (choice D), and relaxation of the zonular fibers (choice E), all occur during near accommodation. The pupils also constrict during near accommodation (choice B), perhaps to increase depth of field.

42. (D) A fixed lesion of the renal artery results in impaired perfusion. When the kidney is poorly perfused, it increases renin secretion, which increases blood pressure and thus improves renal blood flow. Hence the appropriate treatment is surgical correction of the renal artery lesion. Adrenal insufficiency (choice A), estrogen deficiency (choice B), and volume depletion (choice E) are situations that tend to diminish blood pressure. There is no clear relationship between hyperparathyroidism (choice C) and hypertension.

43. (D) In smooth muscle, increased cytoplasmic [Ca^{2+}] activates myosin light chain kinase, which acts to phosphorylate the light chain of the myosin molecule. Phosphorylation of the light chain activates myosin ATPase activity, initiating contraction. Troponin (choice E) is a calcium-binding protein that functions in both skeletal and cardiac muscles to regulate contractile activity. Troponin is not expressed in smooth muscle. Calcium (choice B) does regulate contractile activity. Increased intracellular [Ca^{2+}] serves to activate contraction in both skeletal and smooth muscles. Myosin (choice C) and actin (choice A) are contractile proteins present in both skeletal and smooth muscles. Though essential to muscle contraction, these proteins function in contraction in both muscle types.

44. (A) When the airway is obstructed, an alveolus will not be adequately ventilated. In this condition, effective gas exchange does not occur and alveolar gas composition and end pulmonary blood gas compositions approach 46 mm Hg O_2 and 44 mm Hg CO_2—the gas composition of mixed venous blood. In normal breathing (choice D) alveolar air equilibrates with pulmonary capillary blood, with a gas composition of approximately 100 mm Hg O_2 and 40 mm Hg CO_2. With hyperventilation (choice C), CO_2 partial pressure will fall and O_2 partial pressure may increase relative to the normal values quoted above. With a pulmonary capillary embolus (choice E), blood flow to an alveolus or to a group of alveoli is blocked. In this case, efficient gas exchange does not occur and gas composition of alveolar air approaches that of tracheal air (150 mm Hg O_2 and 0 mm Hg CO_2). This condition is referred to as wasted ventilation. In a healthy individual, breathing 100% O_2 (choice B) will increase alveolar O_2 partial pressure and thereby increase end pulmonary capillary O_2 partial pressure.
45. (A) Pulmonary fibrosis is a restrictive lung disease. Figure 2-12 illustrates pulmonary function testing data in a normal subject and a patient with fibrosis. Volume-time curves reveal FEV₁ and FVC in both subjects. The FEV₁/FVC ratio, which is typically about 0.8, is increased in patients with pulmonary fibrosis. Lung volumes such as vital capacity (choice E) are decreased. Patients with restrictive lung disease tend to exhibit shallow breathing, thus tidal volume is decreased (choice D). Increased elasticity causes a decrease in FRC, the mechanical balance point between lungs and chest wall (choice B). Though as noted above and illustrated in Figure 2-29 the FEV₁/FVC ratio is increased in patients with pulmonary fibrosis, FVC itself is decreased (choice C).

46. (C) Both Na⁺ and K⁺ excretion are tightly regulated. Thus, as GFR decreases in disease, the percentage of filtered Na⁺ or K⁺ excreted increases to maintain a normal amount of Na⁺ or K⁺ excretion (assuming Na⁺ and K⁺ intake remain the same). Substances like urea (choice A) (some reabsorption) and creatinine (choice D) (almost exclusively excreted by glomerular filtration) have no adaptive mechanisms to regulate plasma levels. Thus, a significant decrease in GFR results in significant increases in plasma creatinine and urea (assuming production of both substances remains constant). This is because the amount of substance x that is excreted \( (U_x \cdot V) \) equals the amount produced. Furthermore, \( U_x \cdot V = GFR \cdot P_x \). If GFR decreases, \( P_x \) increases. Because of the increase in percent filtered Na⁺ and K⁺ that is excreted, an increase in plasma Na⁺ (choice B) or a decrease in plasma K⁺ (choice E) would not be expected with a GFR that is 50% of normal. \( U_x \div \text{urine concentration} \) of \( x \); \( P_x \div \text{plasma concentration} \) of \( x \); \( V \div \text{urine volume} \).

47. (D) Elevated serum potassium levels cause membrane depolarization with a resulting Na-channel inactivation. Fibers are thus less able to fire action potentials, leading to impaired excitation contraction coupling, with muscle weakness (choice D is correct). Though hyperpolarization would also impede action potential generation, by moving the Na-channel away from its activation threshold, choices C and E are incorrect since high potassium causes membrane depolarization. Calcium required for skeletal muscle contraction is derived from internal stores (the sarcoplasmic reticulum) and is not dependent on calcium influx through surface membrane channels (choice B). There is no evidence that potassium interferes with the acetylcholine receptor (choice A).

Hyperkalemia in this patient is probably due to multiple factors. Since insulin promotes potassium uptake into cells, too low an insulin dosage in the diabetic can lead to hyperkalemia. In addition, propranolol can cause a shift of potassium from cell to blood. Finally, the elevated BUN indicates some renal failure, and failing kidneys cannot efficiently excrete potassium into the urine.

48. (A) The major control mechanism for gastric emptying involves duodenal gastric feedback, hormonal as well as neural. The major hormone involved in the inhibition of gastric emptying is cholecystokinin (CCK), which is released by fat and protein digestion products. Gastrin (choice B) stimulates hydrochloric acid secretion and exerts a trophic effect on the gastric and intestinal mucosa. When the gastrin concentration is elevated to supraphysiologic levels, various other actions can be demonstrated including inhibition of gastric emptying. However, the physiologic importance of these actions is uncertain. Glucose-dependent insulinotropic peptide (GIP, choice C) is released from the intestinal mucosa by acid, fat, or hyperosmolality and acts to some extent by inhibiting stomach functions including gastric motility. Although this function gave GIP its initial name
(gastric inhibitory peptide), GIP’s action as an enterogastrone is now controversial. The major physiologic action of GIP is to cause insulin release. Motilin (choice D) stimulates gastric motor activity, especially during the interdigestive phase, when it regulates contractions that serve to empty the GI residual contents. Pancreatic polypeptide (choice E) is a negative feedback regulator for pancreatic enzymes and bicarbonate secretion. It is considered to be a candidate hormone since it satisfies some, but not all of the criteria for hormonal status.

49. (D) In the adrenogenital syndrome, the failure to make cortisol due to lack of the adrenal enzyme 21-β-hydroxylase results in an inability to provide negative feedback suppression of ACTH production. As a result, the adrenal glands are under constant stimulation to maximize steroidogenesis. Substrates that cannot reach cortisol flow down other pathways and by mass action drive the massive overproduction of androgens, which can also be peripherally aromatized to estrogens. No significant change in serum cholesterol is observed (choice E), probably because the cholesterol reservoir in the body is large, even compared to the massive levels of steroids being synthesized in this syndrome. Cortical atrophy (choice A) and release of excess cortisol (choice C) are the opposite of what is observed. There is no mechanism to achieve selective hypertrophy of the adrenal medulla (choice B) because the action of ACTH to drive adrenal hypertrophy is limited to the cortex.

50. (C) By Ohm’s law, a reduction in flow should also reduce pressure if resistance is constant. Therefore a rise in total peripheral resistance in the face of reduced flow would account for the preservation of arterial pressure. Choice A is incorrect since cardiac output and venous return must rise and fall together. Choice B is incorrect since end-diastolic ventricular filling pressure falls with decreased venous return. Choice D is incorrect since heart rate can maintain pressure only if venous return is also maintained. Choice E is incorrect since Ohm’s law states the inverse relationship of venous return and pressure.

51. (C) Testosterone directly inhibits the secretion of GnRH from the hypothalamus, which affects secretion of LH and FSH and consequently secretion of testosterone. To initiate spermatogenesis, both FSH and testosterone are necessary. To maintain spermatogenesis after puberty, extremely high concentrations of testosterone seem to be required. Systemically administered testosterone does not raise the androgen level in the testes to as great a degree and it additionally inhibits LH secretion. Consequently, the net effect is generally a decrease in sperm count. There are two forms of inhibin (choice A) that are produced by Sertoli cells in males. They are activated by FSH, not testosterone, and inhibit FSH secretion by a direct action on the pituitary. Testosterone has been shown to have a suppressive, not activating (choice B) effect on leptin production. Prostaglandins (choice D) are produced by seminal vesicles and found in large quantities in semen. They are not known to play a role in spermatogenesis. They are believed to aid fertilization by reacting with female cervical mucus and to support smooth muscle movements in the uterus and fallopian tubes. Testosterone stimulates basic metabolic rate and can raise, not lower body core temperature (choice E). Excessive temperature of the testes can temporarily cause sterility.

52. (E) Hyponatremia of this magnitude for any reason is likely to cause seizures and coma, especially if the deviation from normal occurred rapidly (e.g., over 1 or 2 days). Withdrawal from painful stimuli (choice A) is a normal reaction. If intact, it would have provided information on the intactness of sensation and motor reflexes on the tested side. However, lack of withdrawal would be consistent with either a structural or a metabolic cause of coma, and therefore does not help. Blood in the cerebral spinal fluid (choice B) in a nontraumatic lumbar puncture suggests a structural rather than a metabolic cause of coma. Pupillary light responses (choice C) are typically preserved in metabolic encephalopathies. Posturing of limbs (choice D) is suggestive of a focal process involving the brainstem or midbrain rather than a metabolic encephalopathy.
53. (A) The concentration of exogenous insulin is higher at the site of injection in the periphery, compared to its concentration in the liver. On the other hand, endogenous insulin is higher concentrated in the liver than in the periphery. Insulin is normally secreted by the endocrine pancreas into the portal venous drainage. Thus, it passes through the liver before being seen by the periphery. A certain fraction of insulin is extracted by the liver; so that the concentration of insulin seen by the liver is normally higher than that seen by the periphery. This discrepancy between exogenous and endogenous insulin might contribute to the problems experienced by diabetics such as hypertension and cardiovascular disease. Injected insulin is missing C-peptide (choice B), while endogenous insulin is cosecreted with C-peptide, the physiologic functions of which remain unknown. Injected insulin is biologically active and not in the proinsulin form (choice E). Exogenous insulin generally used today in the United States is recombinant human insulin, not from animal sources (choice D). The problem of developing anti-insulin antibodies is now rarer since the injected insulin is not from animals. Insulin resistance (choice C) is generally due to receptor downregulation or desensitization, or anti-insulin antibodies. Tissues become equally resistant to both the body’s own (endogenous) and administered (exogenous) insulin.

54. (B) The accident trauma produces extensive loss of fluid from the vasculature into the interstitial fluid space. Hence venous return to the heart, and thus left atrial pressure will be reduced. The decrease in arterial pressure will trigger arterial baroreflexes which will activate the sympathetic nervous system and increase catecholamine release (choice A). Likewise the fall in pressure will cause increased renin/angiotensin/aldosterone (choices C and E). Finally, the reduced perfusion of the tissues will generate increased lactate formation (choice D).

55. (D) Deficiency of vitamin B<sub>12</sub> results in hematological, neurological, and GI effects. The hematologic symptoms include a low red blood cell count with large-sized macrocytic red blood cells as described. Absorption of vitamin B<sub>12</sub> is relatively complicated. The large and not very lipophilic molecule is released from food by the low pH of the stomach and pepsin digestion and binds to R protein (also called haptocorin). Pancreatic proteases digest these complexes and the liberated cobalamin (vitamin B<sub>12</sub>) now complexes with an intrinsic factor (which is produced by gastric parietal cells) and is absorbed as such in the terminal ileum. Hence, vitamin B<sub>12</sub> absorption will be low in this patient. Liver storage is thought to be sufficient for 3–6 years so that the 3-year latency of the anemia further supports a vitamin B<sub>12</sub> deficiency. The water-soluble vitamins B<sub>1</sub> and B<sub>6</sub> (choices B and C) are absorbed in the duodenum by simple diffusion. Absorption of the lipid-soluble vitamins A and K (choices A and E) is supported by bile-acid mixed micelles, although vitamin A and vitamin K<sub>3</sub> do not heavily rely on bile acids and can also enter the enterocytes by simple diffusion. Additionally, of the stated choices, only vitamin B<sub>12</sub> deficiency is associated with anemia.

56. (D) The plot shows that carbon monoxide fails to equilibrate with pulmonary capillary blood during the time that blood is exposed to alveolar air. Since pulmonary partial pressure rises to only a few percent of alveolar partial pressure, carbon monoxide is a diffusion-limited gas. In contrast, nitrous oxide, which does equilibrate, is a perfusion-limited gas (choice E). Carbon monoxide does cross the respiratory membrane (choice C), dissolve in pulmonary capillary blood (choice A), and binds with hemoglobin (choice B). In fact, its affinity for hemoglobin is about 250-fold greater than that of oxygen.

57. (D) Water deprivation will eventually increase extracellular fluid osmolality, which triggers release of ADH. ADH acts on the collecting duct to increase water reabsorption, thus making the excreted urine more concentrated via a negative free-water clearance. Choices B and C will reduce the sensitivity of the collecting duct to normal circulating ADH. Choices A and E will reduce the amount of ADH secreted by the posterior pituitary.
58. **(B)** Glucuronyl transferase is the enzyme that conjugates bilirubin in the liver, after which it is excreted in bile or urine. A hereditary defect in glucuronyl transferase concentration, or activity, is called Gilbert syndrome. It may lead to mild jaundice and general discomfort with typical onset in childhood or early adulthood. Alcohol poisoning (choice A) leads to liver damage, and an elevation of conjugated bilirubin. Abnormalities of liver enzyme tests would be expected. Lactate dehydrogenase (choice C) catalyzes the conversion of lactate to pyruvate as part of cellular energy production. Since many cells including red blood cells are rich in LDH, increased serum LDH levels could point toward excessive hemolysis, but would not be a cause for it. Although hemolysis that exceeds the capacity of the liver to clear bilirubin from serum (choice D) would lead to increased unconjugated bilirubin, it is not the best choice due to the woman's normal hemoglobin (12–16 g/dL for females). Obstruction of bile flow (choice E) leads to backup of largely conjugated bilirubin in the blood stream.

59. **(D)** The bicycle racer is likely dehydrated from his exercise and ADH would be secreted by the posterior pituitary in response to increased extracellular osmolality. The area of the nephron with the lowest osmolality will be the early distal tubule (choice D), a nephron-diluting segment. The fluid in Bowman’s capsule (choice A) will be at the same osmolality as the plasma entering the glomerular capillaries. The fluid at the end of the proximal tubule (choice B) is isoosmotic with the Bowman’s capsule fluid while the fluid in the thin descending loop of Henle (choice C) is greatly concentrated due to water reabsorption into the hyperosmotic medullary interstitium. The fluid at the end of the collecting duct (choice E) can be very concentrated or very dilute, but since ADH greatly increases water reabsorption in this segment, the fluid becomes very concentrated.

60. **(C)** The primary control over prolactin secretion is inhibition by hypothalamic dopamine; all other anterior pituitary hormones are primarily controlled by hypothalamic hormone stimulation. Hence, with stalk transection, loss of connection of the hypothalamus to the pituitary is associated with decreased secretion of all pituitary hormones except prolactin, the secretion of which increases in the absence of dopamine. Secretion of growth hormone (choice B), proopiomelanocortin (choice D), and thyroid-stimulating hormone (choice E) all decrease. Gonadotropin-releasing hormone (choice A) is a hypothalamic hormone, and is not made in the pituitary gland.

61. **(C)** Hirschsprung disease is a genetic disorder caused by the absence of enteric nerve cells in the wall of the sigmoid colon and/or rectum. The portion of the bowel wall without nerve ganglia (aganglionic) cannot relax in response to bowel content so that the stool builds up behind the obstruction. In some children the problems begin shortly after birth, other infants are not acutely ill, but develop chronic symptoms such as constipation or anemia. Cholecystitis (choice A), caused by inflammation of the gallbladder, gastroesophageal reflux disease GERD (choice B), and polymyositis (choice D), a disorder affecting esophageal skeletal muscle, do not affect the neuronal regulation of the large intestine. Hirschsprung disease is almost always treated by surgical removal of the affected bowel segment and then joining the healthy bowel segments (choice E). A GI motility disorder might improve on its own due to the ability of the enteric nervous system in healthy GI tract portions to learn new motility patterns. However, it takes a very long time and the success is not certain.

62. **(B)** By definition, arterial pulse pressure is the difference between peak systolic and minimum diastolic pressure. His resting pulse pressure was $105 - 75 = 30$ and his exercise pulse pressure increased to $140 - 65 = 75$.

63. **(B)** True mean arterial pressure cannot be determined without a pressure transducer, which averages the systolic and diastolic pressures throughout the cardiac cycle. However, mean arterial pressure can be estimated by adding one-third of pulse pressure to the minimum diastolic pressure. At rest his mean pressure is $30/3 + 75 = 85$; during exercise mean pressure
is 75/3 + 65 = 90. Hence, estimated mean pressure increased by 5 mm Hg.

64. (B) The vast majority of metabolic acid excretion is in the form of the volatile acid carbon dioxide which is removed via the lungs. Much smaller quantities of nonvolatile acids must be excreted in the urine. Titratable acids, such as phosphoric acid (choice E), make up a large fraction of the acids normally excreted in the urine. When stored fats are metabolized in large quantities, such as in diabetes mellitus, keto acids such as acetoacetic acid (choice C) make up a larger portion of the renal excreted titratable acids. Likewise, when the ischemic tissues pursue anaerobic metabolism, lactic acid (choice D) makes up a larger portion of the renal excreted titratable acids. Ammonia (choice A) is not a titratable acid, but it provides a mechanism for the kidney to excrete large amounts of acid during chronic metabolic acidosis.

65. (D) A negative free-water clearance occurs when the kidney is reabsorbing more water than it is excreting into the urine and is regulated by ADH. Choice D is correct because lung cancer can cause exogenous production of ADH, which will stimulate increased renal water reabsorption and thus a negative free-water clearance. Choice A is incorrect because the decreased ADH secretion that may occur following a severe head injury will result in a positive free-water clearance. Choice B is incorrect because rapid intake of 2 L of water will inhibit ADH secretion and thus trigger a positive free-water clearance. Choice C is incorrect because the insensitivity to ADH that occurs during lithium treatment will increase water excretion and thus cause a positive free-water clearance. Choice E is incorrect because a person with neurogenic diabetes insipidus has a reduced secretion of ADH, which will cause reduced renal water reabsorption and thus a positive free-water clearance.

66. (D) The symptoms are consistent with acromegaly. It is a rare disease resulting from chronic exposure to growth hormone in adulthood and presents with elevated serum growth hormone levels and elevated serum IGF-1 levels. One treatment option for acromegaly is medication with somatostatin-analogues. These synthetic forms have a longer half-life than the normal polypeptide hormone, which is also called somatotropin release inhibiting factor (SRIF). Growth hormone (choice B), growth hormone-stimulating factors such as GHRH (choice A), and thyroid hormones (choice E) are incorrect treatments. Insulin (choice C) increases bone formation and the calcium content of bone and is therefore not part of the treatment. This can easily be remembered since insulin-like growth factor 1 (IGF-1) is an important stimulator of childhood growth.

67. (D) The described symptoms are typical for hypothyroidism. A primary thyroid gland deficiency leads to low T4 levels and high TSH levels. The most common cause of thyroid gland failure is called autoimmune thyroiditis or Hashimoto thyroiditis. It develops slowly due to persistent inflammation of the thyroid caused by the patient’s own immune system. Middle-aged women are most commonly affected. The measurement of elevated TSH levels in blood is of high diagnostic value, since it helps determine even minor degrees of hypothyroidism. Correct diagnosis is critical because treatment usually continues for life, and stopping of the treatment and reevaluating the original diagnosis is often difficult. Opposite to hypothyroidism, hyperthyroidism (choices A, B, and C) presents with symptoms such as weight loss, warm moist skin, nervousness, and trembling hands. Secondary hypothyroidism (choice E) is caused by reduced TSH levels due to hypothalamic or pituitary insufficiency.

68. (C) Destruction of lung tissue is a hallmark of emphysema. Due to this loss of elastic tissue, lung elastic recoil is decreased. Decreased elastic recoil (not increased, choice E) shifts the mechanical balance point between chest wall and lung to a higher volume—FRC is, therefore, increased. The barrel chest is characteristic of emphysema. Destruction of alveolar walls impairs gas exchange, causing an increase in physiological dead space (choice A). Tissue loss also causes a loss of radial traction with an
increase in airway resistance—FVC is decreased (choice D). Emphysema is one type of chronic obstructive pulmonary disease. A decrease in the FEV₁/FVC is characteristic of an obstructive disease (choice B).

69. (C) Chlorpromazine is an antipsychotic drug with anticholinergic action (i.e., it inhibits the effects of parasympathetic stimulation). Parasympathetic stimulation causes copious secretion by nasal, lacrimal, and parotid glands. Consequently, parasympathetic blockade is leading to a dry mouth. Parasympathetic fibers slow the heart rate and anticholinergic drugs cause tachycardia rather than bradycardia (choice A). Functions of the parasympathetic nervous system include decreasing GI sphincter tone, increasing GI motility, and increasing emptying of the rectum and urinary bladder. Parasympathetic blockade would thus cause increased GI sphincter tone (choice B), urinary retention (choice D), and decreased GI motility (choice E) leading to constipation.

70. (D) In fever, cytokines act to increase prostaglandin levels in the hypothalamus. By an undefined mechanism, prostaglandins increase the hypothalamic set point temperature. The body’s heat-generating mechanisms are activated to increase core body temperature until it approaches the new set point. Core temperature will approach but not exceed the set point temperature (choice B). Sweating lowers core temperature (choice E). Though bacterial toxins can be important in the etiology of fever, they do not act directly to increase muscle heat production (choice A). Leukocytes generate cytokines, which act centrally to influence the hypothalamus (choice C). The cellular activity that is most important in heat generation is muscle contraction.

71. (A) Tension generation depends on attachment of the myosin head group to actin, this is referred to as cross bridge formation. The amount of tension that can be generated in response to a stimulus depends, in part, on the number of cross bridge attachments that can be formed. Since myosin molecules form the thick filament and actin comprises the thin filament, as overlap between thick and thin filaments increases more myosin head groups can bind to actin and more cross bridges can form. Because of this, active tension generation depends on the extent of overlap of thick and thin filaments. Because skeletal muscle is quite compliant, very little passive tension is encountered until the muscle is stretched almost to its maximal length (choice C). During contraction neither the thick nor the thin filaments shortens (choice B). Contraction occurs as thick and thin filaments slide past each other. Velocity of shortening decreases with increasing load (choice E). In skeletal muscle, thin filaments attach to the Z line (choice D).

72. (C) Foreign agents react with pulmonary irritant receptors, which participate in the cough reflex. Carotid body and central chemoreceptors (choices A and B) supply sensory information on arterial blood gas (O₂ and CO₂) composition and thus modulate respiratory rate. Stretch receptors in the lung (choice D) provide afferent information on the depth of breathing and can also influence respiration. Information from peripheral muscle spindles (choice E) can also modulate ventilation and is probably very important in setting the level of increased ventilation seen in moderate physical activity.

73. (E) At high elevation the decreased atmospheric pressure means that there is less available O₂. Decreased arterial PO₂ is sensed by peripheral chemoreceptors with a resultant increase in ventilation. Hyperventilation helps to bring alveolar and thus arterial O₂ levels back toward normal. In hypoxic conditions, erythrocyte 2,3-DPG levels (choice D) increase. This causes the oxygen-hemoglobin dissociation curve to shift to the right—thereby delivering a greater fraction of hemoglobin bound O₂ to the tissues. At high elevation EPO levels (choice C) increase because the kidneys sense low-tissue oxygenation and respond by releasing EPO into the circulation. This hormone stimulates erythrocyte production thereby increasing total blood hemoglobin levels, helping to offset the hypoxia. In low-O₂ conditions slight bronchoconstriction (choice A) can occur.
This is an adaptive response to hypoxia, since it will decrease dead space volume. With decreased dead space volume, a greater fraction of each breath contributes to alveolar ventilation, with more $O_2$ delivered to the system. In hypoxic conditions cardiac output (choice B) increases to deliver more blood.

74. (E) During exercise in the heat, blood flow must increase to the actively contracting muscles, as well as the cutaneous vessels to shunt heat from the interior of the body to the skin at the surface of the body. Activation of sweat glands allows cooling via evaporation from the surface of the skin. To increase blood flow to the muscles and the skin, it is necessary to increase sympathetic tone to the heart to increase cardiac output. Most sweat glands are activated by sympathetic cholinergic nerves that are activated during sweating. However, the cutaneous vasculature involved in bringing warm blood to the surface of the skin for cooling is constricted by a strong sympathetic tone at rest. During exercise, when body cooling is necessary, sympathetic tone to these cutaneous capillary loops is reduced, causing vasodilation and increased cutaneous blood flow, thus choice E is appropriate.

75. (D) The picture, representing the back of the retina as seen through the ophthalmoscope, shows a normal optic disk, a normal macula lutea, and no obvious neovascularization. On the other hand, there are dot hemorrhages as well as one flame-shape hemorrhage site present in the peripheral retina. This indicates an early stage of diabetic retinopathy, known as background retinopathy, in which microaneurysms occur due to damage of existing blood vessels. Since the damage occurred in the peripheral retina, rod vision, also called scotopic vision, is affected. There is no obvious damage yet in the macula lutea and the fovea centralis. At these places, cones are found in the greatest number. Since cones are responsible for color vision, choice A is incorrect. Since the fovea centralis is the place for high acuity vision, choice B is incorrect. Changes in near point vision (choice C) indicate an error in the refractive power of the eye which is associated with abnormalities at the cornea, the lens, or the geometry of the eyeball. Spatial vision (choice E) refers to the ability to discriminate between spatially defined features. It is mainly determined by visual neuronal networks that enhance visual acuity and contrast, which are both associated with photopic vision.

76. (E) The central points of this question concern the definitions of hematocrit and anemia. Hematocrit is the proportion of blood that is packed cells. The hematocrit reading will be decreased by anything that lowers the number of cells, as well as by anything that increases the volume of plasma. Anemia refers to a condition in which the total circulating erythrocyte mass has decreased. In this student, a long-term regime of exercise in a warm environment has chronically increased her plasma volume, hence her hematocrit is low. However, since her total red blood cell mass is normal, there is no anemia. Choice E is correct. It is common to see a chronic increase in plasma volume develop in response to long-term exercise in a warm environment. Exercising in a warm environment places demands on the circulatory system, which must perfuse working muscles as well as skin capillary beds (to facilitate heat loss). In addition, volume is lost to sweating. Increased plasma volume helps the body meet these demands. In choice A, hematocrit could be low if erythrocyte mass decreased more than blood volume. However, this profile does not fit the question because this individual would be anemic, since erythrocyte mass is low. Choice B could not be correct since decreased plasma volume and increased red cell mass cause increased hematocrit. In choice C, the patient would not be anemic and hematocrit would be increased. However, this is not the best response since, as described above, in an individual exercising in a warm environment the hematocrit is often decreased and plasma volume is usually increased. In choice D, hematocrit would have to be increased.

77. (C) Blood passes through the aortic valve, starting when the aortic valve opens at point C until it closes at point D. Hence aortic valve stenosis
will cause turbulent blood flow (murmur) between C and D. Between A and B (choice A) is the interval of diastolic filling when the aortic valve is closed. Between B and C is the period of isovolumetric contraction (choice B) before the aortic valve opens. Between D and A is the period of isovolumetric relaxation (choice D) after the aortic valve closes. Between D and B the aortic valve is also closed.

78. (A) These red blood cells are large (macrocytic) but have a normal hemoglobin concentration (normal MCH). Since MCH is mean hemoglobin content per red cell, this value must be elevated since the cells are large and the concentration in the cell is normal. Choice A excludes choices B–D.

79. (C) In clinical trials, a class of drugs, the aminopyridines, that blocks certain potassium channels has shown some promise for symptomatic relief of the symptoms of multiple sclerosis. The neuronal action potential is terminated by sodium channel inactivation and potassium channel activation. A drug that blocks potassium channels would thus prolong the action potential. Activating potassium channels (choice A) or increasing sodium channel inactivation (choice E) would shorten the action potential. Blocking sodium channels (choice D) would either shorten the action potential or block it altogether. Since calcium channels are not involved in the neuronal action potential, calcium channel blockade would not be expected to have much effect (choice B).

80. (B) EPO is a glycoprotein produced primarily in the kidney, thus EPO levels tend to be depressed in chronic renal failure. EPO is a growth factor that stimulates the production of red blood cells. Its production by the kidney is triggered by low tissue oxygenation. Any condition that decreases the oxygen-carrying capacity of the blood (such as anemia, choice D) or that causes hypoxia by decreasing lung function (such as emphysema or pulmonary fibrosis, choices C and E) will produce elevated levels of circulating EPO. Alkalosis (choice A) increases hemoglobin’s affinity for oxygen, making it more difficult for tissues to extract oxygen from the blood. In alkalosis, tissues thus tend to have lower oxygen content, with a resultant increase in circulating EPO levels.

81. (C) Compliance of the lung is the change in lung volume divided by the change in airway pressure (ΔV/ΔP). This patient’s lungs have a compliance of 4 L/10 cm H₂O = 400 mL/cm H₂O. Lung elasticity (choices A and B) is the inverse of compliance, and this patient’s lungs have an elasticity of 1.25 cm H₂O/L.

82. (B) Normal lung compliance is about 0.2 L/cm H₂O and this patient’s lung compliance is significantly higher than normal. High lung compliance occurs in α₁-antitrypsin deficiency. Acute obstruction of the glottis (choice A) does not affect lung compliance. Asbestosis (choice C), sarcoidosis (choice E), and idiopathic pulmonary fibrosis (choice D) are diseases that show a restrictive pattern and would have a compliance less than normal (< 0.2 L/cm H₂O).

83. (D) At the neuromuscular junction, an invading action potential opens voltage-gated calcium channels and Ca²⁺ enters the presynaptic terminal. Elevated cytoplasmic Ca²⁺ causes release of vesicles containing acetylcholine. Acetylcholine diffuses across the cleft and activates postsynaptic acetylcholine receptors with a resultant depolarization (the EPP). Lack of presynaptic calcium channels in LEMS means that less Ca²⁺ enters the terminal of the presynaptic membrane—therefore less transmitter is released and the size of the EPP is decreased. Postsynaptic properties, neither action potential threshold nor size are altered due to the deficit of presynaptic calcium channels in LEMS (choices A and B). The MEPP is due to spontaneous transmitter release. The amplitude depends on the amount of transmitter in each vesicle. Lack of presynaptic calcium channels will not affect the size of the MEPP, since each vesicle still has the same amount of transmitter (choice C). Quantal content is the amount of transmitter per vesicle which, as described above, will not be altered in LEMS (choice E).

84. (E) Although the early maturation of an ovarian follicle depends on the presence of FSH,
ovulation is induced by a surge of LH. Although estrogens (choices A and B) usually have a negative feedback effect on LH and FSH secretion, the LH surge seems to be a response to elevated estrogen levels. In concert with FSH, LH induces rapid follicular swelling. LH also acts directly on the granulosa cells, causing them to decrease estrogen production, as well as initiating production of small amounts of progesterone. These changes lead to ovulation. FSH (choice C) causes follicle maturation, and is also required for Sertoli cells to mediate the development of spermatids into mature sperm cells. Inhibin (choice D) is a polypeptide secreted by the testes and ovaries that inhibits FSH secretion.

85. (A) Atrial fibrillation is a continuous, chaotic reentry of electrical impulses within the atrial myocardium that arises in a diseased or stretched left atrium. The chaotic patterns of atrial excitation prevent P-waves from being seen in the electrocardiogram. The ventricular response is rapid and irregular. In all the other alternatives (choices B–E), a P-wave should be distinguishable in some part of the electrocardiogram, although not necessary in a constant relationship to the QRS complex.

86. (A) Stenosis of the outlet valve of the left ventricle greatly increases the work of the ventricle in ejecting blood and will result in left ventricular hypertrophy. Mitral valve stenosis (choice B) will impede filling of the left ventricle and will not cause left ventricular hypertrophy. Tricuspid valve regurgitation (choice D), pulmonary valve regurgitation (choice C), and tricuspid valve stenosis (choice E) cause congestion of the right atria and/or right ventricles and impede flow of blood toward the left ventricle and thus will not result in left ventricular hypertrophy.

87. (D) Peptic ulcers refer to areas of the stomach or duodenal lining which became eroded by stomach acid. Stomach acid is produced by parietal cells which are stimulated by gastrin. Since gastrin-secreting G cells are primarily found in the gastric glands of the distal stomach (gastric antrum), the surgically removed stomach portion, the patient’s prevalence for peptic ulcer disease is lower after the surgery, and not unchanged as stated in choice E. However, the surgery is a dramatic event and increases the risk for many GI problems, including symptoms resulting from nutritional deficiencies. Hence, the surgery is only used for morbidly obese people (the patient’s body mass index is above 50), who had no success with diet and medication. Inflammation potentially triggered by the surgical staples (choice A) might trigger prostaglandin release which has a protective function of the stomach lining. Although secretin (choice B) is known to suppress gastric acid release by inhibiting gastrin release, the lower number of G cells after surgery does not make this a good choice. Chief cells (choice C) are primarily present in the proximal stomach, the portion that remains after surgery.

88. (A) The RTA refers to related conditions that are disorders of urine acidification even though other renal functions are not impaired. In type 4 RTA, distal nephron dysfunction is due to either inadequate aldosterone production or aldosterone resistance resulting from intrinsic renal disease. Thus, patients develop hyperchloremic acidosis with hyperkalemia, due to impaired distal tubular secretion of both potassium and hydrogen ions. Treatment of patients is directed at controlling serum potassium. Choices B, C, D, and E are inconsistent with the known actions of aldosterone.

89. (A) Acute dehydration results in decreased plasma volume, cardiac output, and arterial pressure, which leads to a lower firing rate of the baroreceptors. Plasma osmolarity increases (choice B) because more water than salt is lost in sweat. The increase in plasma osmolarity leads to increased ADH secretion (choice D). High plasma ADH levels cause increased water permeability of collecting duct cells (choice E). Therefore, more water is reabsorbed by the kidneys and renal water excretion is low (choice C).

90. (A) The hallmark of poorly controlled diabetes mellitus is elevated blood glucose, which causes unphysiological glycosylation of proteins. An
important long-term measure of blood glucose control in patients with diabetes mellitus is to monitor the modification of hemoglobin A to form glycated hemoglobins. HbA1c is the major subfraction, and determination of HbA1c is usually achieved by ion-exchange or gel electrophoresis. The level of glycated hemoglobins in the blood is directly related to the average blood glucose levels over the life span of the hemoglobin in the circulation. Since the half-life of red blood cells is about 120 days, a single determination of glycated hemoglobin reflects the average blood glucose level during the preceding 8–12 weeks. Lipoprotein (a) (choice B) is a lipoprotein particle implicated in atherosclerosis and thrombosis. Albumin (choice C) is the most abundant plasma protein, but is not significantly affected by glycosylation. Myoinositol (choice D) is a signaling molecule the decrease in response of which to elevated sorbitol has been suggested as a complication of diabetes. Sorbitol (choice E) is another sugar derivative, unrelated to HbA1c that is believed important in causing other diabetic complications such as cataracts and peripheral neuropathy.

91. (B) Respiratory alkalosis is due to hyperventilation, which lowers CO2. Decreasing tidal volume will reduce alveolar ventilation and correct the respiratory alkalosis. Assuming a dead space of 150 mL, alveolar ventilation in this patient is 450 mL × 12/min = 5400 mL/min. If the tidal volume were decreased from 600 to 300 mL and the frequency increased from 12 to 24 per minute, then the alveolar ventilation would decrease to 150 × 24/min = 3600 mL/min even though the minute ventilation (12 × 600 mL/min = 24 × 300 mL/min) remains unchanged. The fraction of O2 (choice D) in the respiratory air does not affect respiratory volumes or frequencies in a mechanically ventilated patient. Increasing minute ventilation (choice C) or decreasing dead space (choice A) would increase alveolar ventilation and worsen respiratory alkalosis. PEEP (choice E) is positive pressure applied during the expiratory phase to prevent the collapse of alveoli and to increase FRC of the lungs. It is used primarily to improve arterial oxygenation in severely hypoxic patients.

92. (E) This patient has increased extra- and intracellular volumes and a decreased osmolarity. SIADH results in inappropriately low water permeability of the renal collecting duct tubular cells and inappropriate water retention. As a result, patients with SIADH often present with hypotonic overhydration. Adrenal insufficiency (lack of aldosterone) (choice A) and chronic vomiting (choice B) lead to dehydration. Fluid overload with isotonic NaCl (choice C) results in volume expansion without change in osmolarity. Fluid overload with hypertonic solution (choice D) results in volume expansion with increased osmolarity.

93. (D) This problem addresses two issues: (1) the mechanism of action of inhibitory neurotransmitters and (2) the relationship of equilibrium potential and membrane potential. First, an inhibitory neurotransmitter acts by increasing conductance of an ion the equilibrium potential of which is either equal to or more negative than the cell resting membrane potential. If the equilibrium potential of the ion is more negative than the resting membrane potential, increasing the conductance of that ion will hyperpolarize the membrane—will generate an inhibitory postsynaptic potential (IPSP). Second, if the equilibrium potential of the ion is equal to resting membrane potential, increasing the conductance of that ion will “clamp” the membrane potential more tightly at its resting level—this will make the cell less excitable. In this problem, the membrane potential must equal −80 mV (D). If, and only if, the resting membrane potential equals the equilibrium potential for an ion, will an increase in the conductance to that ion not cause a change in membrane potential.

94. (D) A light spot exclusively hitting the center would be perceived as deep red. Some of the light hits the inhibitory surround area. In this area, light is processed coming from cones that are best excited by green light (middle wavelength) and inhibited by red light (long wavelength). In the Figure 2-20 the on-response dominates the off-response so that the perceived light is different from deep red, but not green (choice B). At the retina ganglion level,
the trichromate signals from the cones are transferred into the neuronal stage of color processing, the opponent color stage. The cone photoreceptors are linked together to form opposing color pairs, in this case red versus green. Activation of one member of the pair inhibits the activity in the other so that a color pair cannot be seen at the same location. We cannot experience reddish green (choice E). Physiological color image formation differs from the physical process of coloring a piece of paper with a red and green pencil (choice A), one on top of the other, called subtractive color mixture. It starts with the presence of all colors of light and then dyes subtract some of the reflected light so that adding more dyes results in a darker image such as brown. For physiological color mixing, the presence of all colors is perceived as white, the absence as black (choice C).

95. (C) Creatinine clearance is independent of plasma creatinine concentration; otherwise, creatinine would not be a useful measure of GFR. Clearance is defined as the amount of plasma that delivered the excreted substance, and for a substance that is neither actively secreted nor reabsorbed by the kidneys; its clearance equals the amount of plasma filtered through the glomerular membrane. All creatinine contained in that amount of plasma is excreted by the kidney, no matter what the concentration of creatinine in that plasma volume was. Because in the normal person a small amount of creatinine is secreted by the renal tubules, clearance at low plasma concentrations is slightly higher than at elevated plasma concentration (slight initial upward bend of curve). Curve A describes the relationship between creatinine plasma concentration and renal excretion of creatinine. Note that excretion and clearance are not synonymous. Curves B and D describe the clearance of a substance that is secreted and filtered, or filtered and reabsorbed, respectively. At large plasma concentration, the active transporters become saturated and the clearance of these substances approaches the creatinine clearance. Curve E depicts an improbable event with relatively increased clearance at both low and high concentrations of a substance, although there is an independent linear clearance at intermediate substance concentrations.

96. (C) Microcytic anemia can often be associated with defective hemoglobin synthesis. In the case of iron deficiency, heme synthesis is impaired due to the lack of iron. Acute bleeding (choice A) is normally associated with erythrocytes of normal size, since the anemia is due to simple loss of blood, with plasma expansion to maintain total volume. Both vitamin B₁₂ and folate (choices B and D) are required for DNA synthesis. Due to the extremely active cell division required to sustain the erythrocyte pool, impaired DNA synthesis first normally manifests as a lack of erythrocyte production. Anemia due to vitamin B₁₂ or folate deficiency is macrocytic. Vitamin K (choice E) is required for synthesis of several clotting factors. Lack of vitamin K often presents as a problem with coagulation.

97. (B) Lipid is the most concentrated form of energy storage, holding 9.4 kcal/g. For a typical 70 kg human over 130,000 kcal is typically stored as fat. Storage of energy as available protein (choice D) is about 20,000 kcal, while storage as carbohydrate (choice A) is about 3,000 kcal. Though blood glucose (choice C) is critically important, in particular as a source of energy for the brain, blood glucose does not provide a significant fraction of total body energy storage. While total body energy stores typically exceed 150,000 kcal, resting metabolic rate (depending on age and body mass) is about 2100 kcal/day (choice E).

98. (B) The dorsal column-medial lemniscus (DC/ML) system is the sensory pathway that transmits conscious proprioceptive information with fine gradations such as a fine touch on the index finger to the cerebral cortex. The brain interprets any signals coming along the “labeled lines,” the nerves that carry messages from the sensory organ to the cortex, as being information about a particular sense. Hence, activation of certain neurons in the somatic sensory system can cause a sensation as if it originated from mechanical pressure on the finger (choice E). Thermal sensations (choice A), tingling (choice C),
and crude undetermined pain (choice D) are sensory modalities that are processed in the spinothalamic or anterolateral system.

99. (B) After a meal about 90 percent of the bile acids and bile salts are absorbed from the lower ileum by way of active transport. They are directed to the liver, from where they can be released again via bile into the intestine. This enterohepatic circulation of bile acids between intestine and liver is physiologically very important for normal absorption of fat and fat-soluble vitamins, and if distorted, will lead to GI and other symptoms. The quantity of iron in the body (choice A) is maintained by controlled absorption from the duodenum, not the ileum. Although sodium (choice C) is actively absorbed in the ileum, there are additional absorption mechanisms available in the jejunum and in the colon. For instance, in the jejunum, sodium is absorbed by cotransport coupled with sugars and neutral amino acids, and in the colon, there are active sodium transport mechanisms as well. Hence, no immediate sodium imbalance is expected. Although vitamin B₁₂ (choice D), complexed with intrinsic factor, binds to a transmembrane receptor in the ileum for absorption, a large amount of vitamin B₁₂ (up to 5 mg) is stored in the liver. This liver storage is thought to be sufficient for 3–6 years so that symptoms from vitamin B₁₂ deficiency will be expected at a later time, but not soon after removal of the ileum. Protein digestion (choice E) occurs in the small intestine, with absorption of amino acids primarily in the jejunum and to a lesser extent in the ileum, and with dipeptide absorption at about equal rates in these two segments. Removal of the ileum will not immediately lead to problems due to protein malabsorption.

100. (A) Parietal cells secrete an essentially isotonic solution of pure HCl containing 150 mM Cl⁻ and 150 mM H⁺ into the gastric lumen. This is achieved by active transport of H⁺ (Y) via H⁺/K⁺-ATPase in the apical membrane that exchanges H⁺ for K⁺ (Z). Chloride ions (X) are extruded passively down their electrical gradient through Cl⁻-selective ion channels. They enter the cell via Cl⁻/HCO₃⁻ exchange that takes place at the basolateral membrane. The HCO₃⁻ comes from H₂CO₃ (the product of carbonic anhydrase). None of the other choices (B–E) reflect the correct ion distribution across the gastric parietal cell.

101. (B) Most patients with primary aldosteronism (Conn syndrome) have an adrenal adenoma. The increased plasma aldosterone concentration leads to increased renal Na⁺ reabsorption, which results in plasma volume expansion. The increase in plasma volume suppresses renin release from the juxtaglomerular apparatus and these patients usually have low plasma renin levels. Secondary aldosteronism is due to elevated renin levels and may be caused by heat failure (choice A) or renal artery stenosis (choice C). Salt restriction (choice D) and upright posture (choice E) decrease renal perfusion pressure and therefore increase renin release from the juxtaglomerular apparatus.

102. (C) Increase in the conductance of an ion, the equilibrium potential of which is negative with respect to the cell’s resting membrane potential, will cause the membrane potential to hyperpolarize (to become more negative). Increased K⁺ permeability would thus cause hyperpolarization, since its equilibrium potential is negative with respect to the cell’s resting membrane potential. Increased Ca²⁺, Na⁺, or Mg²⁺ permeability (choices A, D, and E) would cause the cell membrane potential to depolarize. Increased Cl⁻ permeability (choice B) would not alter the membrane’s potential.

103. (C) The neuron, at the arrow, is in the refractory period following the action potential. The membrane potential is more negative (hyperpolarized) than its normal resting level because potassium conductance is elevated. The after hyperpolarization is also due to the fact that sodium channels are inactivated causing lower than normal sodium conductance (choice D). In skeletal muscle neither calcium (choice A) nor chloride (choice B) conductances should be elevated. After the action potential, intracellular sodium concentration could be slightly elevated due to the sodium influx that occurred.
during the action potential. This could stimulate the Na, K-ATPase (choice E).

104. (B) Thrombin is a critical enzyme in the coagulation cascade. It not only can activate factors VIII and V, it also acts on fibrinogen to form fibrin. Thrombin is essential for clot formation. Antithrombin III modulates the coagulation cascade, serving to inhibit thrombin activity. Heparin acts as an anticoagulant because it accelerates the action of antithrombin III. Heparin does not stimulate vitamin K activity (choice E) and, in any case, anything that promoted vitamin K activity would increase coaguability, since vitamin K is necessary for synthesis of multiple coagulation factors. Activation of prothrombin (choice A) promotes coagulation. Though calcium is an essential cofactor for coagulation, heparin does not act via calcium inhibition (choice D). Because heparin inhibits thrombin action, it would prolong prothrombin time (choice C).

105. (E) Choice E is correct since the clearance of potassium is normally regulated by the action of aldosterone on the distal tubule exchange of sodium reabsorption with potassium secretion. Choice A is incorrect because renal clearance represents the volume of plasma completely cleared of a substance per unit time, hence the units for renal clearance are milliliter per minute, and not milligram per minute. Choice B is incorrect because a normal kidney reabsorbs 100% of the filtered glucose, so glucose clearance is zero. By contrast, a significant amount of inulin is usually cleared by the kidney. Choice C is incorrect because although inulin is not secreted by the tubule as is PAH, inulin is filtered but not reabsorbed and thus a normal kidney will clear approximately 20% of the inulin from the plasma. Choice D is incorrect because PAH is actively secreted by the proximal tubule. Above a certain plasma level, PAH secretion no longer can increase and thus clearance (calculated as the ratio of urine to plasma concentration multiplied by urine flow) will decline as plasma PAH concentration increases faster than urine PAH concentration.

106. (C) For about 20–30 seconds after the rotation stops, the endolymph of the vestibular system continues to rotate due to its inertia. The brain still receives the input of rotation, while the input from the person’s eyes and mechanoreceptors signal that the motion stopped. This conflicting information causes dizziness which would disappear if the person continue rotating. The eyes of a healthy person would be “flicking” in the direction opposite to the direction of rotation, so that nystagmus would be to the left, not to the right (choice B). If the person attempts to reach out and touch a target during the postrotatory nystagmus, the movement will miss the target in the direction of the slow phase of nystagmus, to the right in this case, not to the left (choice D). An attempt to walk during the period of nystagmus and vertigo induced by ceasing rotation often leads to a fall, in this case to the right, not to the left (choice E). The compensatory movements to the right are due to the fact that the brain interprets the continuing rotation of the endolymph in relation to the now unmoving outer walls of the vestibular organs as if a rotation to the left has begun. This incorrect input signal is processed by the brain to influence eyes, trunk, and limb muscles to exert compensatory actions. The responses are entirely normal and their absence could indicate dysfunction of the peripheral or central vestibular system (choice A).

107. (D) Glucose excretion by the kidneys depends on the glomerular filtration and tubular reabsorption rates. Glucose first appears in the urine, when the capacity of the glucose transporters in the proximal tubuli cells is exceeded. This usually occurs at plasma glucose levels higher than 180 mg/dL. Patients with longstanding diabetes mellitus often have decreased renal function and reduced GFR. Under these circumstances the threshold (i.e., plasma level) for excretion of glucose is higher than in a healthy person. Urine dipsticks nowadays are both sensitive and specific for glucose, detecting as little as 100 mg/dL (choice A). Earlier dipstick tests were sensitive but not specific (they detected other reducing sugars in addition to glucose). A defect in glucose transporters (choice B) results in glucosuria even at normal plasma glucose concentration. Patients
with diabetes insipidus (choice C) have a large urine output due to absence of ADH or defective renal ADH receptors, but should not have a plasma glucose level of 200 mg/dL. Antidiuresis (choice E) increases the concentration of solutes in the urine and increases the sensitivity to detect urine glucose. Reabsorption of filtered glucose occurs in the proximal tubule by active transport.

108. (D) The principal cell is the major sodium-reabsorbing and potassium-secreting cell in the collecting duct. It functions via specific sodium and potassium channels that increase luminal cell membrane permeability to these ions and a sodium/potassium ATPase in the basolateral cell membrane. Choice A is incorrect because the specific movement of sodium through the luminal membrane via specific sodium channels creates an excess of negative charges in the tubular lumen. Choice B is incorrect because sodium is reabsorbed while potassium is predominantly secreted by this cell. Choice C is incorrect because aldosterone regulates sodium and potassium transport, not water transport. ADH does increase water transport via aquaporins. Choice E is incorrect because a sodium/potassium/2 chloride transporter is not located in this cell type, but is located in the thick ascending loop of Henle cells instead.

109. (C) Glucagon and catecholamines such as epinephrine stimulate the mobilization of glycogen by triggering the cAMP cascade. Hormones that increase liver cell cAMP promote glycogen breakdown, and hormones that decrease liver cell cAMP promote glycogen synthesis. Cortisol, the main glucocorticoid, regulates the metabolism of proteins, fats, and carbohydrates. It acts on most organs catabolically. However, on the liver it has anabolic effects, increasing glycogen synthesis and accumulation in the liver. Choices A, B, D, and E do not correctly reflect the effects of the three different agents on glycogen metabolism.

110. (E) Tolerance is commonly observed with many pharmacologic agents, including opioids. Difficulty sleeping (choice A), hypermotility of the GI tract (choice B), and respiratory alkalosis (choice D) are opposite to the expected effect of opiates. The placebo effect (choice C) is, at least in part, likely due to the release of endogenous opioid peptides in anticipation of pain relief, but is not a complication or side effect of therapy.

111. (C) During resting conditions, approximately 15% of the cardiac output goes to the brain, 15% to the muscles, 30% to the GI tract, and 20% to the kidneys. However, when normalized by organ weight, the kidneys receive the largest specific blood flow (400 mL/100 g) at rest and are particularly vulnerable during hemorrhagic shock. The brain (choice A) also receives relatively high specific blood flow (50 mL/100 g). Heart muscle (choice B), not surprisingly, also has a relatively high resting specific blood flow (60 mL/100 g), which may increase fivefold during exercise. Skeletal muscles (choice D) have low specific blood flow (2–3 mL/100 g) at rest, which may increase up to 20-fold during strenuous exercise. Blood flow through the skin (choice E) varies between 1 and 100 mL/100 g and serves temperature regulation.

112. (D) The receptive relaxation reflex is a feature of the orad stomach, composed of the fundus and upper stomach body. Without food, the orad stomach shows low frequency, sustained contractions that are responsible for generating a basal pressure within the stomach. When food enters the stomach, a reflex is initiated, which allows gastric accommodation of large increases in volume with only small increases in intragastric pressure. The tonic contractions of the orad stomach also contribute to some extent to gastric emptying (choice B), since they generate a pressure gradient from the stomach to the intestine. However, neural and hormonal components play a more important role in regulating gastric emptying, which makes this not the best choice. Since the lower stomach is not affected by the surgery, characteristic motility patterns of the distal stomach remain (choice A). Features of the distal stomach include strong peristaltic waves of contractions, which cause the mixing of the chyme with digestive secretions (choice C), the grinding of the particles to a small size, and the propulsion through the gastroduodenal junction (choice E). All these...
motility patterns would still be a feature of the remaining stomach.

113. (D) Increasing the lifetime of acetylcholine by inhibiting its enzymatic breakdown might help existing brain cells to work better. Studies found that Alzheimer patients at early stages might benefit from cholinergic therapy by small improvements in cognitive abilities and a delay in the progression of the disease. However, the side effects of acetylcholine therapy may outweigh the benefits of it. The increased concentration of acetylcholine at postsynaptic nerve endings of the parasympathetic nervous system can result in excessive stimulation of peripheral organ muscarinic and nicotinic receptors. Increased GI motility may occur resulting in nausea and diarrhea. For the same reason, increased salivation, not decreased as in choice A, and increased micturition, and not decreased as in choice B, are expected. Less common side effects include muscle cramps, not muscle weakness as in choice C, due to overstimulation of the cholinergic neuromuscular junction. Acetylcholine overdosing for an extensive time might eventually lead to muscle weakness due to desensitization of postsynaptic acetylcholine receptors, but this is not the best choice in this case. Vertigo (choice E) is the sensation that the room is spinning. Although neurological problems can always lead to kineses, there is no direct connection between acetylcholine esterase inhibitors and vertigo.

114. (D) The proximal tubule reabsorbs the majority (about two-thirds) of filtered salt and water. Both the luminal salt concentration and the luminal osmolality remain constant (and equal to plasma values) along the entire length of the proximal tubule. Water and salt are reabsorbed proportionally because the water is dependent on and coupled with the active reabsorption of Na⁺. The water permeability of the proximal tubule is high, and therefore a significant transepithelial osmotic gradient is not possible. Sodium is actively transported, mainly by basolateral sodium pumps, into the lateral intercellular spaces; water follows. Increased glucose filtration in diabetes will osmotically prevent water reabsorption at this site. The collecting duct (choice A) reabsorbs only a small fraction of filtered Na⁺ and has a variable water permeability (dependent on ADH levels). The glomerulus (choice B) is where solutes are filtered from the plasma, no reabsorption of salt and water occurs here. The juxtaglomerular apparatus (choice C) produces renin. The thick ascending limb of the loop of Henle (choice E) actively transports Na⁺ and Cl⁻ from lumen to the peritubular space using a Na⁺/K⁺/Cl⁻ cotransporter, but is water impermeable so osmotic diuresis will not be produced here.

115. (C) Normally, an elevated plasma osmolarity will stimulate increased ADH secretion and cause increased renal water reabsorption, which should lower the elevated plasma osmolarity. Since in this case ADH is reduced in the face of elevated osmolarity and the kidney is not reabsorbing water, it is clear that neurogenic diabetes insipidus is present (choice C). Choice A is incorrect because congestive heart failure will trigger water retention via the reduced cardiac output and lower arterial pressure, which stimulates ADH release via arterial baroreceptors. Choice B is incorrect because nephrogenic diabetes insipidus results from renal insensitivity to normal, or elevated circulating ADH levels. Choice D is incorrect because primary polydipsia is associated with reduced plasma osmolarity which will suppress ADH release. Choice E is incorrect because diabetes mellitus will be associated with elevated plasma and urine glucose levels.

116. (D) Nitric oxide has important neurotransmitter-like functions. Its short half-life, due to spontaneous decay, limits its range and action. Nitric oxide acts on smooth muscle cells in a generally inhibitory manner; it relaxes the GI muscles and sphincters and dilates blood vessels. In blood vessels, nitric oxide is derived from endothelial cells and has been identified as the long-hypothesized endothelium-derived relaxing factor (EDRF). Acetylcholine (choice A) is the classic neurotransmitter of the parasympathetic nervous system. Although activation of the pelvic parasympathetic nerves leads to erection, it is nitric oxide and not acetylcholine that relaxes penile artery smooth muscle cells.
GABA (choice C) is an inhibitory neurotransmitter found in the central nervous system. Epinephrine (choice B) and norepinephrine (choice E) play a role during the ejaculation phase of the male sexual act, but do not contribute to penile artery dilation during the erectile phase.

117. (B) Cardioactive steroids inhibit the Na, K-ATPase present in the plasma membrane of the cardiac muscle cell. At the therapeutic dosages that are employed, there will be partial ATPase inhibition with decreased active sodium efflux from the myoplasm and a resultant increase in myoplasmic sodium ion concentration. Due to increased intracellular sodium concentration the Na:Ca exchange protein (NCX) can extrude less calcium from the cell and the intracellular concentration of calcium will increase. This increases force, since contractile force depends on calcium. Though calcium influx through N-type calcium channels is also an important source of calcium to regulate contraction, calcium channel activity is not regulated by the cardioactive steroids (choice A). Similarly, neither potassium (choice D) nor sodium (choice E) channels are immediately involved in the mechanism of action of digoxin. PMCA (choice C) acts in cardiac muscle to pump calcium out of the cell, thereby helping to maintain a low myoplasmic [Ca^{2+}]. However, PMCA activity is not directly involved in the mechanism of action of digoxin.

118. (D) The epithelial cells of the early portion of the distal tubule contain a Na^+/Cl^- cotransporter that is inhibited by thiazide diuretics which promote a diuresis and a natriuresis, and which secondarily, promote increased renal reabsorption of filtered calcium. Choices A and B denote the proximal and thin loop of Henle segments, respectively; which do not have the properties of the early distal tubular segment. Likewise, choices C and E denote the thick ascending loop of Henle and the collecting duct, which also do not have the same properties as the early distal tubular segment.

119. (A) Eosinophils normally constitute about 2% of all blood leukocytes. These cells are phagocytic and exhibit chemotaxis. Their primary role is in fighting parasitic infection. In schistosomiasis the eosinophil attaches to the immature parasite and, by releasing various cytotoxic compounds, is able to kill the parasite. Erythrocytes (choice B) are the most numerous blood cells. They are not leukocytes, but function in blood gas transport. Erythrocyte number would not be increased in schistosomiasis. Monocytes (choice C) are leukocytes found in the blood. They are immature cells which mature to the tissues, where they mature into macrophages. These cells are very active in phagocytosis and play a prominent role in the inflammatory response. They are not, however, particularly important in parasitic infections. Neutrophils (choice D) are another type of leukocyte that, though essential to combat bacterial infections, are not particularly sensitive to parasitic challenge. Platelets (choice E) are not leukocytes. The platelet is a cell fragment that functions in hemostasis.

120. (C) A positive Trousseau sign indicates increased neuromuscular irritability, which is caused by low serum calcium levels. A positive Trousseau sign or a positive Chvostek sign (spasms of facial muscles) can often diagnose hypocalcemia before other gross manifestations develop. Serum calcium is regulated by parathyroid hormone produced by the parathyroid glands. During the woman’s accident, the glands, or their vasculature, were most likely damaged enough so that they could not be saved during the total thyroidectomy. If total thyroidectomy occurs as a consequence of thyroid cancer, damage to all four parathyroid glands would be considered an operative mishap. A consequence of hypocalcemia is hyperreflexia and not hyporeflexia (choice A). Calcitonin is secreted by parafollicular or “C” cells in the thyroid gland. Since no other cells of the body make this hormone, serum calcitonin levels do not rise (choice B), but instead go to zero postoperative. Low serum phosphate levels (choice D) typically signify secondary hyperparathyroidism or low dietary phosphate intake. In the current case, high or unchanged serum phosphate would be expected. The Q-T interval of the ECG represents the time for both ventricular depolarization and repolarization.
to occur. It therefore roughly estimates the duration of an average ventricular action potential. Hypocalcemia leads to a long Q-T interval, not a short Q-T as in choice E. In severe cases, this can lead to arrhythmias, hypotension, and heart failure.

121. (D) VIP is a neurotransmitter in the brain and in the parasympathetic nerves of the digestive tract. It also acts as a hormone. VIP has a secretin-like effect on the pancreas. It increases the volume of water and bicarbonate output and affects GI blood flow and motility. All this contributes to severe secretory diarrhea in the case of VIP overproduction. Somatostatin is the best choice because it has a broad range of inhibitory effects, inhibiting GI secretions, slowing GI motility, and reducing splanchnic blood flow. An analogue of somatostatin, called octreotide, was found useful for treatment of syndromes related with VIP overproduction. Octreotide has a longer half-life than physiologic somatostatin. Erythromycin (choice A) is known to have antibiotic features. This is not the best choice, since no pathogens were found. Histamine (choice B) is a physiologic stimulant of gastric hydrochloric acid secretion, potentiating the effects of acetylcholine and gastrin. Motilin (choice C) stimulates gastric motility, which is contraindicated for diarrhea. Trypsin (choice E) is a protease released by pancreatic cells, breaking peptide bonds as well as converting many other proteolytic enzymes to their active form. All of the negative choices will not affect, and in fact may even worsen the VIP-related symptoms.

122. (D) Malignant hyperthermia is caused by a mutation to the calcium release channel of the skeletal muscle sarcoplasmic reticulum (the so-called ryanodine receptor). Increased calcium release into the myoplasm causes strong, sustained skeletal muscle contraction. This causes excessive ATP hydrolysis, increased metabolic activity to replenish ATP levels, heat generation, and carbon dioxide production. Decreased acetylcholine release would decrease muscle contraction (choice A). Myosin light chain kinase is involved in contractile activation in smooth muscle (choice B). Activation of K channels would hyperpolarize muscle fibers and tend to decrease susceptibility to contractile activation (choice C). Inhibition of sodium channels would diminish the ability of skeletal muscle to generate action potentials and thus decrease excitability (choice E).

123. (D) It represents the estrogen estradiol, which is produced from androgen by granulosa cells of the ovaries and released into the capillaries. A woman’s estradiol serum concentration roughly reflects the activities of her ovaries. Estradiol levels rise during the follicular phase of the menstrual cycle (days 0–13). They reach peak levels shortly before ovulation on day 13–14, and drop back during the luteal phase (days 14–28). They reach menstrual/follicular levels at the end of the luteal phase unless there is a pregnancy. After menopause, the ovaries atrophy and estradiol levels become very low. During reproductive cycles, androgens are the main substrate for estrogen synthesis in the granulosa cells. The androgen-estrogen conversion is under the influence of FSH (choice E). FSH concentrations are high after menopause compared to their premenopausal concentrations. The source of androgens is theca cells. They produce it from cholesterol under the influence of LH (choice B). LH concentrations, like FSH, are high postmenopausal. Both, FSH and LH levels are used as a diagnostic tool to determine menopause. Granulosa cells also produce progesterone (choice C) from cholesterol. Progesterone serum levels are low during follicular phase of the menstrual cycle and high during the luteal phase of the menstrual cycle. The transition of cholesterol to progesterone is under the influence of LH (choice A).

124. (D) These choices revolve around the Starling forces that directly regulate glomerular filtration. Choice D is correct and choice C is incorrect because glomerular capillary pressure is regulated by the ratio of upstream (afferent arteriole) and downstream (efferent arteriole) resistance to flow. Dilation of the afferent arteriole (choice C) will increase glomerular capillary pressure and increase filtration, whereas dilation of the efferent arteriole (choice D) will decrease the pressure and thus decrease filtration. Choice A is
incorrect because Bowman’s space pressure normally acts to oppose filtration, hence a decreased pressure will increase filtration. Choice B is incorrect because the osmotic pressure of the plasma proteins opposes filtration, so a decreased plasma protein concentration will predictably increase filtration. Choice E is incorrect, first of all because the juxtaglomerular apparatus does not secrete aldosterone, but instead secretes renin, which ultimately can trigger aldosterone secretion from the adrenal cortex via angiotensin II. Secondly, aldosterone is likely to trigger salt and water retention by an action on the distal nephron of the kidney, which is likely to alter the Starling forces in favor of increased glomerular filtration.

125. (E) SGLT-1 is a sodium-dependent cotransport protein that uses the sodium electrochemical gradient to actively move glucose into the cell. GLUT2 (choice B) does transport glucose, but it is a facilitated diffusion carrier that moves glucose down its concentration gradient. The Na,K-ATPase (choice C) is a primary active transport protein. It uses the energy liberated from ATP hydrolysis to actively transport sodium and potassium. It establishes and maintains the sodium electrochemical gradient. The sodium:calcium countertransport protein (choice D, also termed NCX) uses the sodium electrochemical gradient to move calcium ions out of, not into, the cell. The calcium ATPase (choice A, also termed PMCA) is a primary active transport protein that actively transports calcium out of the cell. Both NCX and PMCA serve to maintain a low intracellular calcium concentration.

126. (C) Among other actions, insulin is known to stimulate the uptake of potassium into cells of the body via stimulation of the Na⁺, K⁺ ATPase. Choices A, B, D, and E, will either have the opposite action, or no effect.

127. (B) Exercise recruits both non-insulin-dependent and insulin-dependent glucose transport proteins to the plasma membrane of active skeletal muscle cells. This effectively increases sensitivity to insulin and the response to ingested glucose is blunted after exercise training. This excludes choice E, which states that no effect can be expected from exercise and choice A (curve 1), which represents a state of lower insulin receptor sensitivity compared to the sedentary state R. Ingestion of glucose will cause an initial rise of blood glucose in both active and sedentary people (excludes choices C and D).
BIBLIOGRAPHY


Questions

1. A deficiency of argininosuccinate synthetase (ASD) can be suspected in a 24–48-hour-old neonate with elevated serum ammonia. To discriminate the fact that the hyperammonemia is indeed due to ASD and not due to a deficiency in other urea cycle enzymes, one can assay for the serum concentration of citrulline and urinary orotic acid concentration. Which of the following would best describe the expected findings?

   (A) Both citrulline and orotate levels will be low.
   (B) Citrulline levels will be absent but orotate will be elevated.
   (C) Citrulline levels will be between 100–300 μM and orotate levels will be elevated.
   (D) Citrulline levels will be >1000 μM, orotate will be near normal.

2. A 7-year-old boy is examined by his pediatrician because of complaints of severe cramping pain in his legs whenever he rides his bike. He also experiences nausea and vomiting during these attacks. The child has noted that the severity of the cramps is most intense after dinners that include baked potatoes or pasta, and sometimes bread. Clinical studies undertaken following a treadmill test demonstrate myoglobinuria, hyperuricemia, and increased serum bilirubin. Which of the following enzyme deficiencies is associated with these clinical findings?

   (A) glucose-6-phosphatase
   (B) glycogen synthase
   (C) liver glycogen debranching enzyme
   (D) muscle phosphofructokinase
   (E) muscle phosphorylase

3. An adult man suffered from stable angina pectoris for 15 years, during which time there was progressive heart failure and repeated pulmonary thromboembolism. On his death at age 63, autopsy disclosed enormous cardiomyopathy (1100 g), cardiac storage of globotriaosylceramide (11 mg lipid/g wet weight), and restricted cardiocytes. Which of the following lipid storage diseases would result in these clinical findings?

   (A) Fabry disease
   (B) Gaucher disease
   (C) Krabbe disease
   (D) Niemann-Pick disease (NPD) type I A
   (E) Tay-Sachs disease

4. An investigational diabetes treatment involving a hypoglycemia-inducing drug has been developed. This drug is designed to inhibit dipeptidylpeptidase IV (DPP IV) activity and has been shown to decrease plasma glucose concentration and pancreatic glucagon secretion. DPP IV hydrolyzes which of the following hormones such that its inhibition results in the observed effects?

   (A) glucagon
   (B) glucagon-like peptide-1 (GLP-1)
   (C) insulin
   (D) insulin-like growth factor-I (IGF-I)
   (E) pancreatic polypeptide
5. A 25-year-old man has experienced chronic blistering and scarring of his skin when exposed to sunlight. This man is a smoker and drinks heavily, both of which exacerbate his responses to sunlight. Analysis of his urine and plasma indicates a high accumulation of complex porphyrins, predominantly uroporphyrin. The symptoms and clinical signs displayed by this patient indicate he is suffering from which of the following disorders?

(A) acute intermittent porphyria (AIP)
(B) hereditary coproporphyria (HCP)
(C) porphyria cutanea tarda (PCT)
(D) variegate porphyria
(E) X-linked sideroblastic anemia

6. A 4-month-old boy presents with painful progressive joint deformity (particularly the ankles, knees, elbows, and wrists), hoarse crying, and granulomatous lesions of the epiglottis and larynx leading to feeding and breathing difficulty. Biopsy of the liver indicates an accumulation of ceramides. The observed symptoms and the results of the liver biopsy are indicative of which disease?

(A) Farber lipogranulomatosis
(B) fucosidosis
(C) Gaucher disease
(D) metachromic leukodystrophy
(E) Sandhoff-Jatzkewitz disease

7. Interference with the action of angiotensin-converting enzyme (ACE) is an effective means at reducing elevations in blood pressure. The circulating concentration of which of the following hormones would be affected as a consequence of the use of ACE inhibitors?

(A) ACTH
(B) aldosterone
(C) corticotrophin-releasing hormone, CRH
(D) estradiol
(E) gonadotropin-releasing hormone, GnRH

8. AIP is the major autosomal-dominant acute hepatic porphyria. This disease is caused by a deficiency in porphobilinogen (PBG) deaminase, an enzyme of heme biosynthesis. Patients afflicted with this disease would be expected to excrete excess amounts of which of the following?

(A) delta-aminolevulinic acid (ALA)
(B) coproporphyrinogen III
(C) hydroxymethylbilane
(D) protoporphyrin IX
(E) type III uroporphyrinogen

9. In a comparative study of two related cell lines, you find that one responds normally to insulin while the other has an impaired response. You discover that both cell lines bind insulin with equal affinity but that the impaired response is manifest in an inability to recruit the insulin response substrate-1 (IRS-1) protein to the receptor. This would most likely be due to which of the following?

(A) inability of the receptor to phosphorylate the RAS G-protein
(B) loss of activation of phospholipase C-gamma (PLC-γ)
(C) mutation in the tyrosine phosphorylation site of IRS
(D) serine phosphorylation of the insulin receptor preventing IRS binding
(E) tyrosine phosphorylation of the insulin receptor leading to the loss of the IRS binding site

10. There is but a single enzyme-catalyzed reaction in the human body known to generate carbon monoxide (CO) as one of its products. Which of the following enzymes represents the one that catalyzes this CO-producing reaction?

(A) biliverdin reductase
(B) coproporphyrinogen oxidase
(C) heme oxygenase
(D) protoporphyrinogen oxidase
(E) uroporphyrinogen decarboxylase

11. An infant admitted to the emergency room has been found to be suffering from ammonia intoxication, which was verified by measurement of an elevation of NH₄⁺ in the serum. Treatment of this infant with arginine results in
a reduction serum NH₄⁺ and a lessening of the effects of the ammonia toxicity. The ability of arginine to render this effect stems from its role in the synthesis of an allosteric activator of the urea cycle enzyme, carbamoylphosphate synthetase-I (CPS-I). Which of the following represents this potent allosteric effector of CPS-I?

(A) argininosuccinate  
(B) bicarbonate ion  
(C) fumarate  
(D) N-acetylcysteine  
(E) N-acetylglutaminate

12. Which of the following peptide hormones is released in response to stimulation of pituitary gonadotropes?

(A) ACTH  
(B) follicle-stimulating hormone  
(C) growth hormone  
(D) prolactin  
(E) thyroid-stimulating hormone

13. The rate-limiting step in glycolysis occurs at the step catalyzed by which of the following enzymes?

(A) glyceraldehyde-3-phosphate dehydrogenase  
(B) 6-phosphofructo-1 kinase, PFK-1  
(C) 6-PFK-2  
(D) phosphoglycerate kinase  
(E) pyruvate kinase

14. The statin class of drugs that are currently used to control hypercholesterolemia function to lower circulating levels of cholesterol by which of the following mechanisms?

(A) increasing the elimination of bile acids, leading to increased diversion of cholesterol into bile acid production  
(B) increasing the synthesis of apolipoprotein B-100 (apo B₁₀₀), resulting in increased elimination of cholesterol through the action of low-density lipoprotein (LDL) uptake by the liver  
(C) decreasing the absorption of dietary cholesterol from the intestines  
(D) inhibiting the interaction of LDLs with the hepatic LDL receptor  
(E) inhibiting the rate-limiting step in cholesterol biosynthesis

15. Which of the following represents the enzyme deficiency that leads to “essential fructosuria”?

(A) fructose-1-phosphate aldolase (aldolase B)  
(B) fructose-1,6-bisphosphate aldolase (aldolase A)  
(C) fructokinase  
(D) hexokinase  
(E) 6-PFK-1

16. Clinical evidence indicates aspirin is effective in the control of numerous chronic conditions such as atherosclerosis. The principal cardiovascular benefit from aspirin is due to its ability to reduce the incidence and severity of thrombotic episodes. The anticoagulant effect of aspirin occurs through its ability to inhibit which of the following activities?

(A) cyclooxygenase  
(B) fibrin cross-linking by factor XIIIa  
(C) phospholipase A₂  
(D) thrombin binding to activated platelets  
(E) von Willebrand factor

17. Gluconeogenesis is an extremely important reaction carried out in hepatocytes allowing for glucose homeostasis in the blood. The primary positive control of hepatic gluconeogenesis is exerted by which of the following?

(A) high acetylcoenzyme A (acetyl-CoA) levels  
(B) high adenosine triphosphate (ATP) levels  
(C) high citrate levels  
(D) low ATP levels  
(E) low citrate levels
18. A 6-month-old who is failing to thrive is brought to your clinic. Tests reveal hepatosplenomegaly, muscle weakness and atrophy, hypotonia, and decreased deep tendon reflexes. Blood tests reveal that the infant has normal glucose levels. Biopsy of the liver reveals initial stages of cirrhosis due to the accumulation of an abnormal glycogen with few branch points, whose structure resembles amylopectin. The clinical and laboratory results presented are indicative of which glycogen storage disease?

(A) Andersen disease (type IV glycogen storage disease)
(B) Cori or Forbes disease (type III glycogen storage disease)
(C) McArdle disease (type V glycogen storage disease)
(D) Tarui disease (type VII glycogen storage disease)
(E) von Gierke disease (type I glycogen storage disease)

19. Analysis of a tumor cell line indicates that there is a dramatically increased level in the activity of the transcription factor E2F. Which of the following is the most likely explanation for this observation?

(A) an increase in the expression of pRB resulting in increased binding of pRB to E2F
(B) hypophosphorylation of pRB so that it can no longer interact with E2F
(C) loss of expression of pRB which normally activates E2F
(D) mutation in pRB that prevents its phosphorylation so that it cannot interact with the gene to which it normally binds and coactivates with E2F
(E) mutation in the domain of pRB to which E2F binds, the consequences of which lead to constitutive E2F activity

20. Chromatin remodeling is associated with alterations in the transcriptional activity of genes in the region of the remodeling. Which of the following statements is most correct concerning the events of chromatin remodeling?

(A) Chromatin remodeling occurs predominantly in regions enriched in CpG dinucleotides.
(B) Histone acetylation tends to destabilize chromatin structure.
(C) Methylation of cytosine residues induces the remodeling event.
(D) Methylation of histone H1 is sufficient to stimulate remodeling.
(E) Remodeling is necessary to induce the property of genomic imprinting.

21. A 4-month-old Caucasian male infant with a temperature of 38.4°C is examined by his pediatrician. His mother indicates that he has had the fever for the past 4 days, been listless, vomiting, and has watery stools. Blood work indicates the infant is hypoglycemic but this condition does not respond to either epinephrine or glucose administration. In addition, his blood pH is slightly acidic and shows reduced bicarbonate. Other untoward blood chemistry includes elevated triglycerides, cholesterol, and liver enzymes. The child has a protruberant abdomen, thin extremities, and a doll-like face. The pediatrician suspects a specific condition and orders a liver biopsy to test for the activity of which of the following enzyme activities?

(A) glucose-6-phosphatase
(B) glycogen synthase
(C) muscle phosphofructokinase
(D) muscle phosphorylase
(E) pyruvate kinase

22. When cells acquire sufficient energy such that the rate of flux through the tricarboxylic acid (TCA) cycle declines, excess acetyl-CoA that cannot be oxidized is predominantly converted into fat. In order for the carbons in mitochondrial acetyl-CoA to serve as a precursor for fat synthesis, they must be delivered to the cytosol. Which of the following represents the molecule used to transport acetyl-CoA to the cytosol?

(A) acetyl-CoA
(B) carnitine
(C) citrate
23. Which of the following is true with respect to the actions of the mineralocorticoids?
(A) decrease carbohydrate metabolism
(B) increase appearance of the secondary sex characteristics
(C) increase synthesis of androgens
(D) regulate aldosterone secretion
(E) regulate sodium retention by the kidneys

24. A 9-month-old child is presented to the emergency room by his parents who report that he has been vomiting and has severe diarrhea. The episodes of vomiting began when the parents started feeding their child cow’s milk. The infant exhibits signs of failing to thrive. Laboratory tests show elevated blood galactose, hypergalactosuria, metabolic acidosis, albuminuria, and hyperaminoaciduria. These clinical and laboratory findings are most consistent with which of the following disorders?
(A) alkaptonuria
(B) essential fructosuria
(C) hereditary galactosemia
(D) Menkes disease
(E) von Gierke disease

25. Continued consumption of calories in excess of energy expenditure will eventually lead to obesity, a current major health problem in the United States. A major contributing factor in obesity is a disorder in fuel partitioning, as evidenced by a lower rate of fat oxidation in obese individuals. Which of the following situations would best explain a reduction in overall fat metabolism in these individuals?
(A) An increase in the hepatic ATP/adenosine diphosphate (ADP) ratio increases incorporation of carbon into fatty acids by causing an inhibition in acetyl-CoA oxidation in the TCA cycle.
(B) Decreased hepatic gluconeogenesis which requires acetyl-CoA from fatty acid oxidation, thus fat oxidation is secondarily inhibited.
(C) Increased levels of malonyl-CoA occur in these individuals leading to inhibition of carnitine palmitoyltransferase I.
(D) Insulin-induced decrease in the activity of acetyl-CoA carboxylase (ACC) causing reduction in fatty acid synthesis.
(E) Insulin-induced repression of fatty acid synthase (FAS) activity.

26. A 3-month-old infant who otherwise appeared normal during the first 2 months of life except for a bout of hyperbilirubinemia is now clearly exhibiting developmental delay. In addition, the infant’s hair has become grayish and dull and there is a stubble of broken hair over the occiput and temporal regions. The facial appearance has also changed such that the infant has very pudgy cheeks, abnormal eyebrows, and sagging jowls. The occurrence of frequent convulsions was the stimulus for the parents to bring their child to the emergency room. These rapidly deteriorating symptoms are indicative of which of the following disorders?
(A) Crigler-Najjar syndrome type I
(B) Gilbert syndrome
(C) hemochromatosis
(D) Menkes disease
(E) Refsum disease

27. Presentation of the platelet membrane protein complex, GPIIb-GPIIIa, which binds with von Willebrand factor, is necessary for which of the following?
(A) activation of PKC leading to phosphorylation of myosin light chain and platelet morphology changes
(B) cleavage and activation of high molecular weight kininogen
(C) inducing platelet crosslinking
(D) release of thrombin from platelet granules
(E) stimulation of endothelial and smooth muscle cell interaction resulting in vasoconstriction
28. Synthesis of glycogen is inhibited in hepatocytes in response to glucagon stimulation primarily as a result of which of the following?

(A) a decrease in the level of phosphoprotein phosphatase
(B) a decrease in the level of phosphorylated phosphorylase kinase
(C) a decrease in the levels of phosphorylated phosphoprotein phosphatase inhibitor-1
(D) an increase in the level of the dephosphorylated form of glycogen synthase
(E) an increase in the level of the phosphorylated form of glycogen synthase

29. Which of the following occurs in the lipidosis known as Tay-Sachs disease?

(A) Ganglioside GM₂ is not catabolized by lysosomal enzymes.
(B) Phosphoglycerides accumulate in the brain.
(C) Synthesis of a specific ganglioside is decreased.
(D) Synthesis of a specific ganglioside is excessive.
(E) Xanthomas, due to cholesterol deposition, are observed.

30. In Type I diabetes, the increased production of ketone bodies is primarily a result of which of the following?

(A) a substantially increased rate of fatty acid oxidation by hepatocytes
(B) an increase in the rate of the citric acid cycle
(C) decreased cyclic adenosine monophosphate (cAMP) levels in adipocytes
(D) elevated acetyl-CoA levels in skeletal muscle
(E) increased gluconeogenesis

31. Control of the rate of translational initiation can be exerted at the level of the activity of the guanosine triphosphate (GTP)-binding and hydrolyzing initiation factor, eIF-2. The efficiency with which eIF-2 recycles between the active GTP-bound form and the inactive GDP-bound form is controlled by the action of the initiation factor depicted as “Factor？” in Figure 3-1. What is the identity of this factor?

(A) eIF-1
(B) eIF-2B
(C) eIF-4A
(D) eIF-4E
(E) eIF-4G

32. Fragile X syndrome is caused by expansion of a trinucleotide repeat in the fragile X mental retardation-1 (FMR1) gene. This disorder is characterized by which of the following symptoms?

(A) accumulation of copper leading to formation of Kayser-Fleischer rings in the eyes
(B) hypoketotic hypoglycemia and metabolic acidosis
(C) isovaleric acidemia, severe metabolic acidosis, and neonatal fatality
(D) mental retardation of severity linked to the level of trinucleotide repeat expansion
(E) very long-chain fatty acid accumulation and myelin defects
33. A 4-year-old patient is presented in the pediatric clinic with microcytic anemia. An analysis of his blood by nondenaturing electrophoresis reveals the following composition of hemoglobin isoforms: HbF = 75%, HbA = 23%, HbA₂ = 2%, and HbS = 0%. Using these data, is it possible to determine that the infant is most likely homozygous for which of the following?

(A) complete deletion of the alpha-globin locus
(B) complete deletion of the beta-globin locus
(C) mutation in the promoter of the beta-globin genes
(D) nonsense mutation in the alpha-globin genes
(E) nonsense mutation in the beta-globin genes

34. Hepatocytes deliver ketone bodies to the circulation because they lack which of the following enzymes?

(A) beta-hydroxybutyrate dehydrogenase
(B) hydroxymethylglutaryl-CoA-lyase
(C) hydroxymethylglutaryl-CoA-synthetase
(D) succinyl-CoA-acetoacetate-CoA-transferase
(E) the form of the beta-ketothiolase necessary to hydrolyze acetoacetyl-CoA

35. Which of the following statements reflects the process by which the telomeric ends of chromosomes are replicated?

(A) A unique RNA molecule serves as the primer for synthesis.
(B) A unique RNA molecule serves as the template for synthesis.
(C) Short template-independent block of DNA are ligated to the ends using a 5’-5’ bond.
(D) Telomeres are replicated as short tandem-repeated stretches of ribonucleotides instead of deoxyribonucleotides.
(E) Telomeres are replicated in a template-independent process.

36. In carrying out an assay using cultured hepatocytes, you find that addition of hemin (Fe³⁺ heme) does not have the expected consequence of reduced protoporphyrin IX synthesis. This result suggests that your hepatocytes harbor a mutant form of one of the heme-regulated enzymes of porphyrin biosynthesis. Which of the following represents the likely enzyme?

(A) ALA dehydratase
(B) ALA synthase
(C) ferrochelatase
(D) heme oxygenase
(E) PBG deaminase

37. Hemochromatosis, a disorder that is the result of excess iron accumulation, is caused by deficiencies in which of the following proteins?

(A) divalent metal transporter-1 (DMT1)
(B) human leukocyte antigen (HLA) complex iron protein (HFE)
(C) ferritin
(D) ferroportin
(E) transferrin

38. A mother has brought her 3-month-old baby to the pediatrician and indicates that the infant is lethargic and has poor suckling and seems uninterested in eating. In addition, the mother notes that the baby’s diapers often smell like burnt sugar. This infant likely has a defect in which of the following enzymes?

(A) branched-chain alpha-keto acid dehydrogenase
(B) cystathionine synthase
(C) glycine cleavage complex (GCC)
(D) homogentisate oxidase
(E) phenylalanine hydroxylase
39. A male infant, delivered at 38 weeks’ gestation, presents with severe bowing of long bones, blue sclera, and craniotabes at birth. Radiographs show severe generalized osteoporosis, broad and crumpled long bones, beading ribs, and a poorly mineralized skull. Histologic examination of the long bones revealed the trabecula of the calcified cartilage with an abnormally thin layer of osteoid, and the bony trabeculae are thin and basophilic. The symptoms observed in the infant are characteristic of which disease?

(A) Ehlers-Danlos syndrome
(B) Marfan syndrome
(C) occipital horn syndrome
(D) osteogenesis imperfecta
(E) scurvy

40. Obesity, genetic profile, and aging all contribute to the development of Type II diabetes. Of the following, which is the most important additive factor for these three conditions in the development of Type II diabetes?

(A) elevated hepatic ketogenesis
(B) elevated pancreatic glucagon secretion
(C) impaired renal clearance of glucose
(D) increased adipose tissue activity leading to hyperlipidemia
(E) muscle resistance to insulin

41. A 2-month-old infant suffering from increased vomiting and diarrhea is seen in the hospital and observed to have significant abdominal distention due to hepatosplenomegaly. Unfortunately, the infant does not survive. Autopsy reveals calcification of the adrenals and massive accumulation of cholesteryl esters and triglycerides in most tissues. Analysis of enzyme activity in fibroblasts and lymphocytes demonstrates a significant acid lipase (cholesteryl ester hydrolase) deficiency. These clinical findings are indicative of which of the following disorders?

(A) hyperlipoproteinemia, type I (familial lipoprotein lipase deficiency)
(B) I-cell disease (mucolipidosis type II)
(C) Maroteaux-Lamy syndrome
(D) Sanfilippo syndrome
(E) Wolman disease

42. As a hypothetical approach to treating the hyperglycemia associated with Type II diabetes, a drug firm proposes to develop an inhibitor of liver glycogen phosphorylase. What is the biochemical rationale for this approach to inducing hypoglycemia?

(A) Hepatic fatty acid oxidation will decrease leading to reduced energy production needed for gluconeogenesis.
(B) Hepatocytes will have a reduced capacity to store glucose following meals.
(C) Liver glucose output will be reduced early during fasting.
(D) The resultant increase in glycogen storage will inhibit glucose uptake by the liver, leading to increased usage in skeletal muscle.
(E) There will be an increase in hepatic gluconeogenesis.

43. Lipoprotein lipase (LPL) is the endothelial cell-associated enzyme necessary for release of fatty acids from circulating lipoproteins. Which of the following apolipoproteins is required to activate LPL-mediated release of fatty acids from chylomicrons?

(A) apo A
(B) apo B48
(C) apo B100
(D) apo CII
(E) apo E

44. Which of the following is the hypophyseotropic hormone that regulates the activity of the lactotrophs of the anterior pituitary?

(A) CRH
(B) GnRH
(C) growth hormone-releasing hormone (GRH)
(D) prolactin-releasing factor (PRF)
(E) thyrotropin-releasing hormone (TRH)
45. An individual harboring a mutation in ornithine transcarbamoylase (OTC) would be expected to exhibit which of the following measurable abnormalities?

(A) citrullinemia  
(B) elevated urinary excretion of arginosuccinic acid  
(C) elevation in blood orotic acid  
(D) excess production of foam cells  
(E) uric acid deposition in the joints

46. You are examining the biochemical characteristics of the liver dysfunction in your patient, who is exhibiting signs of a glycogen storage disease. You have isolated the microsomal fraction (contains the endoplasmic reticulum) of a liver biopsy homogenate from your patient and a control individual for your studies. Incubation with radioactive phosphate-labeled glucose-6-phosphate results in an increase in isotope associated with the microsomes from your control sample but no increase in association with the microsomes from your patient. These results are best explained by a defect in which of the following?

(A) glucose-6-phosphatase activity in the microsomes  
(B) microsomal glucose-6-phosphate transporter  
(C) cytosolic glucose-6-phosphatase  
(D) microsomal glucose transport  
(E) microsomal phosphate transporter

47. Which of the following correctly defines the term: pK_a?

(A) equilibrium constant for the dissociation of HA to A^- and H^+  
(B) ion constant of water  
(C) negative log of the concentration of H^+  
(D) pH at which a molecule is neutrally charged  
(E) pH at which an equivalent distribution of acid and conjugate base exist in solution

48. Muscle membrane will depolarize in response to acetylcholine binding its receptors at the neuromuscular junction. Associated with this depolarization are changes in glycogen metabolism in skeletal muscle cells. Which of the following represents the correct changes in enzyme activity seen in response to acetylcholine binding?

(A) decreased glycogen phosphorylase kinase activity due to an increase in calcium binding to its calmodulin subunit  
(B) decreased phosphorylation of, and inhibited activity of glycogen phosphorylase kinase  
(C) increased glycogen phosphorylase kinase activity due to an activation of phosphoprotein phosphatase  
(D) increased glycogen phosphorylase kinase activity due to an increase in calcium binding to its calmodulin subunit  
(E) increased phosphorylation of, and inhibited activity of glycogen phosphorylase kinase

49. A 42-year-old man presents with hepatomegaly, jaundice, refractory ascites, and renal insufficiency. Peripheral leukocytes exhibit only 20% of normal glucocerebrosidase activity. Which of the following would explain his symptoms?

(A) Fabry disease  
(B) Gaucher disease  
(C) Krabbe disease  
(D) Niemann-Pick disease type II C  
(E) Tay-Sachs disease
50. The parents of a 1-year-old boy are alarmed at the increasing frequency of their child biting his lips and finger tips. In addition, on several occasions they have noticed what appear to be particles of “orange sand” in their son’s diapers. They report to their pediatrician that they believe their child is delayed in acquiring motor skills such as holding up his head and sitting unaided. Clinical tests performed on serum and urine indicate a threefold increase in serum uric acid and a tenfold elevation in the urinary ratio of uric acid to creatinine. These findings are suggestive of which of the following disorders?

(A) adenosine deaminase deficiency
(B) adenylosuccinate lyase deficiency
(C) Lesch-Nyhan disease
(D) purine nucleotide phosphoribosylase deficiency
(E) orotic aciduria

51. The ability of the liver to regulate the level of blood glucose is critical for survival. A number of sources of carbon atoms of nonhepatic origin are used by the liver for gluconeogenesis. However, the net conversion of carbons from fat into carbons of glucose cannot occur in humans because of which of the following?

(A) Fat oxidation occurs in the mitochondria and gluconeogenesis occurs in the cytosol.
(B) States of catabolism and anabolism are never concurrently active.
(C) Storage of fats occurs in adipose tissue and gluconeogenesis occurs in liver and kidney.
(D) The carbons of acetyl-CoA from fat oxidation are lost as CO₂ in the TCA cycle.
(E) The carbons of acetyl-CoA from fat oxidation inhibit conversion of pyruvate to oxaloacetate.

52. Endothelial cells respond to certain stimuli by inducing the conversion of arginine to citrulline leading to the activation of a signaling cascade that involves which of the following?

(A) adenylate cyclase
(B) guanylate cyclase
(C) phosphatidylinositol-3-phosphate kinase (PI3K)
(D) PLC-gamma
(E) protein kinase C (PKC)

53. The metabolic pathway depicted in Figure 3-2 is critically important as a means of energy production in skeletal muscle cells. Which of the following correctly identifies this pathway?

(A) ADA cycle
(B) hypoxanthine-guanine phosphoribosyltransferase (HGPRT) cycle
(C) nonoxidative cycle in pentose phosphate pathway
(D) purine nucleotide cycle
(E) urea cycle

54. During the process of protein synthesis, the factor eEF-2 induces the hydrolysis of GTP. The energy of this hydrolysis is coupled to which of the following?

(A) amino acid activation by attachment to a tRNA
(B) correct alignment of the mRNA on the 40S ribosome
(C) formation of the 80S initiation complex
(D) formation of the peptide bond
(E) translocation of the ribosome

55. Patients with poorly controlled diabetes mellitus have elevated levels of blood glucose. One severe consequence of the hyperglycemia is an increase in glucose attachment to serum proteins. Which of the following proteins, when
glycosylated, is an excellent measure of the length of time someone has suffered from an episode of hyperglycemia?

(A) albumin  
(B) cholesterol  
(C) fatty acids  
(D) hemoglobin  
(E) transferrin

56. The ability of rod cells in the eye to respond to light and transmit that response to the optic nerve requires that the 11-cis form of vitamin A be attached to which of the following proteins?

(A) cGMP phosphodiesterase  
(B) Na+ channel  
(C) rhodopsin  
(D) scotopsin  
(E) transducin

57. In an assay for the presence of a specific disease gene allele in several individuals, you isolate genomic DNA from each and perform polymerase chain reaction (PCR) using gene-specific primers. The PCR product is expected to have a recognition site for the restriction endonuclease BamHI. Following PCR and BamHI digestion, the products are separated by gel electrophoresis and the results are shown in Figure 3-3. Which lane corresponds to the individual demonstrating heterozygosity for the BamHI site?

(A) 1  
(B) 2  
(C) 3  
(D) 4  
(E) 5

58. Which of the following symptoms can occur frequently in infants suffering from medium-chain acyl-CoA dehydrogenase (MCAD) deficiency if periods between meals are protracted?

(A) bone and joint pain and thrombocytopenia  
(B) hyperammonemia with decreased ketones  
(C) hyperuricemia and darkening of the urine  
(D) hypoglycemia and metabolic acidosis with normal levels of ketones  
(E) metabolic alkalosis with decreased bicarbonate

59. Reticulocytes control the rate of globin synthesis as a consequence of the level of heme in the cell. This prevents globin protein from being made when there are insufficient amounts of heme. Which of the following best explains the effects of heme on protein synthesis in these cells?

(A) A heme-controlled phosphatase dephosphorylates cap-binding factor, which prevents recognition of globin mRNA by the ribosomes.  
(B) A tRNA-degrading enzyme is active in the absence of heme.  
(C) Heme normally activates peptidyltransferase in reticulocytes.  
(D) RNA polymerase activity is decreased in reticulocytes by low heme.  
(E) The initiation factor eIF-2 becomes phosphorylated, reducing its level of activity.
60. Infants exhibiting profound metabolic ketoacidosis, muscular hypotonia, developmental retardation, and who have very large accumulations of methylmalonic acid in their blood and urine suffer from a disorder known as methylmalonic acidemia. This disorder results from a defect in which of the following enzymes?

(A) alpha-keto acid dehydrogenase  
(B) homogentisic acid oxidase  
(C) methylmalonyl-CoA mutase  
(D) phenylalanine hydroxylase  
(E) tyrosine aminotransferase

61. Following a minor respiratory illness, a seemingly healthy, developmentally normal 15-month-old boy exhibited repeated episodes of severe lethargy and vomiting following periods of fasting, such as during the middle of the night. The parents brought the infant to the emergency room following a seizure. The child was hypoglycemic and was administered 10% dextrose, but remained lethargic. Blood ammonia was high, liver function tests were slightly elevated, and his serum contained an accumulation of dicarboxylic acids. Only low levels of ketones were detectable in the urine. This infant suffers from which of the following disorders?

(A) glutaric acidemia type II  
(B) Lesch-Nyhan syndrome  
(C) MCAD deficiency  
(D) pyruvate dehydrogenase (PDH) deficiency  
(E) type III (Cori) glycogen storage disease

62. A 28-year-old man has the following symptoms: diffuse grayish corneal opacities, anemia, proteinuria, and hyperlipemia. Renal function is normal and serum albumin level is only slightly elevated. Plasma triglycerides and unesterified cholesterol levels are elevated, as are levels of phosphatidylcholine. These symptoms are indicative of which lipoprotein-associated disorder?

(A) produce mannose-6-phosphate modifications in lysosomal enzymes  
(B) recycle the lysosomal receptor for mannose-6-phosphate present on lysosomal enzymes  
(C) remove mannose-6-phosphates from lysosomal enzymes prior to their transport to the lysosomes

63. A 23-year-old man sees his physician to ask about the recent appearance of several large closely spaced bumps on his elbows. Suspecting that these are fatty eruptions, the physician tests the man’s blood for lipid, cholesterol, and lipoprotein levels. Results show elevated cholesterol and triglycerides and the presence of a variant form of very low-density lipoprotein (VLDL) identified as beta-migrating VLDL (β-VLDL). A more careful analysis of the biochemical properties of the apoproteins associated with the beta-VLDL particles identifies a form of apo E that has a more negative charge than apo E from normal individuals. These results indicate the individual is afflicted with which of the following hyperlipoproteinemias?

(A) type I (familial LPL deficiency)  
(B) type II (FH)  
(C) type III (dysbetalipoproteinemia)  
(D) type IV (familial hypertriglycerolemia)  
(E) Wolman disease

64. I-cell disease (also identified as mucolipidosis type II) is characterized by the presence of inclusion bodies in fibroblasts (hence the derivation of the term I-cell), severe psychomotor retardation, corneal clouding, and dystosis multiplex. These symptoms arise from a defect in the targeting of lysosomal enzymes due to an inability to carry out which of the following processes?

(A) produce mannose-6-phosphate modifications in lysosomal enzymes  
(B) recycle the lysosomal receptor for mannose-6-phosphate present on lysosomal enzymes  
(C) remove mannose-6-phosphates from lysosomal enzymes prior to their transport to the lysosomes
(D) synthesize the mannose-6-phosphate receptor found in lysosomes
(E) transport mannose-6-phosphate receptors to lysosomes

65. A 30-month-old child presents with coarse facial features, corneal clouding, hepatosplenomegaly, and exhibiting disproportionate short-trunk dwarfism. Radiographic analysis indicates enlargement of the diaphyses of the long bones and irregular metaphyses, along with poorly developed epiphyseal centers. Other skeletal abnormalities typify the features comprising dystosis multiplex. The child’s physical stature and the analysis of bone development indicate the child is suffering from which of the following disorders?

(A) Hunter syndrome
(B) Hurler syndrome
(C) Maroteaux-Lamy syndrome
(D) Morquio syndrome type B
(E) Sanfilippo disease type A

66. Loss of the hepatic protein hepcidin can lead to severe iron overload with symptoms resembling those of hemochromatosis. Which of the following functions of hepcidin accounts for the iron overload when the protein is deficient?

(A) activates the expression of the iron-response element-binding protein that regulates transferring receptor and ferritin mRNA translation
(B) decreases the level of intestinal membrane iron transporters, resulting in reduced iron uptake
(C) facilitation of the interaction of transferrin with the transferrin receptor
(D) forms a complex with ferritin allowing for higher intracellular storage
(E) promotes the formation of hemosiderin, thus detoxifying iron

67. In an enzyme with a critical Glu residue in the active site, which of the following amino acid substitutions would be expected to have the least effect on enzyme activity?

(A) Arg
(B) Asp
(C) Lys
(D) Ser
(E) Tyr

68. Many proteins undergo modifications during and/or following translation. The ATP-dependent polyubiquitination of proteins is a signal for which of the following events?

(A) addition of the oligosaccharide core to the N-linkage site adjacent to the ubiquitin
(B) recognition by the toxin of diptheria
(C) recycling of the protein back to the endoplasmic reticulum (ER) from the cis-Golgi to allow proper folding
(D) targeting the protein for degradation in the proteosome
(E) translocation of the protein into the nucleus

69. Some viruses, for example, poliovirus, contain a protease that cleaves one of the eukaryotic initiation factors allowing for cap-independent translational initiation of viral RNAs at internal ribosome entry site (IRES). Which of the following factors is the target of these viral proteases?

(A) eIF-2
(B) eIF-2B
(C) eIF-4A
(D) eIF-4E
(E) eIF-4G

70. A 37-year-old man presents with tophaceous deposits within the articular cartilage, synovium, tendons, tendon sheaths, pinnae, and the soft tissue on the extensor surface of the forearms. These clinical observations suggest the patient is suffering from which of the following disorders?

(A) ADA deficiency
(B) gout
(C) Lesch-Nyhan syndrome
(D) purine nucleoside phosphorylase (PNP) deficiency
(E) von Gierke disease
71. The initial reaction of the de novo synthesis pathway for pyrimidine nucleotides begins with glutamine and CO₂ and is complete with the formation of uridine monophosphate. Which of the following represents the rate-limiting enzyme in this pathway?

(A) aspartate transcarbamoylase  
(B) orotate monophosphate decarboxylase  
(C) phosphoribosylpyrophosphate (PRPP) amido transferase  
(D) PRPP synthetase  
(E) ribonucleotide reductase

72. One important function of nitric oxide (NO) is the induction of vascular smooth muscle relaxation in response to acetylcholine. The production of NO requires which amino acid?

(A) arginine  
(B) asparagine  
(C) cysteine  
(D) glutamine  
(E) lysine

73. In renal insufficiency, calcium absorption is reduced and leads to increased bone resorption, a condition referred to as renal osteodystrophy. Treatment with which of the following can assist in the amelioration of the symptoms of this condition?

(A) antidiuretic hormone  
(B) calcitonin  
(C) calcitriol  
(D) growth hormone  
(E) parathyroid hormone

74. A 32-year-old woman is diagnosed with hypertension, hypernatremia, hypokalemia, and alkalosis. Measurements of plasma glucocorticoid levels show them to be within the normal range; however, renin and angiotensin II levels are suppressed. Ultrasound indicates the possible existence of an adrenal cortical mass. These symptoms are likely due to excess production of which of the following hormones?

(A) aldosterone  
(B) androstenedione  
(C) dehydroepiandrosterone (DHEA)  
(D) estradiol  
(E) testosterone

75. The anticancer drug, Taxol, has been an effective chemotherapeutic agent in the fight against ovarian cancer. Which of the following represents the mechanism of action of Taxol?

(A) binds to the activated form of the RAS protein, which in turn interferes with the signaling cascades involving this protein  
(B) binds to microtubules, which stabilizes them preventing their shortening and interfering with cell division  
(C) interacts with the tumor supressor protein (pRB) encoded by the retinoblastoma susceptibility gene inducing its suppressive activity  
(D) interacts with topoisomerase II preventing its role in DNA synthesis, which effectively terminates replication  
(E) interferes with steroid hormone receptor interaction with DNA, thus preventing the growth induction by this class of hormone

76. A 17-year-old man who reports to his physician that he is incapable of obtaining an erection is also quite embarrassed by the apparent enlargement of his breasts (gynecomastia). These symptoms, when present in males, are associated with an excessive production of which of the following hormones?

(A) corticotropin-releasing hormone  
(B) GnRH  
(C) growth hormone  
(D) melanocyte-stimulating hormone  
(E) prolactin

77. Numerous inherited disorders are the result of the expansion of trinucleotide (triplet) repeats either within the coding regions of genes or the untranslated regions of the resultant RNAs. Which of the following diseases has been shown to be caused by triplet expansion?
78. Correct targeting of newly synthesized hydrolytic enzymes to the lysosomes requires which of the following modifications?

(A) attachment of mannose-6-phosphate to the enzymes
(B) gamma-carboxylation of glutamate residues in the enzymes
(C) O-linkage of carbohydrate to the enzymes
(D) prenylation of the enzymes
(E) proteolytic activation following transport to the lysosome

79. When dividing cells are progressing through the cell cycle, many checks are imposed to ensure that the process is occurring with fidelity. A critical checkpoint in the cell cycle occurs in response to DNA damage, such as that induced by ultraviolet light. Which of the following cell-cycle proteins is involved in DNA damage-mediated cell-cycle arrest?

(A) CDK2
(B) cyclin A
(C) cyclin D
(D) E2F
(E) p53

80. Severe combined immunodeficiency disease (SCID) is characterized by a complete lack of cell-mediated and humoral immunity. This disorder results from a deficiency in which of the following enzymes?

(A) adenosine deaminase
(B) asparatate transcarbamoylase
(C) HGPRT
(D) orotic acid decarboxylase
(E) purine nucleotide phosphorylase

81. The forensic analytical technique identified as DNA fingerprinting refers to which of the following processes?

(A) the establishment of a complete collection of cloned fragments of DNA
(B) the identification of sequences of DNA to which specific proteins bind, thereby rendering them resistant to digestion by DNA-degrading nucleases
(C) the specific association of complimentary strands of DNA to one another
(D) the synthetic oligonucleotide-directed enzymatic amplification of specific sequences of DNA
(E) the use of repeat sequences to establish a unique pattern of fragments for any given individual

82. Glucagon binding to liver cells induces an increase in intracellular cAMP concentration. The rate-limiting step in cholesterol biosynthesis is regulated as a consequence of this glucagon-mediated rise in cAMP. The effect of increased cAMP on the rate of cholesterol biosynthesis occurs because of which of the following?

(A) AMP-activated protein kinase (AMPK) is activated and directly phosphorylates human menopausal gonadotropin (HMG)-CoA reductase, leading to an increase in the activity of the latter enzyme.
(B) Cyclic AMP-dependent protein kinase (PKA) is activated and directly phosphorylates HMG-CoA reductase, reducing the activity of the latter enzyme.
(C) PKA is activated and phosphorylates AMP-regulated kinase, which then phosphorylates and activates HMG-CoA reductase.
(D) Removal of phosphate from HMG-CoA reductase increases its activity. Activated PKA results in a reduced level of phosphate removal from HMG-CoA reductase so that the latter enzyme is kept less active.
(E) The increased cAMP directly inhibits HMG-CoA reductase.
83. You are tending to a patient with a high tendency to bleed. He bruises easily and has bleeding from his gums. Analysis of coagulation factors in his blood shows normal levels of factor V but low levels of factor VIII. Injection of factor VIII provides only minimal benefit and you find that the injected protein is rapidly degraded. Using a platelet aggregation test, you find that combination of your patient's serum with normal platelets results in only 20% of the platelet aggregation seen with both samples from a normal individual. Based on these findings, you determine that your patient is deficient in which of the following factors of coagulation?

(A) factor X  
(B) factor XII  
(C) fibrinogen  
(D) thrombin  
(E) von Willebrand factor

84. A 3-month-old infant exhibits profound neurologic deficit in addition to being blind and deaf. Pathologic examination indicates renal cysts, hepatomegaly, and facial dysmorphism. Biochemical analysis reveals plasma accumulations of very long-chain fatty acids, abnormal intermediates of bile acid synthesis, and a marked deficiency of plasmalogens. These physical and biochemical features are characteristic of which of the following disorders?

(A) hyperpipecolic acidemia  
(B) infantile Refsum disease  
(C) neonatal adrenoleukodystrophy  
(D) rhizomelic chondrodysplasia punctata (RCDP)  
(E) Zellweger syndrome

85. Which of the following apoproteins is found exclusively associated with chylomicrons?

(A) apo A  
(B) apo B₄₈  
(C) apo CII  
(D) apo D  
(E) apo E

86. A 9-month-old infant who suffered bouts of jaundice and was diagnosed with severe non-hemolytic icterus shortly after birth has died of kernicterus. During the periods of jaundice, serum analysis showed an increased concentration of indirect-reacting bilirubin with no detection of conjugated bilirubin. The premature death and early clinical findings in this infant suggest which of the following disorders?

(A) AIP  
(B) Crigler-Najjar syndrome, type I  
(C) Dubin-Johnson syndrome  
(D) Gilbert syndrome  
(E) Rotor syndrome

87. Acromegaly is characterized by protruding jaw, enlargement of the nose, hands, feet, and skull, and a thickening of the skin. This disorder is the result of excessive production of which of the following hormones?

(A) corticotropin-releasing hormone  
(B) GnRH  
(C) growth hormone  
(D) insulin-like growth factor-II (IGF-II)  
(E) thyroid-stimulating hormone

88. Under conditions of anaerobic glycolysis, the NAD⁺ required by glyceraldehyde-3-phosphate dehydrogenase is supplied by a reaction catalyzed by which of the following enzymes?

(A) glycerol-3-phosphate dehydrogenase  
(B) alpha-ketoglutarate dehydrogenase  
(C) lactate dehydrogenase  
(D) malate dehydrogenase  
(E) PDH

89. The level of iron in the body must be tightly regulated due to the severe toxicity associated with elevated levels in the circulation and within cells. Which of the following proteins is primarily responsible for iron homeostasis?

(A) ceruloplasmin  
(B) ferritin  
(C) haptoglobin
90. A laboratory analysis of isolated mitochondria demonstrates that oxygen consumption is normal when succinate is added, but extremely low when pyruvate and malate are used. The mitochondria are subsequently shown to have normal cytochromes, but reduced iron content. The reduced pyruvate/malate oxidation is due to a defect in which of the following respiratory components?

(A) cytochrome c  
(B) cytochrome oxidase  
(C) NADH-coenzyme Q reductase  
(D) succinate dehydrogenase  
(E) ubiquinone

91. The phosphorylase kinase-associated regulatory protein identified by the letter A in Figure 3-4 is a calcium-binding protein. Which of the following proteins represents this regulatory subunit?

(A) calmodulin  
(B) fructose-2,6-bisphosphate  
(C) glycogen synthase kinase-3  
(D) phosphoprotein phosphatase  
(E) phosphoprotein phosphatase inhibitor-1

92. Mosaicism refers to a condition in which an individual has two or more genetically distinct cell types, derived from a single zygote, but that differ because of mutation or chromosomal aberration. Mosaicism occurs with a frequency of approximately 30% in females who are phenotypically normal but harbor gonadal dysgenesis, sexual immaturity, and infertility. These affected females also are short in stature, have webbing of the neck, and swelling of the hands and feet, as well as cardiovascular and renal abnormalities. These symptoms are associated with which of the following diseases?

(A) achondroplasia  
(B) Duchenne muscular dystrophy  
(C) fragile X syndrome  
(D) Kleinfelter syndrome  
(E) Turner syndrome

93. A child born and raised in Chicago planned to spend the summer on a relative’s fruit farm and help with the harvest. The summer passed uneventfully, but several days after the harvest began the child became jaundiced and very sick. On admission to the hospital the following clinical findings were recorded: in addition to the expected hyperbilirubinemia, the patient was hypoglycemic, had a markedly elevated rise in blood fructose concentration, and was hyperlactic acidemic. Further history taking revealed that during the harvest it was customary for the family to indulge in fruit-filled meals and to snack freely on fruit while carrying out the harvest. The following conclusions were reached. The elevated blood fructose was due to which of the following?

(A) an allergic reaction to constituents in the fruit diet  
(B) defective hepatic fructokinase  
(C) defective hepatic glucokinase  
(D) defective hepatic fructose-1-phosphate aldolase (aldolase B)  
(E) defective hepatic fructose-1,6-bisphosphate aldolase (aldolase A)
94. The incretins are hormones that are released in response to the consumption of food. Which of the following represents one of the major effects of incretin release from intestinal epithelial cells?

(A) activation of gastric emptying ensuring release of ingested food
(B) enhancement in adipocyte triacylglycerol synthesis
(C) enhancement of insulin secretion from the pancreas
(D) repression of pancreatic cell proliferation
(E) stimulation of gastric acid secretion to aid in digestion

95. PDH is a complex multisubunit enzyme. Which of the following exerts a positive influence on the activity of PDH?

(A) acetyl-CoA
(B) ATP
(C) dephosphorylation
(D) NADH
(E) phosphorylation

96. Vitamin K serves as a coenzyme in reactions that result in the modified activity of several enzymes of the blood coagulation cascade. Which of the following amino acid modifications requires the activity of vitamin K?

(A) aspartate to beta-carboxyaspartate
(B) glutamate to gamma-carboxyglutamate
(C) lysine to hydroxylysine
(D) lysine to beta-methyllysine
(E) proline to hydroxyproline

97. Steroid hormones interact with specific receptors within target cells. The steroid-receptor complexes then regulate the rate of which of the following intracellular processes?

(A) posttranscriptional processing of specific mRNAs
(B) posttranslational processing of specific proteins
(C) replication of DNA
(D) transcription of specific genes
(E) translation of specific mRNAs

98. Resistance to Type I diabetes has been shown to be associated with a specific polymorphic allele. Which of the following loci represents this allele?

(A) a VNTR in the 5' region of the insulin gene
(B) glutamic acid decarboxylase (GAD)
(C) HLA-B27
(D) HLA-DQ
(E) HLA-DR3

99. The inability to rapidly synthesize DNA during the process of erythrocyte maturation leads to abnormally enlarged erythrocytes. This disorder is referred to as macrocytic anemia and is caused by a deficiency in which of the following vitamins?

(A) ascorbate
(B) biotin
(C) folate
(D) niacin
(E) thiamine

100. A 12-year-old boy has suffered from chronic sinusopulmonary disease including persistent infection of the airway with Pseudomonas aeruginosa. He has constant and chronic sputum production as a result of the airway infection. Additionally, he suffers from gastrointestinal (GI) and nutritional abnormalities that include biliary cirrhosis, meconium ileus, and pancreatic insufficiency. The symptoms are classical for which of the following disorders?

(A) congenital adrenal hyperplasia
(B) CF
(C) Renal Fanconi syndrome
(D) sickle cell anemia
(E) Tay-Sachs disease
101. Hypersensitive individuals have IgE to specific antigens (e.g., pollen, bee venom) on the surface of their leukocytes (monocytes, macrophages, basophils, eosinophils). When these individuals are challenged with antigen, the antigen-IgE complexes induce synthesis and release of which of the following physiologically potent lipids?

(A) arachidonic acid
(B) leukotriene B₄
(C) platelet-activating factor (PAF)
(D) prostaglandin E₂
(E) thromboxane A₂ (TXA₂)

102. Acetyl-CoA enhances the rate of gluconeogenesis by acting as an allosteric activator of which of the following enzymes?

(A) ACC
(B) PEP-carboxykinase
(C) pyruvate carboxylase
(D) PDH
(E) pyruvate kinase

103. You are studying the effects of a compound on the respiratory activity of isolated mitochondria. Your experiments demonstrate that oxygen consumption is normal when pyruvate and malate are added. Oxygen consumption is also seen to be normal when succinate is added. However, you find that the production of ATP is severely impaired in the presence of pyruvate/malate or succinate when the compound is added to the reaction. These results most closely resemble the effects that would be seen by the addition of which of the following inhibitors of oxidative phosphorylation?

(A) antimycin A
(B) azide
(C) dinitrophenol
(D) oligomycin
(E) rotenone

104. An observation that has been made over the past several decades is that certain dominantly inherited disorders exhibit earlier age of onset along with increasing severity in successive generations. This phenomenon is referred to as anticipation. A most striking example of this genetic trait is characterized by muscle wasting beginning with the face, neck, and hands gradually becoming generalized and by the inability of muscles to relax after contraction. These symptoms and the phenomenon of anticipation are associated with which of the following diseases?

(A) becker muscular dystrophy (BMD)
(B) DMD
(C) Marfan syndrome
(D) myotonic dystrophy
(E) osteogenesis imperfecta

105. The bacterial lac operon is controlled by both glucose and lactose levels. Which of the following conditions would result in the greatest level of transcription from the lac operon?

(A) both glucose and lactose present
(B) glucose present but no lactose
(C) lactose present but no glucose
(D) no glucose or lactose present

106. The term “genomic imprinting” refers to the phenomenon of gene expression dependence on the mode of inheritance. A typical example of this phenomenon is the control of the expression of the growth factor IGF-II. Genomic imprinting, termed “epigenesis,” is defined by which of the following?

(A) Gene expression results from regulated levels of DNA methylation.
(B) Gene expression that is restricted to a specific cell lineage.
(C) Gene regulation is exerted by sex-type specific factors.
(D) Genotype differences are not reflected by phenotype differences.
(E) Phenotype differences are independent of genotype variation.
107. The process of RNA editing leads to sequence changes that are not reflective of the genetic information contained within the gene for an edited RNA. RNA editing occurs through the action of specific nucleotide deaminases that change either adenine to inosine or cytidine to uridine. These nucleotide changes can affect the coding or splicing capacity of the RNA. Which of the following proteins is an important example of the result of RNA editing?

(A) apo B_{48}  
(B) calcitonin gene-related peptide  
(C) ferritin  
(D) glutamate dehydrogenase  
(E) tissue factor (factor III)

108. Carnitine, a zwitterionic compound derived from lysine, is involved in fatty acid metabolism and is required at which two points in the transport of fatty acids from the cytoplasm to the mitochondria (see Figure 3-5)?

(A) A and E  
(B) A and C  
(C) B and C  
(D) B and D  
(E) E and D

109. When the body becomes acidotic, the liver and the kidneys play central roles in reactions designed to reduce the proton level (i.e., increase the pH) of the circulation. Which of the following constitutes the hepatic reaction occurring during periods of acidosis?

(A) ammonia incorporation into glutamate-forming glutamine  
(B) ammonia incorporation into alpha-ketoglutarate-forming glutamate  
(C) glutamine conversion to glutamate-releasing ammonia  
(D) glutamine conversion to alpha-ketoglutarate-releasing ammonia  
(E) increased production of urea to dispose of ammonia

110. The occurrence of Type II diabetes (NIDDM) in adolescent females can lead to the development of polycystic ovarian syndrome (PCOS). PCOS is the result of follicular atresis and ovulatory dysfunction brought about by a hyperandrogenic microenvironment in the ovary. Which of the following statements reflects the underlying cause of the hyperandrogenic state in females with NIDDM?

(A) Hyperinsulinemia, associated with NIDDM, reduces the level of sex hormone-binding globulin leading to increased free testosterone.  
(B) NIDDM in adolescents is primarily the result of obesity and the associated disruption in fatty acid metabolism negatively affects adrenal estrogen production.  
(C) The increased level of circulating lipid in NIDDM patients competes for steroid binding to sex hormone-binding globulin, resulting in a reduced transport of estrogen within the ovary.  
(D) The persistent hyperglycemia associated with NIDDM causes increased levels of glycosylated hemoglobin, which interferes with the need for increased ovarian vascularization at puberty.
111. A 15-year-old boy has been diagnosed with retinitis pigmentosa, peripheral polyneuropathy, and cerebellar ataxia. Analysis of his cerebrospinal fluid indicated a high protein content but no elevation of cell number. A telling clinical finding was a high level of serum phytanic acid. These findings are indicative of which of the following disorders?

(A) carnitine palmitoyltransferase I deficiency
(B) fragile X syndrome
(C) MCAD deficiency
(D) Refsum disease
(E) rhizomelic chondrodysplasia punctata

112. In analyzing a sample of double-stranded DNA, it has been determined that the molar ratio of adenosine is 20%. Given this information, what is the content of cytidine?

(A) 10
(B) 20
(C) 30
(D) 40
(E) 60

113. Measurement of the rate of creatinine clearance is used as a key determinant of renal function. In which of the following tissues is creatinine generated?

(A) adipose
(B) kidney
(C) liver
(D) lung
(E) skeletal muscle

114. Numerous cancers are caused by a genetic phenomenon termed “loss of heterozygosity,” LOH. This phenomenon led to the identification of genes termed tumor suppressors, because it is the loss of their function that leads to cancer. Which of the following has been shown to result from defects in a tumor suppressor gene as a consequence of LOH?

(A) Creutzfeldt-Jakob disease (CJD)
(B) Crouzon syndrome

115. Following a relatively normal early developmental period, a 6-month-old boy becomes pale and lethargic and begins to show signs of deteriorating motor skills. The infant has severe megaloblastic anemia; however, serum measurements of iron, folate, vitamins B₁₂ and B₆ demonstrate they are within normal range. Urine samples were clear when fresh, but when left to stand for several hours showed an abundant white precipitate that was composed of fine needle-shaped crystals. Analysis of the crystals identified them as orotic acid. Analysis of the crystals is indicative of which of the following?

(A) HD
(D) Li-Fraumeni syndrome (LFS)
(E) Prader-Willi syndrome

116. If the DNA strand shown below is used as a template for RNA polymerase, what would be the sequence of the resultant mRNA following transcription?

\[5'-CATTCCATAGCATGT-3'\]

(A) 5'-ACAUGCUAUGGAAUG-3'
(B) 5'-CAUCCAUGCAUGU-3'
(C) 5'-GUAAGGUAUCGUACA-3'
(D) 5'-UGUACGAUACCUUAC-3'
117. If the RNA synthesized in Question 398 were translated in a eukaryotic in vitro translation system, what would be the composition of the resultant peptide?

- ACA threonine (T)
- ACG threonine (T)
- AUG methionine (M)
- AAU asparagine (N)
- AUA isoleucine (I)
- GGA glycine (G)
- UG G trypophan (W)

(A) C-T-I-P-Y  
(B) H-S-I-A-C  
(C) M-L-W-N  
(D) T-C-Y-G-M  
(E) V-R-Y-R-T

118. Which of the following statements most correctly reflects the effect of epinephrine stimulation of adipocytes?

- (A) enzyme-dependent addition of fatty acids to glycerol-3-phosphate  
- (B) enzyme-dependent stepwise release of fatty acids from triglycerides  
- (C) increased synthesis and activation of LPL  
- (D) increased synthesis of HDL to transport fatty acids to peripheral tissues  
- (E) release of glycerol-3-phosphate for gluconeogenesis in the liver

119. Which of the following familial cancers results from a defect in the tumor suppressor gene, p53?

- (A) familial adenomatous polyposis coli (APC)  
- (B) Li Fraumeni syndrome  
- (C) neurofibromatosis type 1  
- (D) retinoblastoma  
- (E) Wilms tumor

120. Which of the following clotting factors forms an active complex with tissue factor (factor III) to initiate the extrinsic clotting cascade?

- (A) factor I (fibrinogen)  
- (B) factor VII (proconvertin)  
- (C) factor VIII  
- (D) factor IX  
- (E) protein S

121. Many effective anticancer drugs function as such by interfering with processes of DNA replication. The drug, doxorubicin, is useful in the treatment of lymphomas and breast cancers because of its ability to interfere with which of the following enzyme activities?

- (A) DNA ligase  
- (B) DNA polymerase-alpha  
- (C) primase  
- (D) topoisomerase II  
- (E) uracil N-glycosylase

122. When fatty acids with odd numbers of carbon atoms are oxidized in the beta-oxidation pathway the final product is 1 mole of acetyl-CoA and 1 mole of the 3-carbon molecule, propionyl-CoA. In order to use the propionyl carbons, the molecule is carboxylated and converted ultimately to succinyl-CoA and fed into the TCA cycle. Which of the following represents the vitamin cofactor required in one of the steps of this conversion?

- (A) cobalamin (B₁₂)  
- (B) pantothenic acid (B₅)  
- (C) pyridoxine (B₆)  
- (D) riboflavin (B₂)  
- (E) thiamine (B₁)

123. Mutant genes that affect several organ systems and bodily functions frequently show variable expressivity, a phenomenon referred to as phenotypic variation. The most striking example of phenotypic variability is manifest in an autosomal-dominant condition characterized by the appearance of café au lait spots on the skin and cutaneous and subcutaneous neurofibromas. These symptoms are associated with which of the following?

- (A) familial adenomatous polyposis  
- (B) FH
124. Which of the following factors of blood coagulation is the major inhibitor of the extrinsic clotting cascade?

(A) antithrombin III  
(B) high molecular weight kininogen  
(C) lipoprotein-associated coagulation factor  
(D) alpha-2-macroglobulin  
(E) protein C

125. Regulation of iron homeostasis occurs by controlling the amount that circulates in the serum, as well as the amount contained within cells. One mechanism that plays a role in this homeostasis is iron-mediated control of the level of the intracellular iron-binding protein ferritin. Which of the following represents the mechanism of iron regulation of ferritin levels?

(A) Binding of iron to ferritin leads to secretion of the complex from cells and subsequent excretion in the urine.  
(B) Ferritin exists as a tetramer and when iron binds, the affinity for additional iron atoms increases.  
(C) Iron binds an additional protein that acts as a regulator of ferritin mRNA translation, high iron leads to increased translation and thus increased iron-binding capacity.  
(D) When excess iron binds to ferritin, it decreases the half-life of the protein allowing the iron to be released to the plasma and excreted.

126. Regulation of cholesterol, fatty acid, phospholipid, and triglyceride synthesis is controlled in part by the level of sterols. These sterol-regulated biosynthesis pathways involve a unique family of transcription factors that are best described by which of the following?

(A) Binding of sterols to these factors induces a conformational change preventing interaction with RNA polymerase.  
(B) They are membrane-bound proteins and only released on activation of a sterol-regulated protease.  
(C) They contain zinc fingers that bind sterols leading to their activation.  
(D) They require interaction with sterols, much like steroid hormone receptors, prior to binding to DNA.  
(E) On sterol binding, these factors are recognized by the proteosome and thus targeted for degradation.

127. Metformin is one of the most prescribed hypoglycemia-inducing drugs in the treatment of Type II diabetes. One of the effects of metformin is a reduction in adipose tissue lipolysis, which is effected via the activation of AMP-activated kinase (AMPK). Which of the following actions of AMPK explains the adipose tissue benefits of metformin?

(A) activation of ACC  
(B) activation of FAS  
(C) inhibition of hormone-sensitive lipase  
(D) inhibition of mammalian target of rapamycin (mTOR)  
(E) inhibition of 6-PFK-2

128. The protein encoded by the APC gene is a tumor suppressor the role of which is to regulate the activity of cellular signaling induced by the Wnt growth factor. Therefore, loss of APC activity is associated with unrestrained cellular proliferation. Which of the following signaling molecules is the target for APC interaction?

(A) beta-catenin  
(B) MYC  
(C) p53  
(D) pRB  
(E) von Hippel-Lindau protein (pVHL)
1. **(D)** A urea cycle disorder (UCD) is likely in a neonate that has elevated serum ammonia appearing, not before, but between 24 and 48 hours after a normal term delivery. There are three hallmark symptoms associated with UCDs. These are hyperammonemia, encephalopathy, and respiratory alkalosis. Thus, elevated serum ammonia is not, in and of itself, indicative of a specific defect in the urea cycle. An analysis of the levels of various amino and organic acids in the plasma and urine is the primary key to determining which defect led to the elevation in serum ammonia. Differential diagnosis of neonatal hyperammonemia, as a consequence of a UCD can be accomplished by measurement of plasma citrulline and urinary orotic acid levels. Shown in Figure 3-6 is the standard differential diagnosis chart for determining which of four possible neonatal UCDs is the cause of the hyperammonemia. First, the hyperammonemia appears in the absence of any significant acidosis or ketosis. If analysis of serum citrulline demonstrates that it is >1000 μM it is confirmation that the clinical symptoms are due to a deficiency in ASD. In this circumstance it is not necessary to assay for levels of urinary orotic acid but they would be expected to be normal. Since citrulline levels are dramatically elevated in cases of ASD, choices A, B, and C are not correct.

2. **(D)** A deficiency in muscle phosphofructokinase results in glycogen storage disease type VII (Tarui disease). Clinically, the symptoms seen in Tarui disease are very similar to those seen in muscle phosphorylase deficiency (choice E), glycogen storage disease type V (McArdle disease) such as exercise-induced cramping and early fatigue. There are five...
clinical characteristics allowing distinction between Tarui and McArdle diseases: exercise intolerance is evident in childhood, is more severe, and is associated with nausea and vomiting; the intolerance is particularly acute following meals rich in carbohydrates; hyperuricemia is more severe; compensated hemolytic anemia is evidenced by increased serum bilirubin and reticulocyte count, and lastly; an abnormal polysaccharide is present in muscle fibers. Deficiency in glucose-6-phosphatase (choice A) is one cause of glycogen storage disease type I (specifically type Ia, von Gierke disease). Classic symptoms of this deficiency include neonatal hypoglycemia and lactic acidosis. If symptoms do not appear until the third or fourth month they include hepatomegaly and hypoglycemic seizures. Liver glycogen synthase deficiency (choice B) presents with morning fatigue and ketotic hypoglycemia on fasting—both of which rapidly disappear on feeding. Symptoms can be rapidly relieved and chemical signs corrected by introducing frequent protein-rich meals and nighttime feedings of suspensions of uncooked corn starch. Deficiency in glycogen debranching enzyme (choice C) results in glycogen storage disease type III (Cori or Forbes disease). Symptoms of type III disease are short stature, variable skeletal myopathy, cardiomyopathy, hepatomegaly, and hypoglycemia.

3. (A) Fabry disease is an X-linked disorder that results from a deficiency in alpha-galactosidase A. This leads to the deposition of neutral glycosphingolipids with terminal alpha-galactosyl moieties in most tissues and fluids. Most affected tissues are heart, kidneys, and eyes. The predominant glycosphingolipid accumulated is globotriaosylceramide \([\text{galactosyl-(}\alpha_1\rightarrow4]\text{-}\text{galactosyl-(}\beta_1\rightarrow4]\text{-}\text{glucosyl-(}\beta_1\rightarrow1')\text{-cer amide}]\). With increasing age, the major symptoms of the disease are due to increase in deposition of glycosphingolipid in the cardiovascular system. Indeed, cardiac disease occurs in most hemizygous males. Three types of Gaucher disease (choice B) have been characterized and are caused by defects in lysosomal acid beta-glucosidase (glucocerebrosidase). Defects in this enzyme lead to the accumulation of glucocerebrosides, which leads, primarily, to central nervous system (CNS) dysfunction and also hepatosplenomegaly and skeletal lesions. NPD (choice D) comprises three types of lipid storage disorder, two of which (type A and B NPD) result from a defect in acid sphingomyelinase. Type A is a disorder that leads to infantile mortality. Type B is variable in phenotype and is diagnosed by the presence of hepatosplenomegaly in childhood and progressive pulmonary infiltration. Pathologic characteristics of NPD are the accumulation of histiocytic cells that result from sphingomyelin deposition in cells of the monocyte-macrophage system. Tay-Sachs disease (choice E) results from a defect in hexosaminidase A leading to the accumulation of GM\(_2\) gangliosides, particularly in neuronal cells. This defect leads to severe mental retardation, progressive weakness, and hypotonia, which prevents normal motor development. Progression of the disease is rapid and death occurs within the second year. Krabbe disease (choice C), also called globoid-cell leukodystrophy, results from a deficiency in galactosylceramidase (galactocerebroside beta-galactosidase). This disease progresses rapidly and invariably leads to infantile mortality.

4. (B) GLP-1 is derived from the product of the proglucagon gene. This gene encodes a preproprotein that is differentially cleaved depending on the tissue in which it is synthesized. In the gut, prohormone convertase 1/3 action leads to release of several peptides including GLP-1. On nutrient ingestion GLP-1 is secreted from intestinal enteroendocrine L-cells. Bioactive GLP-1 consists of two forms: GLP-1(7-37) and GLP-1(7-36) amide, where the latter form constitutes the majority (80%) of the circulating hormone. The primary physiologic responses to GLP-1 are glucose-dependent insulin secretion, inhibition of glucagon secretion, and inhibition of gastric acid secretion and gastric emptying. The latter effect will lead to increased satiety with reduced food intake along with a reduced desire to ingest food. The action of GLP-1 at the level of insulin and glucagon secretion results in significant reduction in circulating levels of glucose following nutrient intake. The glucose-lowering
activity of GLP-1 is highly transient as the half-life of this hormone in the circulation is less than 2 minutes. Removal of bioactive GLP-1 is a consequence of N-terminal proteolysis catalyzed by DPP IV. DPP IV is also known as the lymphocyte surface antigen CD26 and has numerous activities unrelated to hormone inactivation. Although targeting compounds that can inhibit the enzymatic action of DPP IV would seem like ideal candidates for treating the hyperglycemia of uncontrolled diabetes, there are several unknowns associated with DPP IV inhibition. One of these issues is the fact that GLP-1 is only one of the many known substrates for DPP IV cleavage. Thus, prolonged inhibition of DPP IV enzymatic activity may have unexpected consequences unrelated to control of hyperglycemia. DPP IV is not known to hydrolyze glucagons (choice A), insulin (choice C), IGF-I (choice D), nor pancreatic polypeptide (choice E).

5. (C) PCT is the most common porphyria. Symptoms of PCT include cutaneous involvement and liver abnormalities, cutaneous features include chronic blistering lesions on sun-exposed skin. These lesions lead to skin thickening, scarring, and calcification. Symptoms usually develop in adults and are exacerbated by excess hepatic iron, alcohol consumption, induction of cytochrome P₄₅₀ enzymes as occurs in smokers. Symptoms of AIP (choice A) usually appear after puberty and are more frequent in females than in males. The majority of AIP carriers (>80%) do not exhibit symptoms, those who do manifest intermittent neurologic complications with no cutaneous photosensitivity. HCP (choice B) has clinical features and precipitating factors that are essentially identical to those of AIP with the addition of occasional skin photosensitivity. Veriegate porphyria, VP (choice D), symptoms are also very similar to those of AIP and HCP, but photosensitivity is more common than in HCP. X-linked sideroblastic anemia (choice E) is due to a defect in erythroid-specific porphyrin synthesis. The reduction in heme synthesis in affected individuals leads to erythropoiesis, which is ineffective. This results in nonferritin iron accumulation in the mitochondria of erythroblasts giving rise to the characteristic ring sideroblasts.

6. (A) Farber lipogrammatosis is characterized by painful and progressively deformed joints and progressive hoarseness due to involvement of the larynx. Subcutaneous nodules form near the joints and over pressure points. Granulomatous lesions form in these tissues and there is an accumulation of lipid-laden macrophages. Significant accumulation of ceramide and gangliosides is observed, particularly in the liver. If these compounds accumulate in nervous tissue there may be moderate nervous dysfunction. The illness often leads to death within the first few years of life, although milder forms of the disease have been identified. Fucosidosis (choice B) is characterized by the accumulation and excretion of glycoproteins, glycolipids, and oligosaccharides-containing fucoside moieties. Symptoms of fucosidosis include psychomotor retardation, dystosis multiplex (a term referring to multiple skeletal abnormalities), growth retardation, and coarse facial features. Gaucher disease (choice C) is characterized by an accumulation of glucosylceramide (glucocerebroside). Several forms of the disease have been identified and vary in severity. Typical symptoms include hepatosplenomegaly, bone lesions, and CNS involvement. Occasionally, the lungs and other organs may be involved. Metachromatic leukodystrophy (choice D) is a disorder of myelin metabolism. It is characterized by the accumulation of galactosyl sulfatide (cerebroside sulfate). Symptoms may appear at any age and include mental regression, urinary incontinence, blindness, loss of speech, peripheral neuropathy, and seizures. Sandhoff-Jatzkewitz disease (choice E) is a disorder related to Tay-Sachs disease. It is characterized by a defect in the degradation of GM₂ gangliosides with symptoms of severe mental retardation, blindness, and early mortality.

7. (B) ACE is responsible for the cleavage of two amino acids from angiotensin I, generating angiotensin II. Angiotensin II is a peptide hormone of the rennin-angiotensin system responsible for regulation of blood pressure. The
intra-renal baroreceptor system is a key mechanism for regulating renin secretion. A drop in pressure results in the release of renin from the juxtaglomerular cells of the kidneys. Renin secretion is also regulated by the rate of Na⁺ and Cl⁻ transport across the macula densa. The higher the rate of transport of these ions, the lower is the rate of renin secretion. The only function for renin is to cleave a 10-amino acid peptide from the N-terminal end of angiotensinogen-yielding angiotensin I. ACE action then generates angiotensin II, one of the most potent naturally occurring vasoconstrictors. In addition to the vascular effects, other physiological responses to angiotensin II include induction of adrenal cortex synthesis and secretion of aldosterone. Release of aldosterone leads to further Na⁺ retention by the kidneys with the consequences being an additional pressive effect on the vasculature. Thus, the use of ACE inhibitors would not only reduce the production of angiotensin II but also aldosterone. Synthesis and secretion of none of the other hormones (choices A, C–E) would be affected by ACE inhibitor administration.

8. (A) PBG deaminase (also called hydroxymethylbilane synthase) catalyzes the heme biosynthesis reaction involving the head-to-tail condensation of four molecules of PBG to produce the linear tetrapyrrole intermediate, hydroxymethylbilane. Hydroxymethylbilane can nonenzymatically cyclize into uroporphyrinogen I, which is why PBG deaminase is also known as uroporphyrinogen I synthase. ALA is the precursor for PBG, thus a defect in PBG deaminase would lead to excess ALA excretion. The compounds in choices B–E all represent products of reactions that are downstream of PBG deaminase in the heme biosynthetic pathway and thus would not be excreted in high amounts in someone with AIP.

9. (C) Many causes of insulin-resistance are due to defects that occur in events of the insulin-induced signaling cascade, which takes place after insulin binds to its receptor. All of the postreceptor responses initiated by insulin binding to its receptor are mediated as a consequence of the activation of several signal transduction pathways that require tyrosine phosphorylation of sites in the intracellular portion of the receptor. These include receptor activation of PI3K. Activation of PI3K involves a linkage to receptor activation of insulin receptor substrates (of which there are four: IRS-1, IRS-2, IRS-3, and IRS-4). Activated PI3K phosphorylates membrane phospholipids, the major product being phosphotidylinositol 3,4,5-trisphosphate, PIP₃. PIP₃ in turn activates the enzymes protein kinase B, PKB (also called Akt), PIP₃-dependent kinase (PDK), some isoforms of PKC, principally PKC-1, and small ribosomal subunit protein 6 kinase, S6K. The mitogen-activated protein (MAP) kinase pathway is also activated either through receptor activation of the protein tyrosine phosphatase (Shp-2) or growth factor receptor-binding protein-2 (Grb2). With respect to insulin responses, activation of PKB and PKC-1 leads to translocation of GLUT4 molecules to the cell surface, resulting in increased glucose uptake which is significant in skeletal muscle. Activation of PKB also leads to the phosphorylation of GSK3, which is a major regulatory kinase of glycogen homeostasis. In addition, PKB phosphorylates and inhibits the activity of a transcription factor (FKHRL1) that has proapoptotic activity. This results in reduced apoptosis in response to insulin action. Activation of S6K leads to the phosphorylation of the regulator of translation eIF-4E-binding protein, 4E-BP. Phosphorylation of 4E-BP prevents it from binding to eIF-4E, the consequences of which would normally lead to a reduction in translation rate. Insulin also has profound effects on the transcription of numerous genes, effects that are primarily mediated by regulated function of sterol-regulated element-binding protein (SREBP). These transcriptional effects include (but are not limited to) increases in glucokinase, PK, LPL, FAS, and ACC and decreases in glucose-6-phosphatase, fructose-1,6-bisphosphatase, and PEPCK. The insulin receptor does not phosphorylate the RAS gene product (choice A). Loss of activation of PLC-γ (choice B) would not prevent IRS proteins from binding to the activated insulin receptor. Serine phosphorylation of the insulin receptor (choice D) is not involved in IRS binding. Tyrosine phosphorylation of the insulin
10. (C) Heme is oxidized, with the heme ring being opened by the endoplasmic reticulum enzyme, heme oxygenase (see Figure 3-7). The oxidation step requires heme as a substrate, and any hemin (Fe³⁺) is reduced to heme (Fe²⁺) prior to oxidation by heme oxygenase. The oxidation occurs on a specific carbon producing the linear tetrapyrrole biliverdin, ferric iron (Fe³⁺), and CO. This is the only reaction in the body that is known to produce CO. Most of the CO is excreted through the lungs, with the result that the CO content of expired air is a direct measure of the activity of heme oxidase in an individual. Biliverdin reductase (choice A) catalyzes the conversion of biliverdin to bilirubin as shown in Figure 3-7. Coproporphyrinogen oxidase (choice B), protoporphyrinogen oxidase (choice D), and uroporphyrinogen decarboxylase (choice E) are all involved in the synthesis of heme and do not produce CO in the course of catalyzing their reactions.

11. (E) CPS-I is absolutely dependent on the allosteric effector N-acetylglutamate for its activity. This allosteric effector is synthesized by the enzyme N-acetylglutamate synthetase, which is activated by the urea cycle amino acid arginine. None of the other compounds (choices A, B, C, and D) have any effect on CPS-I activity.

12. (B) The pituitary gonadotrophs are cells that secrete the gonadotrophic peptide hormones, follicle-stimulating hormone (FSH), and luteinizing hormone (LH). FSH acts on Sertoli cells of the testis inducing androgen-binding protein synthesis, which maintains a high concentration of testosterone in tubules increasing spermatogenesis. In the ovary, FSH stimulates aromatase activity in the granulose cells stimulating ovum maturation and estradiol production. Pituitary corticotrophs are the ACTH-secreting cells (choice A), somatotrophs secrete growth hormone (choice C), lactotrophs secrete prolactin (choice D), and thyrotrophs secrete thyroid-stimulating hormone (choice E).

13. (B) There are three reactions of glycolysis that are thermodynamically irreversible. These are the hexokinase (glucokinase), PFK-1, and PK-catalyzed reactions. Reactions that are essentially irreversible in most metabolic pathways are subject to complex regulatory controls and represent rate-limiting steps in the pathway. The primary site of regulation of glycolysis occurs at the level of the PFK-1-catalyzed step. Hence, this reaction is the rate-limiting step in glycolysis. PFK-1 is subject to allosteric control by numerous compounds. Citrate and ATP inhibit the activity of PFK-1, while AMP and fructose 2,6-bisphosphate (F2,6-BP) activate the enzyme. The principal control of PFK-1 activity is exerted by alterations in the level of F2,6-BP. This compound is synthesized from fructose-6-phosphate by the bifunctional enzyme, PFK-2/fructose-2,6-bisphosphatase (PFK-2/F2,6-BPase). PFK-2 (choice C) contains two catalytic domains, one a kinase and the other a phosphatase, the activities of which are affected by the state of phosphorylation. The phosphatase domain is active when the enzyme is phosphorylated and converts F2,6-BP back to F6-P, thereby reducing the levels of this powerful activator of PFK-1. Thus, although the activity of PFK-2 will determine the rate of activity of PFK-1, it is itself not the rate-limiting enzyme in glycolysis. Glyceraldehyde-3-phosphate dehydrogenase (choice A) and PGK (choice D) are...
not regulated enzymes of glycolysis. PK (choice E) is regulated during glycolysis, but does not constitute a rate-limiting step.

14. (E) The statin class of cholesterol-lowering drugs all exert their effects on the activity of HMG-CoA reductase. This enzyme carries out the rate-limiting step in cholesterol biosynthesis. The cholestyramine-based resins are used therapeutically to bind up intestinal bile salts, which increases the excretion of bile (choice A). The net effect of increased bile excretion is increased diversion of cholesterol into bile acid synthesis, thereby lowering circulating cholesterol levels. No current therapy targets synthesis of apolipoprotein synthesis (choice B), decreasing intestinal absorption of cholesterol (choice C), or inhibition of LDL-receptor interactions (choice D).

15. (C) Essential fructosuria is an autosomal recessive disorder manifesting benign asymptomatic due to a lack of fructokinase. The principal clinical signs of essential fructosuria are hyper-fructosemia and fructosuria. Deficiency in aldolase B (choice A) results in the clinically severe disorder, hereditary fructose intolerance. Symptoms include severe hypoglycemia and vomiting after ingestion of fructose. Prolonged fructose ingestion by infants with this disorder will lead to poor feeding, hepatomegaly, vomiting, jaundice, and eventually hepatic failure and death. Aldolase A deficiency (choice B) is very rare and has only been observed associated with erythrocytes and fibroblasts and leads to hemolytic anemia. Hexokinase deficiency (choice D) is also rare and associated with erythrocyte disfunction leading to chronic hemolytic anemia. Deficiency in PFK-1 (choice E) results in the glycogen storage disease known as Tarui disease. Symptoms of PFK-1 deficiency include exercise-induced cramping and pain, myoglobinuria, and hemolytic anemia.

16. (A) The synthesis of the cyclic eicosanoids (the prostaglandins and the thromboxanes) begins with the cyclization of arachadonic acid. This reaction is carried out by the enzyme prostaglandin endoperoxide synthetase. This enzyme has two distinct activities, cyclooxygenase and a peroxidase. The activity of the cyclooxygenase domain is inhibited by a class of compounds referred to as the NSAIDs. Aspirin is of this class of drug and, therefore, inhibits the cyclooxygenase activity. The inhibition of prostaglandin synthesis has a negative effect on the process of coagulation through a reduction in the production of TXA₂, a potent activator of platelet function. Aspirin also reduces the production of prostacyclin (PGI₂) by endothelial cells. PGI₂ is a vasodilator and an inhibitor of platelet aggregation. Since endothelial cells regenerate active cyclooxygenase faster than platelets, the net effect of aspirin is more in favor of endothelial cell-mediated inhibition of the coagulation cascade. The action of the steroidal anti-inflammatory drugs occurs through the inhibition of phospholipase A₂ (choice C), and inhibition of this enzyme has no direct effect on the coagulation process. The other choices (B, D, and E) are not targets for the action of aspirin.

17. (A) The first step in gluconeogenesis is the formation of oxaloacetate from pyruvate. The enzyme controlling this step is pyruvate carboxylase, an allosteric enzyme that does not function in the absence of its primary effector, acetyl-CoA, or closely related acyl-CoA. Thus, a high level of acetyl-CoA signals the need for more oxaloacetate. Under conditions of low ATP, oxaloacetate will be used for gluconeogenesis. If there is a surplus of ATP, oxaloacetate will be consumed in the citric acid cycle. Citrate is the primary negative effector of glycolysis and the primary positive effector of fatty acid synthesis. High levels of citrate (choice C), but not low levels (choice E), do positively affect the activity of fructose-1,6-bisphosphatase, one of the bypass enzymes of gluconeogenesis, but this is not the primary site of control, since the carbon atoms must first go through the pyruvate carboxylase reaction. Low ATP levels (choice D) would be reflected in an elevation in ADP levels, and ADP negatively affects the activity of pyruvate carboxylase. High ATP levels (choice B) are necessary in order for gluconeogenesis to proceed, and will negatively affect glycolysis at the level of PFK-1, allowing
for an increased net flow of carbon into glucose. However, increased levels of ATP do not directly regulate the enzymes of gluconeogenesis.

18. (A) Andersen disease (also referred to as type IV glycogen storage disease) manifests its symptoms as a result of the accumulation of glycogen, with unbranched long outer chains in tissues. This structure of glycogen resembles that of plant amyllopectin. Symptoms appear within the first year of life and lead to failure to thrive and pronounced heptosplenomegaly. Hypoglycemia is rarely seen with this disorder. Cori disease (choice B) affects both liver and muscle with accumulations of glycogen that has short outer chains (resembles limit dextrin). Symptoms include hepatomegaly, hypoglycemia, hyperlipidemia, and retarded growth. McArdle disease (choice C) usually manifests in adulthood and characteristic symptoms include exercise intolerance, muscle cramping with exercise, and myoglobinuria. The affected tissue in this disease is only skeletal muscle. Tarui disease (choice D) also affects skeletal muscle and as such manifests with clinical symptoms very similar to those of McArdle disease with the exceptions that Tarui patients also experience hemolytic anemia and myogenic hyperuricemia. Symptoms of von Gierke disease (choice E) result from the excessive accumulation of glycogen in liver, kidney, and intestinal mucosa. Symptoms include growth retardation, hypoglycemia, heptomegaly, hyperlipidemia, lactic acidemia, and hyperuricemia.

19. (E) Members of the E2F family of transcription factors play critical roles in regulating cell-cycle transit through the G1-S restriction point. The activity of E2F is regulated by interaction with the protein product of the retinoblastoma susceptibility tumor suppressor gene, pRB. Interaction of pRB and E2F occurs when pRB is in a hypophosphorylated state (Figure 3-8). Members of the cyclin-dependent kinase family of cell-cycle regulating kinases target pRB for phosphorylation. When phosphorylated, pRB dissociates from E2F allowing E2F to enter the nucleus and transcriptionally activate genes involved in DNA synthesis, as well as activate its own transcription. Transcription of both cyclin E and CDK2 are activated by E2F. These two proteins form a complex that promotes progression through S-phase of the cell cycle and also act to keep E2F active by adding to the phosphorylation state of pRB (Figure 3-8). Thus, any defect in the ability of pRB to bind to E2F will lead to constitutive activation of DNA synthesis leading to unrestrained proliferation. None of the other options (choices A–D) represent viable phenomena to account for the observed increase in E2F activity.

20. (B) The posttranslational modification of histone proteins has considerable effect on numerous activities at the level of the chromatin. In particular, the acetylation and/or methylation of histones in the nucleosome (H2A, H2B, H3, and H4) results in an altered stability of the 30-nm chromatin fiber as well as other higher order
chromatin structure. No specific regions of remodeling have been identified relative to sequence content such as CpG islands (choice A). Methylation of cytosine residues in the DNA (choice C) has an effect on transcriptional activity but not on chromatin structure. Methylation of the linker histone, H1 (choice D) has not been demonstrated. Chromatin remodeling does not direct imprinting (choice E). Imprinting is regulated by the state of DNA methylation.

21. (A) Deficiency in glucose-6-phosphatase (choice A) is one cause of glycogen storage disease type I (specifically type Ia, von Gierke disease). Hallmarks of the disease are hypoglycemia, lactic acidosis, hyperuricemia, and hyperlipidemia. If symptoms do not appear until the third or fourth month they include hepatomegaly and hypoglycemic seizures. Afflicted children have a protruberant abdomen due to the massive hepatomegaly. Outward physical signs also include extremely thin extremities, short stature, and chubby doll-like faces. Liver glycogen synthase deficiency (choice B) presents with morning fatigue and ketotic hypoglycemia on fasting—both of which rapidly disappear on feeding. Symptoms can be rapidly relieved and chemical signs corrected by introducing frequent protein-rich meals and nighttime feedings of suspensions of uncooked corn starch. A deficiency in muscle phosphofructokinase (choice C) results in glycogen storage disease type VII (Tarui disease). Clinically, the symptoms seen in Tarui disease are very similar to those seen in muscle phosphorylase deficiency (choice D), glycogen storage disease type V (McArdle disease) such as exercise-induced cramping and early fatigue. There are five clinical characteristics allowing distinction between Tarui and McArdle disease: exercise intolerance is evident in childhood and more severe and is associated with nausea and vomiting; the intolerance is particularly acute following meals rich in carbohydrates; hyperuricemia is more severe; compensated hemolytic anemia is evidenced by increased serum bilirubin and reticulocyte count, and lastly; an abnormal polysaccharide is present in muscle fibers. Deficiency in PK (choice E) is the most common enzyme deficiency leading to hemolytic anemia and the disorder is characterized by lifelong episodes. The most severe deficiency will result in embryonic lethality.

22. (C) Acetyl-CoA cannot freely diffuse across the membranes of the mitochondria, nor is there a transport mechanism to move the molecule to the cytosol. This ensures that all acetyl-CoA generated by PDH or fat oxidation will be used for energy production. However, as cellular energy demand falls, carbon atoms can be diverted into storage molecules such as glycogen and fatty acids. To move acetyl-CoA out of the mitochondria to the cytosol it must first be converted to citrate, which can be transported by the TCA transport system (Figure 3-9). As indicated, acetyl-CoA (choice A) is “trapped” inside the mitochondria. Carnitine (choice B) is necessary for transport of fatty acids into the mitochondria prior to their oxidation, but plays no role in acetyl-CoA transport. Ketone bodies such as beta-hydroxybutyrate (choice D) are generated in hepatic mitochondria when acetyl-CoA is in excess. However, usage of ketone bodies by nonhepatic tissues involves conversion to acetyl-CoA with the mitochondria, not the cytosol. Pyruvate (choice E) can be transported into the mitochondria but not out.

23. (E) The principal mineralocorticoid, produced by the zona glomerulosa cells of the adrenals, is aldosterone. Synthesis of aldosterone is primarily controlled by the rennin-angiotensin system and is thus involved in control of blood pressure. Aldosterone causes sodium reabsorption by the kidneys, which in turn regulate water balance, which leads to increases in blood pressure by increasing fluid volume. Aldosterone action does not directly lead to decreased carbohydrate metabolism (choice A), is not a sex characteristic determining steroid hormone (choice B), does not result in increased synthesis of androgens (choice C), and does not regulate its own secretion (choice D).

24. (C) Severe hereditary galactosemia presents in the first few months of life with symptoms that include poor feeding and associated weight loss, vomiting, diarrhea, lethargy, and hypotonia. Clinical findings will include those presented
in the case. The symptoms are aggravated by consumption of cow's milk and can be resolved provided proper diagnosis is made and treatment is started early. Alkaptonuria (choice A) results from the accumulation of homogentisic acid, a by-product of tyrosine catabolism, in the urine and tissues. Oxidation of homogentisate in the urine causes it to turn dark and in the tissues results in ochronosis, which refers to the ochre color of the deposits in connective tissue, bones, and other organs. Essential fructosuria (choice B) is a benign asymptomatic metabolic disorder manifesting with alimentary hyper-fructosemia and fructosuria. Menkes disease (choice D) results from a defect in intracellular copper transport and the symptoms of the disease are caused by loss of function of copper-dependent enzymes. Symptoms include abnormal (kinky) hair and pigmentation, cerebral degeneration, failure to thrive, and skin laxity. Symptoms of von Gierke disease (choice E) result from the excessive accumulation of glycogen in liver, kidney, and intestinal mucosa. Symptoms include growth retardation, hypoglycemia, heptomegaly, hyperlipidemia, lactic acidemia, and hyperuricemia.

25. (C) The oxidation of long-chain fatty acids is initiated by the sequential action of carnitine palmitoyltransferase-I (CPTI), which is located in the outer mitochondrial membrane, and carnitine palmitoyltransferase II, which is located in the inner mitochondrial, together with a carnitine-acylcarnitine translocase. Major control over the process is exerted at the level of CPTI by virtue of the unique inhibitability of this enzyme by malonyl-CoA. Thus, CPTI has a pivotal role in lipid metabolism. Obese individuals have higher overall dietary intake of lipid and the disruption in fat metabolism exacerbates the increases in malonyl-CoA, which propagates the fuel partitioning disorder. Although an increase in hepatic ATP (choice A) will lower the flux through the TCA cycle, this does not constitute a mechanism for a disruption in fuel partitioning. The rate of hepatic gluconeogenesis (choice B) does not significantly affect fat metabolism. Obese individuals actually have reduced responses to insulin (choice D) and thus any insulin-mediated effects on ACC would be minimal. Insulin does not repress FAS activity (choice E).

26. (D) Menkes disease is an X-linked recessive disorder that is manifest by a defect in copper absorption. This defect leads to dysfunction of numerous enzymes that need copper as a
cofactor, leading to the typical symptoms observed in this patient. In fact, Menkes disease is also referred to as steely hair disease, because of the characteristic brittleness of the hair, which is easily broken. Crigler-Najjar syndrome type I (choice A) is also due to defective bilirubin metabolism as a result of a loss of UDP-glucuronosyltransferase (UGT) activity. UGT is required to transfer 2 moles of glucuronic acid to bilirubin, generating bilirubindiglucuronide, which makes bilirubin much more water soluble and therefore facilitates its excretion. Crigler-Najjar syndrome results in nonhemolytic icterus (jaundice) within the first few days of life and is generally fatal during neonatal life due to severe kernicterus. Gilbert syndrome (choice B) results from a defect in bilirubin metabolism. It is typically diagnosed in young adults and is characterized by mild, chronic, and unconjugated hyperbilirubinemia without associated hemolysis. Hemochromatosis (choice C) is the term applied when organ structure and function are impaired by the presence of excess amounts of iron. The liver, heart, pancreas, skin, joints, and endocrine organs are the principal tissues affected by iron accumulation. Symptoms include cirrhosis, cardiomyopathy, arthritis, abnormal skin pigmentation, and hypogonadism, as well as diabetes mellitus. Refsum disease (choice E) results from a defect in the metabolism of phytanic acid, a plant lipid which must be oxidized by a separate pathway from that of animal fats. Cardinal symptoms include retinitis pigmentosa, peripheral neuropathy, and cerebellar ataxia.

27. (C) The platelet membrane glycoprotein complex, GPIIb-GPIIIa, is a receptor for fibrinogen. Presentation of GPIIb-GPIIIa on the surface of activated platelets leads to platelet cross-linking. The cross-linking occurs between activated platelets that are adhered to the endothelial cell surface via interaction of the platelet surface complex GP1a-GPIIa with exposed collagen, as well as between platelets in the local circulation. The effect is to ensure that a loose platelet plug forms rapidly at the site of vascular injury stemming the flow of blood until a fibrin clot can be formed. Activation of platelet PKC (choice A) is the consequence of thrombin binding to platelet thrombin receptors. Cleavage of high molecular weight kininogen (choice B) occurs upon the activation of factor XII. Release of thrombin from platelet alpha granules (choice D) occurs in response to platelet activation. Activation of platelets must first occur in order for GPIIb-GPIIa to be presented on the surface and, thus, this glycoprotein complex is not directly involved in platelet activation and granule release. Vasoconstriction, in concert with hemostasis (choice E), occurs primarily as a result of the action of serotonin released from alpha granules of activated platelets.

28. (E) Glucagon is released from the pancreas in response to low blood glucose and stimulates hepatocytes to synthesize glucose for delivery to the blood. Therefore, it would be counterproductive for hepatocytes to divert any of the gluconeogenically derived glucose into glycogen. This is accomplished by inhibition of glycogen synthase. Glucagon exerts its effects on the liver through the glucagon receptor. When glucagon binds, the receptor activates adenylate cyclase leading to increased production of cAMP. In turn, cAMP activates cAMP-dependent protein kinase, which then phosphorylates a number of substrates. Glucagon has no effect on the level of phosphoprotein phosphatase (choice A). One of the substrates of PKA is glycogen synthase/phosphorylase kinase. Therefore, there would not be a decrease in the level of phosphorylated phosphorylase kinase (choice B). In turn, synthase/phosphorylase kinase phosphorylates glycogen phosphorylase and glycogen synthase. Therefore, there is no increase in the level of dephosphorylated glycogen synthase (choice C). Phosphorylation inhibits glycogen synthase activity and activates phosphorylase. In addition, PKA itself can phosphorylate glycogen synthase. The net effect is an increase in the rate of glucose phosphorylisis from glycogen and a reduced incorporation of glucose into glycogen. An additional PKA substrate is phosphoprotein phosphatase inhibitor-1, and therefore there would not be a decrease in the level of the phosphorylated form of this enzyme (choice C).
29. (A) In the genetic disorder known as Tay-Sachs disease, ganglioside GM₂ is not catabolized. As a consequence, the ganglioside concentration is elevated many times higher than normal. The functionally absent lysosomal enzyme is beta-N-acetylhexosaminidase. The elevated GM₂ results in irreversible brain damage to infants, who usually die before the age of 3 years. Under normal conditions, this enzyme cleaves N-acetylgalactosamine from the oligosaccharide chain of this complex sphingolipid, allowing further catabolism to occur. The cause of most lipidoses (lipid storage diseases) is similar. That is, a defect in catabolism of gangliosides causes abnormal accumulation. None of the other choices (B, C, D, and E) result in glycosphinogolipidoses such as is characteristic of Tay-Sachs disease.

30. (A) In fasting or diabetes, lipolysis predominates in adipocytes because of the inability of these cells to obtain glucose, which is normally used as a source of glycerol-3-phosphate. Glycerol-3-phosphate is necessary for the esterification of fatty acids into triacylglycerides. Circulating fatty acids become the predominant fuel source, and beta-oxidation in the liver becomes substantially elevated. This leads to an increased production of acetyl-CoA. Although gluconeogenesis is increased (choice E) in the liver as a result of the persistent elevation of glucagon levels, this pathway does not supply acetyl-CoA for the production of ketone bodies. The increased gluconeogenesis predisposes oxaloacetate and reduces (not increases, choice B) the flow of acetyl-CoA through the citric acid cycle. As a consequence, acetyl-CoA is diverted to the formation of ketone bodies. The persistently elevated levels of glucagon also increase the levels of cAMP in responsive tissues, such as adipocytes (choice C). This effect in adipocytes leads to persistently increased release of fatty acids to the circulation. Since skeletal muscle lacks receptors for glucagon, there is no diabetes-mediated increase in muscle metabolism and thus no elevation in acetyl-CoA levels in skeletal muscle (choice D).

31. (B) The eIF-2 cycle consists of the translation initiation factors, eIF-2A and eIF-2B (also called guanine-nucleotide exchange factor, GEF). The cycle involves the binding of GTP by eIF-2A forming a complex that then interacts with the initiator methionyl-tRNA. When the initiator methionyl-tRNA is placed into the correct position of the 40S ribosomal subunit, the GTP is hydrolyzed (generating GDP and release of P) to provide the energy necessary to correctly position the incoming mRNA such that the initiator AUG codon and the initiator methionyl-tRNA anticodon are aligned. In order to regenerate an active eIF-2A for subsequent translation initiation events, the GDP must be exchanged for GTP. The exchange reaction is catalyzed by eIF-2B. The initiation factor, eIF-1 (choice A), facilitates the correct positioning of the initiator methionyl-tRNA and the mRNA. Initiation factor eIF-4A (choice C) binds to the mRNA and is required to “melt” any secondary structure that may exist at the 5’-end of the mRNA. Initiation factor eIF-4E (choice E) acts as a scaffold for eIF-4E facilitating cap structure binding by eIF-4E. Together, the complex composed of eIF-4A, eIF-4E, and eIF-4G is sometimes referred to as eIF-4F.

32. (D) Fragile X syndrome is the most common form of inherited mental retardation. The symptoms of this disorder are caused by a disruption in the FMR1 gene. The disruption occurs as a result of the expansion of a trinucleotide repeat sequence in the 5’ untranslated region of the FMR1 gene. The severity of mental retardation in fragile X syndrome is proportional to the level of expansion of the trinucleotide repeat. Copper accumulation leading to Kayser-Fleisher rings in the eyes (choice A) is indicative of Wilson disease, which results from impaired biliary copper excretion. The symptoms of hypoketotic hypoglycemia and metabolic acidosis (choice B) are indicative of glutaric acidemia type II, which results from deficiencies in mitochondrial ubiquinone oxidoreductase. Isovaleric acidemia (choice C) is a severe neonatal disorder resulting from a deficiency in one of the enzymes of branched-chain amino acid metabolism, isovaleryl-CoA dehydrogenase. Accumulation of
abnormally high levels of very long-chain fatty acids and defects in myelin formation (choice E) are symptoms associated with X-linked adrenoleukodystrophy (X-ALD).

33. (C) An individual with a normal profile of hemoglobin would have the largest percentage in the form of HbA reflecting normal expression from the alpha- and beta-globin genes. All individuals carry a small percentage (1–2%) of the fetal form, HbF, and the form which contains the δ-globin chains in place of the beta-globin of HbA. This latter hemoglobin is termed HbA₂. The increase in the level of the fetal hemoglobin in this patient, along with the presence of a reduced level of the adult form, indicates that there is a defect in the ability to express normal levels of the beta-globin genes. This would be due to a promoter defect in the beta-globin gene. A complete deletion of the alpha-globin locus (choice A) leads to the condition known as hydrops fetalis and is incompatible with life. Complete loss of the beta-globin genes (choice B) results in the condition referred to as beta-thalassemia and there would be no HbA present in the blood. Nonsense mutations in the alpha-globin (choice D) or beta-globin (choice E) genes would result in phenotypes similar to those of gene deletions at these loci.

34. (D) Ketogenesis occurs in the liver from acetyl-CoA during high rates of fatty acid oxidation and during early starvation. The principal ketone bodies are acetoacetate and beta-hydroxybutyrate, which are reversibly synthesized in a reaction catalyzed by beta-hydroxybutyrate dehydrogenase. The liver delivers beta-hydroxybutyrate to the circulation where it is taken up by non-hepatic tissue for use as an oxidizable fuel. The brain will derive much of its energy from ketone body oxidation during fasting and starvation. Within extra-hepatic tissues, beta-hydroxybutyrate is converted to acetoacetate by beta-hydroxybutyrate dehydrogenase. Acetoacetate is reactivated to acetoacetyl-CoA in a reaction catalyzed by succinyl-CoA: acetoacetate-CoA-transferase (also called acetoacetate: succinyl-CoA-CoA transferase), which uses succinyl-CoA as the source of CoA. This enzyme is not present in hepatocytes. The acetoacetyl-CoA is then converted to 2 moles of acetyl-CoA by the thiolase reaction of fatty acid oxidation. Each of the other enzyme choices (A, B, C, and E) are found within hepatocytes.

35. (B) The telomeric end on the lagging strand of a replicating eukaryotic chromosomes are synthesized by an enzymatic activity termed telomerase. None of the other mechanisms (choices A, C–E) represent the accurate replication of telomeres.

36. (B) In the liver, hemin acts as a feedback inhibitor on ALA synthase reducing its activity. In addition, hemin acts to repress transport of ALA synthase into the mitochondria as well as repressing synthesis of the enzyme. Therefore, a continued synthesis of protoporphyrin IX in the presence of hemin indicates that ALA synthase is active but nonresponsive to the inhibitory action of hemin. None of the other enzymes of heme biosynthesis (choices A, C–E) are inhibited by hemin.

37. (B) Hemochromatosis is defined as a disorder in iron metabolism that is characterized by excess iron absorption, saturation of iron-binding proteins, and deposition of hemosiderin in the tissues. The primary affected tissues are the liver, pancreas, and skin. Iron deposition in the liver leads to cirrhosis and in the pancreas causes diabetes. The excess iron deposition leads to bronze pigmentation of the organs and skin. In fact, the bronze skin pigmentation seen in hemochromatosis, coupled with the resultant diabetes lead to the designation of this condition as bronze diabetes. The primary cause of hemochromatosis is the inheritance of an autosomal recessive allele. The locus causing hemochromatosis has been designated HFE and is a major histocompatibility complex (MHC) class-1 gene. The gene encodes an alpha-chain protein with three immunoglobulin-like domains. This alpha-chain protein associates with beta-2-microglobulin. Normal HFE has been shown to form a complex with the transferrin receptor and in so doing is thought to regulate the rate of iron transfer into cells. A mutation in HFE will therefore, lead to
increased iron uptake and storage. The majority of hereditary hemochromatosis patients harbor a mutation in HFE that results in the substitution of Cys 282 for a Tyr. This mutation causes loss of conformation of one of the immunoglobulin domains in HFE. Another mutation found in HFE causes a change of His 68 to Asp. DMT1 (choice A) is responsible for the intestinal absorption of dietary iron and thus, a deficiency in this protein would lead to reduced total body iron, not excess. Ferritin (choice C) is the intracellular iron binding and storage protein. A deficiency in ferritin would lead to less iron deposition, not excess. Ferroportin (choice D) is the iron transport protein that moves dietary iron from within intestinal enterocytes across the basolateral membrane to the circulation, therefore, a deficiency in this protein would have consequences similar to deficiencies in DMT1. Transferrin (choice E) is the iron transport protein of the blood that binds to the trasferrin receptor on cell surfaces, allowing cellular uptake of circulating iron. A deficiency in this protein would lead to less iron deposition not more.

38. (A) The symptoms exhibited by the infant are reflective of maple syrup urine disease (MSUD). This disease is caused by defects in branched-chain alpha-keto acid dehydrogenase, one of the enzymes used in the catabolism of the branched-chain amino acids (BCAAs) and the associated branched-chain alpha-keto acids (BCKAs). The classical symptom of this disease is the odor of burnt sugar in the diapers of afflicted infants. Left untreated, infants will die in the first few months of life from recurrent metabolic crisis and neurologic deterioration. Deficiency in cystathione synthase (choice B) manifests with elevated urine homocysteine. The major sites of organ involvement are the CNS, the skeletal and vascular systems, and the eyes. The involvement of the vascular system leads to thromboembolism and is the major cause of death with cystathionine synthase deficiency. The GCC (choice C) is responsible for the catabolism of glycine to CO$_2$, NH$_4^+$, and N$^6,N^{10}$-methylene-THF. Deficiency in the GCC results in nonketotic hyperglycinemia. Deficiency in homogentisate oxidase (choice D) is the cause of alkaptonuria. Alkaptonuria is characterized by urine that turns brown on exposure to air. Deficiency in phenylalanine hydroxylase causes hyperphenylalaninemia (phenylketonuria, PKU). Newborn screening occurs in many countries including the United States and the disorder can be effectively treated with dietary intervention.

39. (D) Osteogenesis imperfecta consists of a group of at least four types (mild, extensive, severe, and variable). The disorder is characterized by brittle bones and abnormally thin sclerae, which appear blue owing to the lack of connective tissue. The symptoms arise due to defects in two alpha-collagen genes, the COL1A1 and COL1A2 genes. There have been over 100 mutations identified in these two genes. The mutations lead to decreased expression of collagen or abnormal pro1 proteins. The abnormal proteins associate with normal collagen subunits, which prevents the triple helical structure of normal collagen to form. The result is degradation of all the collagen proteins, both normal and abnormal. Ehlers-Danlos syndrome (choice A) comprises at least 10 defined types of a related disorder. Characteristic clinical features are easy bruising, markedly soft hyperextensible skin, extreme joint hypermobility, and the formation of thin, atrophic, “cigarette-paper” scarring following injury. Marfan syndrome (choice B) results in cardiovascular, musculoskeletal, and ophthalmic abnormalities. Hallmark clinical manifestations are aortic dilation, mitral valve prolapse, dissecting aneurysms, arachnodactyly, and ectopia lentis. Occipital horn syndrome (choice C), a disorder that manifests with symptoms similar to other collagen metabolism disorders, results from defects in copper metabolism. Clinical features include loose skin and joints, hernias, and abnormally shaped bones. Scurvy (choice E), which is caused by a deficiency in vitamin C, is characterized by decreased wound healing and hemorrhaging, anemia, osteoporosis, soft swollen gums, and easily bruised skin.

40. (E) The influence of obesity, genetic profile, and age on overall metabolism is most significant at
the level of skeletal muscle sensitivity to the actions of insulin (Figure 3-10). Due to the overall mass of skeletal muscle in the body, the uptake of glucose by this tissue, and consequently its role in blood glucose homeostasis, is a significant factor in insulin responses. Progressive loss of skeletal muscle sensitivity to insulin leads to increased rates of visceral cell lipolysis and pancreatic beta-cell compensation. Eventually, the pancreas can no longer continue compensating for impaired insulin responses and pancreatic beta-cell decompensation occurs, further exacerbating the problem. The disrupted insulin response leads to increased hepatic gluconeogenesis, which further increases circulating glucose levels. The overall outcome of these responses is development of progressively worsening Type II diabetes. Whereas, each of the other options (choices A–D) will ensue due to impaired insulin responses in skeletal muscle, none is significant in the development of diabetes.

41. (E) Wolman disease results from a deficiency in the lysosomal acid lipase enzyme (also called cholesteryl ester hydrolase) and is very nearly always a fatal disease of infancy. Symptoms of the disorder arise from massive accumulation of cholesteryl esters and triglycerides in most tissues. Clinical manifestations include hepatosplenomegaly leading to abdominal distention, GI abnormalities, steatorrhea, and...
adrenal calcification. Type I hyperlipoproteinemia (choice A) results from a deficiency in LPL activity. LPL is the enzyme found on the surface of vessel endothelial cells and is responsible for hydrolyzing fatty acids from the triglycerides found in circulating lipoprotein particles. This action allows cells to get fatty acids for energy production from lipoproteins in the plasma. This disorder leads to massive accumulation of chylomicrons and triglycerides in the plasma. Symptoms associated with type I hyperlipoproteinemia are usually detected in childhood and include eruptive cutaneous xanthomatosis, hepatosplenomegaly, and repeated episodes of abdominal pain. I-cell disease (choice B) results from a deficiency in the targeting of lysosomal enzymes to the lysosomes. Affected cells have dense inclusion bodies filled with storage material, hence the derivation of the disease name. There are elevated levels of lysosomal enzymes in the plasma and body fluids of I-cell patients. Symptoms include severe psychomotor retardation, coarse facial features, and severe skeletal abnormalities. The rapidly progressing disease can lead to death between 5 and 8 years of age. Maroteaux-Lamy syndrome (choice C) results from a defect in the enzyme N-acetylgalactosamine-4-sulfatase (arylsulfatase B) responsible for the catabolism of complex glycosaminoglycans. There are three distinct forms of Maroteaux-Lamy syndrome that range in severity. Symptoms include coarse facial features, skeletal abnormalities corneal clouding, and aortic valve disruption. Sanfilippo syndrome (choice D) comprises at least four distinct genetic defects that result from deficiencies in enzymes required for the catabolism of complex glycosaminoglycans of the heparan sulfate class. In all cases, the clinical symptoms are similar and include severe mental deterioration, hyperactivity, and disorders in the skin, lungs, heart, and skeletal muscle.

42. (C) During early fasting, as the level of glucose in the blood falls, the pancreas releases glucagon into the circulation to counter this drop. The major site of glucagon action is the liver. There it induces the activity of the glycogen phosphorylase leading to an increase in glucose release from glycogen stores. Thus, an inhibition of glycogen phosphorylase would limit the ability of the liver to provide glucose to the blood. Negatively affecting the activity of glycogen phosphorylase would not significantly affect the rate of hepatic fatty acid oxidation (choice A), skeletal muscle glucose usage (choice D), nor hepatic gluconeogenesis (choice E). The liver may have a reduced capacity for de novo storage of glucose following meals (choice B) due to a prior reduction in the release of glucose via the inhibition of glycogen phosphorylase; however, on fasting there would still be a reduction in glucose release.

43. (D) The presence of apo CII on the surfaces of lipoprotein particles is necessary for the activation of endothelial cell LPL. Apo AI (choice A) activates LCAT. Apo B_{48} (choice B) is derived via intestinal-specific RNA editing and is exclusively a component of chylomicrons. Apo B_{100} (choice C) and E (choice E) are necessary for LDL interaction with the LDL receptor.

44. (D) The lactotrophs of the anterior pituitary secrete prolactin in response to the action of PRF. Corticotropin-releasing hormone, CRH (choice A) regulates primarily the secretion of ACTH, but also other products of the ACTH precursor protein, pro-opiomelanocortin, POMC. GnRH (choice B) controls the secretion of follicle-stimulating hormone (FSH) and luteinizing hormone (LH) from the pituitary gonadotrophs. GRH (choice C) stimulates growth hormone secretion from pituitary somatotrophs. TRH (choice E) stimulates the thyrotropes to secrete thyroid-stimulating hormone, TSH (also called thyrotropin).

45. (C) A deficiency in OTC results in one of the urea cycle defect diseases, which are the major causes of hyperammonemia in the newborn. Differentiation of which urea cycle enzyme is defective and causing the hyperammonemia can be accomplished by analysis of the levels of the various intermediates in the cycle (see Figure 3-6 for UCD DDx). A defect in OTC prevents incorporation of carbamoylphosphate into ornithine (see Figure 3-11). The carbamoylphosphate will diffuse out of the mitochondria and serve as a precursor for the
synthesis of the pyrimidine nucleotides in excess of need leading to an elevation of orotic acid (pyrimidine intermediate) in the blood. A deficiency of the urea cycle enzyme, ASD, will lead to citrullinemia (choice A). Elevation in excretion of argininosuccinate (choice B) will result from a deficiency in the urea cycle enzyme, arginosuccinase. Foam cells are lipid-laden cells that are characteristic of disorders in lipid metabolism such as that seen in NPD, which is caused by a deficiency in sphingomyelinase. Uric acid deposition (choice E) results from excess catabolism of the purine nucleotides.

46. (B) The patient is suffering from von Gierke disease, which is glycogen storage disease type I. This disease results from one of several defects in the process of dephosphorylating glucose-6-phosphate to free glucose and the pathways are shown in Figure 3-12. The actual dephosphorylation takes place within the lumen of the ER where glucose-6-phosphatase resides, embedded in the membrane. Thus, glucose-6-phosphate must first be transported into the ER to be acted on by glucose-6-phosphatase. Following dephosphorylation, the free glucose is then transported back out to the cytosol. In addition, the released inorganic phosphate (Pi) must also be transported to the cytosol. Because of this pathway and the multiple activities involved, there have been four distinct subtypes of this particular glycogen storage disease identified. Type Ia results from deficiencies in glucose-6-phosphatase, type Ib from deficiencies in the glucose-6-phosphate transporter, type Ic from deficiencies in the Pi transporter, and type Id from deficiencies in GLUT7, which is the glucose transporter in the membrane of the ER. When the ER is isolated (microsomal fraction) from cells and incubated with radiolabeled glucose-6-phosphate, there will be uptake of the label into the membranes only if
the activity of the glucose-6-phosphate transporter is unaffected. Because the microsomes from the patient failed to take up the label, the data indicates the individual has a defect in the glucose-6-phosphate transporter and is suffering from type Ib glycogen storage disease. A deficiency in glucose-6-phosphatase (choice A) would not prevent uptake by the microsomes. Glucose-6-phosphatase is not found in the cytosol (choice C). Deficiencies in the microsomal GLUT7 (choice D) or the P, transporter (choice E) would lead to failure to take up the radio-labeled glucose.

47. (E) The term pKa defines the pH at which an equivalent distribution of acid and conjugate base (or base and conjugate acid) exists in solution. This term is derived from the equation demonstrating that \( \text{pH} = \text{pK}_a + \log \left( \frac{[A^-]}{[HA]} \right) \).

At the point of the dissociation where the concentration of the conjugate base \([A^-]\) is equal to that of the acid \([HA]\) the value of \([A^-]/[HA]\) is equal to 1 and the log of 1 is 0, therefore, at this point in a dissociation \(pK_a\) is equal to \(\text{pH}\). The equilibrium constant for the dissociation of an acid (or base) is \(K_a\) (choice A). The ion constant for water (choice B) is defined as \(K_w\). The negative log of the hydrogen ion concentration \([H^+]\) (choice C) is \(\text{pH}\). The \(\text{pH}\) at which a molecule or compound is electrically neutral (choice D) is called the isoelectric point, \(\text{pI}\).

48. (D) The binding of acetylcholine to its receptor at the neuromuscular junction results in depolarization of the muscle membrane. This event triggers the release of calcium ions from the sarcoplasmic reticulum. The increase in intracellular calcium concentration leads to many changes in enzyme activity. One effect of calcium is that it is bound by various calcium-regulated binding proteins. One of the subunits of glycogen phosphorylase kinase is calmodulin, a calcium-binding protein. The interaction of calcium with calmodulin alters the conformation of calmodulin, which leads to an activation of glycogen phosphorylase kinase activity in the absence of phosphorylation. The activity of glycogen phosphorylase kinase is increased not decreased (choice A) by calcium interaction with calmodulin present in the enzyme complex. Increases in intracellular calcium (as in response to acetylcholine binding at the neuromuscular junction) do not affect the level of phosphorylation of glycogen phosphorylase kinase (choices B and E) nor does it affect the activity of phosphoprotein phosphatase (choice C).

49. (B) Numerous severe disorders are associated with the inability to properly degrade the complex carbohydrate moieties of glycosaminoglycans, proteoglycans, and glycoproteins. These disorders fall into a broad category of diseases termed the lysosomal storage diseases. Several of the lysosomal storage diseases result in hepatosplenomegaly, renal dysfunction, and skeletal defects, and therefore these symptoms are not diagnostic in themselves of a particular lysosomal storage disease, but only indicative of such disorders. However, disorders such as NPD (choice D) and Tay-Sachs disease (choice E) are of such severity that early childhood mortality occurs and thus would not present in a 42-year-old patient. It is necessary to evaluate enzyme function in skin fibroblasts or white cells of the blood. Gaucher disease is caused by a defect in glucocerebrosidase activity and hence an assayable decrease in the activity of this enzyme would be diagnostic of this disease. Fabry disease (choice A) results from a defect in alpha-galactosidase A. Krabbe disease (choice C) results from a defect in galactocerebrosidase. Based on genetic linkage analyses as well as enzyme studies and the characterization of accumulating lysosomal substances, NPD (choice D) should be divided into type I and type II; type I has two subtypes, A and B (NPA and NPB), which show deficiency of acid sphingomyelinase. NPD type II likewise has two subtypes, types C1 and C2 (NPC) and type D (NPD), both of which show accumulation of abnormal LDL-cholesterol. The NPC1 gene contains regions of homology to mediators of cholesterol homeostasis suggesting why LDL-cholesterol accumulates in lysosomes of afflicted individuals. Tay-Sachs disease (choice E) results from a defect in hexosaminidase A.
50. (C) Deficiencies in the purine nucleotide salvage enzyme, HGPRT, cause three overlapping clinical syndromes. The most severe deficiency (patients having less than 1.5% residual enzyme activity) results in debilitating neurologic disability, overproduction of uric acid, and behavioral abnormalities that include impulsive and self-injurious activities such as biting finger tips and lips. This severe form of HGPRT deficiency is referred to as Lesch-Nyhan disease. The overproduction of uric acid leads to symptoms of gout and the appearance of “orange sand” in the urine. Deficiencies in ADA (choice A), another purine nucleotide salvage enzyme, are the cause of severe-combined immunodeficiency syndrome, SCID. SCID is characterized by a lack of both cell-mediated and humoral immunity. ADSL (choice B) is an enzyme in the pathway of de novo purine nucleotide synthesis. It is also an important component of the purine nucleotide cycle (see Figure 3-2). Deficiencies in ADSL cause psychomotor retardation, epileptic seizures, growth retardation, and muscle wasting. Deficiencies in PNP (choice D) result in a form of immunodeficiency characterized by defective cell-mediated responses. Afflicted individuals may also have normal, hyperactive, or reduced humoral immunity. Orotic aciduria is caused by deficiencies in the de novo pathway of pyrimidine nucleotide synthesis. A deficiency in either of the last two enzymes in the pathway, orotate phosphoribosyltransferase or OMP decarboxylase, leads to orotic aciduria.

51. (D) When the carbons of fatty acids are oxidized for energy production, the by-product of that process is the two-carbon compound, acetyl-CoA. Acetyl-CoA can then enter the TCA cycle for complete oxidation. Although, several compounds of the TCA cycle can be directed into the gluconeogenic pathway of glucose synthesis, the carbons of acetyl-CoA cannot provide a net source of carbon in that latter pathway. This is due to the fact that, following entry of the two carbons of acetyl-CoA into the TCA cycle, two carbons are lost as CO₂ during the subsequent reactions of the cycle. The subcellular compartmentalization of fat oxidation and gluconeogenesis (choice A) has no bearing on net carbon deposition into glucose. Anabolic and catabolic reactions (choice B) are always occurring concurrently in cells but at different rates dependent on cellular status. The site of fat storage (choice C) has no bearing on net incorporation of carbon into glucose. Acetyl-CoA does not inhibit conversion of pyruvate to oxaloacetate (choice E) but acts as an allosteric activator of pyruvate carboxylase, a gluconeogenic enzyme.

52. (B) Certain endothelial cell-stimulating signals, such as vasodilators, induce the production of NO during the conversion of arginine to citrulline via a reaction catalyzed by nitric oxide synthase (NOS). When NO is produced, it passes out of the endothelial cells and enters the underlying smooth muscle cells. Within smooth muscle cells, NO reacts with the heme moiety of a soluble guanylyl cyclase, resulting in activation of the latter and a consequent elevation of intracellular levels of cGMP. The net effect is the activation of cGMP-responsive enzymes, which lead to smooth muscle cell relaxation. None of the signaling enzymes or molecules (choices A, C–E) are involved in the NO-mediated signaling cascade.

53. (D) The synthesis of AMP from IMP and the salvage of IMP via AMP catabolism have the net effect of deaminating aspartate to fumarate. This process has been termed the purine nucleotide cycle. This cycle is very important in muscle cells. Increases in muscle activity create a demand for an increase in the TCA cycle, to generate more NADH for the production of ATP. However, muscle lacks most of the enzymes of the major anapleurotic reactions. Muscle replenishes TCA cycle intermediates in the form of fumarate generated by the purine nucleotide cycle. There is no HGPRT or ADA cycle and hence, choices A and B do not represent valid options. Choices C and E constitute pathways that do not involve nucleotides.

54. (E) The translation factor, eEF-2, is involved in the process of peptide elongation. Specifically, eEF-2 catalyzes the GTP-dependent translocation of the ribosomes along the mRNA to the next codon. Attachment of an amino acid to a tRNA (choice A) is catalyzed by the family of
aminoacyl-tRNA synthetases. Alignment of the mRNA on the 40S ribosome (choice B) is facilitated by the initiation factor eIF-1. Formation of the 80S initiation complex (choice C) occurs after complete assembly of the 40S preinitiation complex and requires the activity of eIF-5. Formation of the peptide bond (choice D) occurs through the action of peptidyltransferase.

55. (D) The formation of glycosylated hemoglobin occurs spontaneously (i.e., nonenzymatically through a reaction known as the Amadori rearrangement) in red blood cells. The amino terminal groups of the beta-chains of hemoglobin complex with the aldehyde groups of glucose to form an amino ketone linkage. This form of hemoglobin is known as HbA1c. Measurement of the circulating level of glycosylated hemoglobin is a diagnostic tool used to determine the relative length of hyperglycemia and can be used as a measure of treatment effectiveness. Glucose does not form covalent bonds with any of the other choices (A, B, C, and E).

56. (D) Both rod and cone cells contain a photoreceptor pigment in their membranes. The photosensitive compound (photoreceptor) of most mammalian eyes is a complex of protein and an aldehyde form of vitamin A. The protein component is a member of the opsin family called scotopsin. The photoreceptor of rod cells is specifically called rhodopsin (choice C) or visual purple, which is a complex between the protein scotopsin and the 11-cis-retinal form of vitamin A. Intracellularly, rhodopsin is coupled to a specific G-protein called transducin (choice E). When the rhodopsin is exposed to light it is bleached releasing the 11-cis-retinal from opsin. Absorption of photons by 11-cis-retinal triggers a series of conformational changes on the way to conversion all-trans-retinal. The release of opsin results in a conformational change in the photoreceptor. This conformational change activates transducin, leading to an increased GTP-binding by the alpha-subunit of transducin. Binding of GTP releases the alpha-subunit from the inhibitory beta- and gamma-subunits. The GTP-activated alpha-subunit in turn activates an associated phosphodiesterase (choice A), an enzyme that hydrolyzes cyclic-GMP (cGMP) to GMP. Cyclic GMP is required to maintain the Na+ channels (choice B) of the rod cell in the open conformation. The drop in cGMP concentration results in complete closure of the Na+ channels.

57. (B) Someone who exhibits heterozygosity would harbor two distinct alleles. In the case of this analysis, they would be identified as containing a copy of the gene that does not harbor the BamHI site and a copy that does harbor the site. The presence of the BamHI site in the PCR product in this example would result in the generation of 300 and 100 bp fragments. The lack of the site would yield a product of 400 bp. Thus, following PCR amplification and BamHI digestion of DNA from a heterozygote, one would be able to observe three bands of equal intensity. A person who was homozygous for having the BamHI-containing sequence would result in two bands (choice A) whose intensities would be greater than the three of the heterozygote. A person homozygous for the lack of the BamHI site would yield a single 400 bp band (choice D). The banding patterns observed in lanes 3 (choice C) and 5 (choice E) would not be possible from this analysis.

58. (D) In infants, the supply of glycogen lasts less than 6 hours and gluconeogenesis is not sufficient to maintain adequate blood glucose levels. Normally, during periods of fasting (in particular during the night) the oxidation of fatty acids provides the necessary ATP to fuel hepatic gluconeogenesis as well as ketone bodies for nonhepatic tissue energy production. In patients with MCAD deficiency there is a drastically reduced capacity to oxidize fatty acids. This leads to an increase in glucose usage with concomitant hypoglycemia. The deficit in the energy production from fatty acid oxidation, necessary for the liver to use other carbon sources, such as glycerol and amino acids, for gluconeogenesis further exacerbates the hypoglycemia. Normally, hypoglycemia is accompanied by an increase in ketone formation from the increased oxidation of fatty acids. In MCAD deficiency there is a reduced level of fatty acid oxidation, hence near normal levels of ketones are detected in the serum. None of the other choices (A, B, C, and E)
reflect symptoms related in any way to MCAD deficiency and are not in themselves indicative of any specific disorder per se.

59. (E) One mechanism by which initiation of translation in eukaryotes is effected is by phosphorylation of a ser(S) residue in the alpha-subunit of eIF-2. The factor eIF-2 requires activation by interaction with GTP. The energy of GTP hydrolysis is used during translational initiation, thereby allowing eIF-2 to have GDP bound instead of GTP. In order to reactivate eIF-2, the GDP must be exchanged for GTP. This requires an additional protein of the GEF family known as eIF-2B. The phosphorylated form of eIF-2, in the absence of the eIF-2B, is just as active an initiator of translation as the nonphosphorylated form. However, when eIF-2 is phosphorylated, the GDP-bound complex is stabilized and exchange for GTP is inhibited. When eIF-2 is phosphorylated, it binds eIF-2B more tightly thus slowing the rate of exchange. It is this inhibited exchange that affects the rate of initiation. Within reticulocytes the phosphorylation of eIF-2 is the result of an activity called heme-controlled inhibitor, HCI (see Figure 3-13). The presence of HCI was first seen in an in vitro translation system derived from lysates of reticulocytes. When heme is limiting it would be a waste of energy for reticulocytes to make globin protein, since active hemoglobin could not be generated. Therefore, when the level of heme falls, HCI becomes activated, leading to the phosphorylation of eIF-2 and reduced globin synthesis. Removal of phosphate is catalyzed by a specific eIF-2 phosphatase which is unaffected by heme. There is no heme-controlled phosphatase activity (choice A) in any cell. No tRNA-specific degrading enzymes (choice B) are present in cells. There is no effect of heme levels on peptidyltransferase activity (choice C) or RNA polymerase activity (choice D).

60. (C) Defects in methylmalonyl-CoA mutase activity comprise four distinct genotypes whose clinical symptoms are remarkably similar. Characteristic findings in methylmalonyl-CoA mutase deficiency include failure to thrive leading to developmental abnormalities, recurrent vomiting, respiratory distress, hepatomegaly, and muscular hypotonia. In addition, patients have severely elevated levels of methylmalonic acid in the blood and urine. Unaffected individuals have near undetectable levels of methylmalonate in their plasma, whereas, affected individuals have been found to have levels ranging from 3 to 40 mg/dL in their blood. Deficiency in alpha-ketoacid dehydrogenase (choice A) results in MSUD, so named because of the characteristic odor of the urine in afflicted individuals. Mental retardation in the MSUD is extensive. Deficiency in homogentisic acid oxidase (choice B) results in alkaptonuria. Alkaptonuria results from the accumulation of homogentisic acid, a byproduct of tyrosine catabolism, in the urine and tissues. Oxidation of homogentisate in the urine causes it to turn dark and in the tissues results in ochronosis, which refers to the ochre color of the deposits in connective tissue, bones, and other organs. Deficiency in phenylalanine hydroxylase (choice D) results in PKU which results in severe mental retardation if not detected and treated properly. Deficiency in tyrosine aminotransferase (choice E) results in eye, skin, and neurologic symptomology. The neurologic symptoms are similar to those seen in PKU.

61. (C) Deficiency in MCAD is the most common inherited defect in the pathways of mitochondrial fatty acid oxidation. The most common presentation of infants with this disorder is episodic hypoketotic hypoglycemia following...
periods of fasting. Although the first episode may be fatal, and incorrectly ascribed to sudden infant death syndrome, patients with MCAD deficiency are normal between episodes and are treated by avoidance of fasting and treatment of acute episodes with intravenous glucose. Accumulation of acylcarnitines (dicarboxylic acids) is diagnostic, in particular octanoylcarnitine. Glutaric acidemia type II (choice A) results from a defect in electron transfer flavoprotein-ubiquinone oxidoreductase and presents with symptoms of hypoketotic hypoglycemia as in the case of MCAD deficiency. However, this disorder manifests within the first 24–48 h after birth and is frequently associated with congenital anomalies. Lesch-Nyhan syndrome (choice B) results from a defect in HGPRT—an enzyme involved in nucleotide metabolism. Symptoms of Lesch-Nyhan syndrome include hyperuricemia, bizarre neurobehavioral manifestations, growth retardation, and anemia. Deficiency in PDH (choice D) results in lactic acidemia, which can be quite severe at birth leading to neonatal fatality. Milder deficiency results in lactic acidemia associated with profound psychomotor retardation. Cori disease (choice E) results from a defect in the glycogen debranching enzymes. Clinical features include hepatomegaly, hypoglycemia, skeletal myopathy and short stature, and cardiomyopathy.

62. (D) Two familial syndromes directly involve defects in LCAT. Familial LCAT deficiency is characterized by near complete absence of the enzyme activity from the plasma. Fish eye disease is characterized by an absence of LCAT activity toward high-density lipoproteins (HDLs) but presence of activity toward LDLs. Clinical features of familial LCAT deficiency include corneal opacities, anemia, and proteinuria. Due to the lack of LCAT activity, the plasma level of esterified cholesterol is lower than normal and phosphatidylcholine (the principal source of fatty acid for esterification to cholesterol) levels are higher than normal. The profile of all classes of plasma lipoproteins in patients with familial LCAT deficiency is abnormal. Bassen-Kornzweig syndrome (choice A), also identified as abetalipoproteinemia, is due to a defect in apo B expression. Clinical symptoms include retinitis pigmentosa, ataxic neuropathy, and erythrocytes that appear thorny (anthocytosis). FH (choice B) is characterized by reduced LDL clearance, which leads to severe hypercholesterolemia. Major clinical symptoms are arterial deposition of LDL-cholesterol, which leads to atherosclerosis and coronary artery disease. Deposition of LDL-cholesterol is also seen in tendons and skin resulting in xanthomas. Familial hypertriacylglycerolemia (choice C), also identified as hyperlipoproteinemia type IV, is a form of LPL deficiency. The defect leads to increased levels of circulating VLDLs and is associated with glucose intolerance and hyperinsulinemia. This disorder is frequently associated with Type II diabetes. Wolman disease (choice E) is cholesterol ester storage disease that leads to massive accumulation of cholesteryl esters and triglycerides in most tissues. This disease is almost always fatal within the first year of life and thus would not be present in a 28-year-old.

63. (C) Familial dysbeta lipoproteinemia (type III hyperlipoproteinemia) results from a genetic variant in the apo E gene that causes poor interaction of chylomicron remnants and VLDLs with the apo E receptor. This results in the presence, in the serum, of beta-migrating VLDL (β-VLDLs), which are cholesterol-rich remnants of both intestinal chylomicrons and hepatic VLDL. Diagnosis of type III hyperlipoproteinemia is indicated by elevated plasma cholesterol and triglyceride, xanthomas (fatty eruptions under the skin), and of course the presence of β-VLDL. Type I hyperlipoproteinemia (choice A) results from defects in the activity or activation of LPL and results in the massive accumulation of chylomicrons in the plasma. The disease is usually detected in childhood following recurrent attacks of abdominal pain, hepatosplenomegaly, and pancreatitis. Familial hypercholesterolemia (choice B) is the result of defects in the LDL receptor. The defects lead to characteristic elevation in LDL, deposition of LDL-derived cholesterol in the tendons and skin and in the arteries. Individuals homozygous for defective LDL receptors have severe hypercholesterolemia (650–1000 mg/dL) and coronary
heart disease begins early in childhood with death caused by myocardial infarct before the age of 20. Type IV hyperlipoproteinemia (choice D) is associated with overproduction VLDLs. An associated glucose intolerance and hyperinsulinemia are also seen in this disorder. Wolman disease (choice E) is caused by a deficiency in lysosomal acid lipase and results in massive accumulation of cholesteryl esters and triglycerides in most tissues. The disease is almost always fatal before the age of 1 year.

64. (A) Enzymes that are destined for the lysosomes (lysosomal enzymes) are directed there by a specific carbohydrate modification. During transit through the Golgi apparatus a residue of N-acetylglucosamine-1-phosphate is added to carbon 6 of one or more specific mannose residues that have been incorporated into these enzymes. The N-acetylglucosamine is activated by coupling to UDP and is transferred by an N-acetylglucosamine phosphotransferase yielding N-acetylglucosamine-1-phosphate-6-mannose-protein. A second reaction removes the N-acetylglucosamine leaving mannose residues phosphorylated in the sixth position. A specific mannose-6-phosphate receptor is present in the membranes of the Golgi apparatus. Binding of mannose-6-phosphate to this receptor targets proteins to the lysosomes. Defects in the proper targeting of glycoproteins to the lysosomes can also lead to clinical complications. Deficiencies in N-acetylglucosamine phosphotransferase lead to the formation of dense inclusion bodies in fibroblasts. Two disorders related to deficiencies in the targeting of lysosomal enzymes are termed I-cell disease (mucolipidosis II) and pseudo-Hurler polydystrophy (mucolipidosis III). I-cell disease is characterized by severe psychomotor retardation, skeletal abnormalities, coarse facial features, painful restricted joint movement, and early mortality. Pseudo-Hurler polydystrophy is less severe; it progresses more slowly, and afflicted individuals live to adulthood. Each of the other choices (B, C, D, and E) represent other potential pathways that are not affected in the processing, delivery, or presentation of lysosomal enzymes or the receptors that recognize the properly processed enzymes.

65. (B) Although multiorgan involvement, liver and spleen enlargement, and skeletal abnormalities are common to all the mucopolysaccharidotic (MPS) diseases, each encompasses features that allow for specific diagnosis. Hurler syndrome is characterized by progressive multiorgan failure and premature death. Hallmark features include enlargement of the spleen and liver, severe skeletal deformity, and coarse facial features (which are associated with the constellation of defects referred to as dystosis multiplex). The disease results from a defect in alpha-L-iduronidase activity, which leads to intracellular accumulations of heparan sulfates and dermatan sulfates. The accumulation of these GAGs (glycosaminoglycan) in Hurler syndrome patients severely affect development of the skeletal system leading, primarily, to defective long bone growth plate disruption. Hunter syndrome (choice A) has features similar to that of Hurler but with a lack of corneal clouding. Additionally, symptoms progress slower, with onset of symptoms occurring between 2 and 4 years of age. Maroteaux-Lamy syndrome (choice C) encompasses symptoms similar to Hurler but with normal mental development. Morquio syndrome (choice D) comprises two related disorders, both of which are characterized by short-trunk dwarfism, fine corneal deposits, and a skeletal dysplasia (spondyloepiphyseal) distinct from other MPS. Sanfilippo syndrome (choice E) comprises four recognized types characterized by severe CNS degeneration with only mild involvement of other organ systems. Symptoms do not appear until 2–6 years of age.

66. (B) Hepcidin is a hepatically synthesized iron regulatory protein that functions by inhibiting the presentation of one or more of the iron transporters [e.g., DMT1 and Ireg1 (ferroportin)] in intestinal membranes. With a high iron diet, the level of hepcidin mRNA increases and conversely its levels decrease when dietary iron is low. This is occurring simultaneous to reciprocal changes in the levels of the transporters proteins themselves. Loss of hepcidin activity would then lead to unregulated iron uptake from the intestines leading to iron overload. In fact, it is now considered that defects in
hepcidin function contribute to the development of hemochromatosis. Hepcidin does not activate expression of iron-response element-binding protein (choice A), facilitate transferring interaction with the transferring receptor (choice C), form a complex with ferritin (choice D), nor promote the formation of hemosiderin (choice E).

67. (B) Glutamic acid is an acidic amino acid at physiologic pH and therefore, substitution for another acidic amino acid, such as aspartic acid, would be expected to have minimal effect on the activity of the enzyme. Arginine (choice A) and lysine (choice C) are both basic amino acids at physiologic pH and would not be able to substitute for an acidic amino acid. Serine (choice D) and tyrosine (choice E) both have ionizable hydroxyl groups but the pKₐ values of those hydroxyl groups would not favor substitution for an acidic amino acid.

68. (D) The ATP-dependent poly-ubiquitination of proteins is a signal that the protein is misfolded and thus, needs to be targeted by the proteosome for degradation. Mono-ubiquitination is known to initiate cell signaling by allowing other proteins that contain ubiquitin-binding domains to interact with the mono-ubiquitinated substrate. Mono-ubiquitination has also been associated with targeting of membrane proteins to the lysosome. None of the other examples (choices A–C, E) are associated with addition of ubiquitin.

69. (E) Eukaryotic viral RNAs are not capped and the host 40S ribosome interacts with these viral RNAs at an IRES. Capped eukaryotic mRNAs are recognized by the complex of eIF-4E and eIF-4G, which in turn allows for interaction of the 40S ribosome with the mRNA (see Figure 3-14). Initiation factor eIF-4E physically binds the cap structure in eukaryotic mRNAs and this function is facilitated by interaction of eIF-4E with eIF-4G. Thus, loss of the interaction of eIF-4E with the protease cleaved eIF-4G results in loss of translational initiation from capped mRNAs. However, the binding of 40S ribosomes to viral RNAs does not require eIF-4E, only eIF-4G. The protease encoded by the poliovirus cleaves the eIF-4E binding site on eIF-4G. None of the other translation factors (choices A–C, E) are targets for poliovirus protease.
70. (B) Gout is characterized by elevated levels of uric acid in the blood and urine. Uric acid is the end-product of purine catabolism and excess production results from a variety of metabolic abnormalities that lead to overproduction of purines via the de novo pathway. Uric acid is very insoluble and when generated in large amounts will precipitate as uric acid crystals in the joints of the extremities and in renal interstitial tissue. These deposits are gritty or sandy in nature and thus are termed tophaceous deposits. ADA (choice A) and PNP (choice D) deficiencies result in various degrees of immune dysfunction and are not associated with gouty episodes. Lesch-Nyhan disease (choice C) is due to loss of HGPRT activity. Characteristic symptoms include severe mental retardation and self-mutilation. A much less severe symptom associated with Lesch-Nyhan disease is hyperuricemia, which leads to gouty episodes. However, other symptoms are of such severity that patients die very early in life. Deficiency in glucose-6-phosphatase results in von Gierke disease (choice E). Clinical symptoms of von Gierke disease include fasting hypoglycemia, lactic acidemia, and mild gouty episodes. The hyperuricemia of von Gierke disease is seldom severe enough to lead to the level of gouty deposits observed in this patient.

71. (A) The first reaction of de novo pyrimidine biosynthesis is catalyzed by ATC. This reaction is also the rate-limiting step in this pathway. OMP decarboxylase (choice B) catalyzes the decarboxylation of OMP, yielding UMP. PRPP amidotransferase (choice C) is an enzyme of the de novo purine biosynthesis pathway. PRPP synthetase (choice D) catalyzes the production of PRPP (used in the synthesis of purines and pyrimidines) from ribose-5-phosphate and ATP. Ribonucleotide reductase (choice E) is required for the reduction of ribonucleotides to deoxyribonucleotides.

72. (A) NO is generated from arginine in a reaction catalyzed by NOS. The other product of the reaction is citrulline. None of the other amino acids (choices B, C, D, and E) are substrates for NOS.

73. (C) Calcitriol [1,25-(OH)2-D] is the hormonally active form of vitamin D and functions in concert with PTH and calcitonin to regulate serum calcium and phosphorous levels. The major function of calcitriol is the induction of synthesis of an intestinal calcium-binding protein, calbindin, which facilitates intestinal absorption of calcium. Oral administration of calcitriol will increase intestinal calcium uptake, but the hormone does not enter the peripheral circulation in significant amounts. Therefore, patients with renal osteodystrophy may need intravenous administration of calcitriol. Antidiuretic hormone (choice A) is responsible for renal water reabsorption in response to increased extracellular Na+ concentrations, which lead to increased plasma osmolarity. Calcitonin (choice B) acts to block bone resorption when there are sufficient levels of calcium in the serum. Growth hormone (choice D) does not influence calcium homeostasis and would therefore not be useful in the treatment of renal osteodystrophy. PTH (choice E) acts to increase bone resorption, in concert with calcitriol, when serum calcium levels fall.

74. (A) Primary aldosteronism (Conn syndrome) leads to elevated production of aldosterone and the symptoms presented by the patient. This disorder is due to small adenomas of the glomerulosa cells of the kidney. The associated hyperkalemia, hypertension, and hypernatremia lead to a reduction in renin release from the juxtaglomerulosa cells. Renin is required for the conversion of angiotensinogen (released from the liver) to angiotensin I (which is in turn converted to angiotensin II by converting enzyme), and so reduced levels of renin lead to reduced levels of angiotensin II. Androstenedione (choice B) is produced from pregnenolone via the 17alpha-hydroxylase pathway of androgen synthesis in the adrenal cortex or of estrogen synthesis in the ovary. Androstenedione is derived from DHEA (choice C) and is converted to estradiol (choice D) in the ovary or to testosterone (choice E) in the testis. Estrogens are responsible for maturation of the ovaries and testosterone maturation of sperm. None of these steroids regulate sodium or potassium and
would therefore not lead to the symptoms presented if elevated or reduced.

75. (B) The compound paclitaxel (the generic name for Taxol) interferes with the normal function of microtubule growth leading to increased stability of the structure. This effect of Taxol destroys the cell ability to use its cytoskeleton in a flexible manner. Specifically, Taxol binds to the tubulin protein of microtubules and locks them in place. The resulting microtubule/Taxol complex does not have the ability to disassemble. This adversely affects cell function because the shortening and lengthening of microtubules (termed dynamic instability) is necessary for their function as a transportation highway for the cell. Chromosomes, for example, rely on this property of microtubules during mitosis. Therefore, the inability of cells to organize and undertake the necessary movements of mitosis prevents cell division. Since cancer cells are rapidly proliferating cells, the action of Taxol inhibits their growth. None of the other choices (A, C–E) reflect the actions of Taxol on cells.

76. (E) Prolactin is necessary for initiation and maintenance of lactation. Physiologic levels act only on breast tissue primed by female sex hormones. Endocrine dysfunction leading to excessive prolactin production is associated with breast enlargement and impotence in males. Excessive production of corticotropin-releasing hormone (ACTH) production, which would lead to enhanced glucocorticoid and mineralocorticoid production. Excessive production of GnRH (choice B) would lead to increased production of luteinizing hormone (LH), follicle-stimulating hormone (FSH), and chorionic gonadotropin (hCG), with consequent effects on the female reproductive system. Excessive production of growth hormone (choice C) leads to gigantism if it occurs prior to epiphysial plate closure. If excessive release occurs following epiphysial plate closure acromegaly results, with characteristic facial changes (protruding jaw, enlarged nose) and enlarged feet, hands, and skull. Excessive production of melanocyte-stimulating hormone (choice D) would lead to hyperpigmentation of the skin.

77. (D) HD is an autosomal-dominant disorder leading to progressive memory loss, personality changes, and peculiar motor problems such as involuntary movements of the arms and legs. The disease results from the expansion of a CAG triplet in the amino terminus of the HD protein, referred to as huntingtin. The triplet repeat number ranges from 10 to 30 on the normal chromosome and from 36 to 121 on the HD chromosome. There is a general correlation between the length of the repeat and the age of onset of symptoms. CF (choice A) is primarily due to a common mutation (in 70% of cases) that deletes three nucleotides in exon 10 of the CF gene, which codes for the CF transmembrane conductance receptor (CFTR). Over 600 other mutations have been identified in the CF gene. DMD (choice B) results from deletions in one or more of the exons of the DMD gene, which encodes the protein referred to as dystrophin. FH (choice C) results from defects in the gene encoding the LDL receptor. These defects encompass insertions and deletions that can be found throughout the length of the LDL-receptor gene. Menkes disease (choice E) is due to defects in copper absorption leading to defective function of numerous enzymes that need copper as a cofactor.

78. (A) Enzymes that are targeted to the lysosomes undergo a specific two-step modification in the Golgi complex. The first step in the modification involves the attachment of an alpha-N-acetylglucosamine 1-phosphate residue to the mannose-6-phosphate marker. The presence of mannose-6-phosphate is necessary for targeting lysosomal enzymes to the lysosomes and deficiencies in the enzyme responsible for the first reaction in the modification lead to severe developmental abnormalities. Carboxylation of glutamate residues (choice B) is necessary to the function of several enzymes of the coagulation cascades. Lysosomal enzymes are not modified by attachment of carbohydrate through O-linkage (choice C). Many membrane-anchored proteins undergo lipid modification
by prenylation (choice D) such as the protein product of the protooncogene RAS. Although many enzymes are activated by proteolytic processing (choice E), this is not required for targeting lysosomal enzymes to the lysosome.

79. **(E)** The p53 protein is a tumor suppressor whose function is to ensure that cells with damaged DNA do not progress through the cell cycle until that damage is repaired. The major response to p53 action is an increase in the expression of the p21Cip gene. Progression through the cell cycle requires, among other activities, the concerted action of cyclins and cyclin-dependent kinases (CDKs) of which there are several. The activity of the CDKs is dependent on interaction with cyclins. However, the presence of CDK inhibitory proteins, CIPs, results in inhibition of the activity of CDKs. CIPs bind and inhibit CDK1, 2, 4, and 6 complexes. Thus, an increase in the activity of p53, which occurs in response to DNA damage, results in a block to cell-cycle progression. The activity of CDK2 (choice A) is regulated by the presence of cyclin A. The cyclins (choice B and C) are regulators of the kinase activity of the CDKs. The transcription factor E2F (choice D) is regulated by interaction with the retinoblastoma susceptibility protein, pRB.

80. **(A)** ADA catalyzes the deamination of adenosine to inosine during the catabolism of purines. Loss of ADA leads to significantly elevated levels of phosphorylated deoxyadenosine (in particular deoxyadenosine triphosphate, dATP). Levels of dATP in ADA deficiency can reach 50 times normal. High concentrations of dATP inhibit ribonucleotide reductase, which is required for the generation of deoxynucleotides from ribonucleotides. The inhibition of ribonucleotide reductase leads to severely impaired cellular DNA synthesis. Since lymphocytes must be able to proliferate dramatically in response to antigenic challenge, the loss of ADA activity results in a near complete lack of immune function. ATC (choice B) is a component of a multifunctional enzyme, which catalyzes the rate-limiting reaction of pyrimidine biosynthesis. No known deficiencies in this enzyme have been identified, likely due to the embryonic lethality predicted if the enzyme were defective. HGPRT (choice C) catalyzes the salvage of hypoxanthine to IMP and guanine to GMP. Deficiency in HGPRT results in Lesch-Nyhan syndrome. Orotic acid decarboxylase (choice D) catalyzes the decarboxylation of OMP to UMP. Deficiency in this enzyme results in orotic aciduria, type II. PNP (choice E) is also a purine catabolic enzyme, which converts inosine to hypoxanthine and guanosine to guanine. Deficiency in PNP leads to a mild immunodeficiency.

81. **(E)** DNA fingerprinting refers to the process of using polymorphic repeat sequences to establish a unique pattern of DNA fragments for any given individual. The polymorphic repeats that are identifiable by the fingerprinting technique are hypervariable repeats such as variable number tandem repeats (VNTRs). The bands are detected by Southern blotting enzyme-digested chromosomal DNA and probing the blot with various different VNTR probes. The generation of a DNA library (choice A) refers to the establishment of a complete collection of cloned fragments of DNA, either from genomic sources or cDNA. DNA footprinting (choice B) refers to the identification of sequences of DNA to which specific proteins bind, thereby rendering the DNA at that site resistant to digestion by DNA degrading nucleases. Hybridization (choice C) refers to the specific association of complimentary strands of DNA to one another. The PCR technique (choice D) uses synthetic oligonucleotides to direct the enzymatic amplification of specific sequences of DNA.

82. **(D)** Regulation of HMG-CoA reductase (the rate-limiting enzyme of cholesterol biosynthesis) activity is complex and involves a number of distinct enzyme activities (Figure 3-15). Since cholesterol biosynthesis consumes large amounts of energy, it needs to be regulated in response to energy demands, particularly in hepatocytes. The principal site for the action of the hypo-glycemic response hormone, glucagon, is the liver. Glucagon binding to hepatocytes triggers the liver to stop catabolizing carbohydrate and to divert carbon atoms into the gluconeogenesis pathway. This change in hepatic metabolism, in response to glucagon, comes about through a
change in the phosphorylation state of numerous enzymes. One of these enzymes is HMG-CoA reductase. HMG-CoA reductase is most active when in the nonphosphorylated state. The enzyme is phosphorylated and rendered less active through the action of AMP-regulated kinase. AMP levels rise as the energy charge in the cell declines and thus the cell is able to recognize this change, at the level of HMG-CoA reductase activity, by inducing its phosphorylation and inhibition. In order to reverse the effect of HMG-CoA phosphorylation the phosphates must be removed. This occurs through the action of HMG-CoA reductase phosphatase. HMG-CoA reductase phosphatase is regulated through the action of protein phosphatase inhibitor-1 (PPI-1). In turn the activity of PPI-1 is regulated by its state of phosphorylation; it is more active when phosphorylated. When glucagon binds to hepatocytes, the result is a glucagon receptor-mediated activation of adenylate cyclase, which in turn produces cAMP from ATP. The effect of cAMP is to activate cAMP-dependent protein kinase which then phosphorylates a number of substrates. With respect to glucagon-mediated regulation of cholesterol metabolism, PKA phosphorylates PPI-1. Phosphorylated PPI-1 is more active at inhibiting HMG-CoA reductase phosphatase so that the removal of phosphate from HMG-CoA reductase is inhibited. This keeps HMG-CoA reductase in the phosphorylated and less active state. AMPK is not directly affected by glucagon-mediated increases in the levels of cAMP (choice A). Although glucagon action leads to an increase in PKA activity, the latter enzyme does not itself phosphorylate HMG-CoA reductase (choice B). The activity of AMP-regulated kinase is affected by its level of phosphorylation but it is not phosphorylated by PKA (choice C). Cyclic AMP itself does not have a direct effect on HMG-CoA reductase (choice E).

83. (E) The von Willebrand factor is associated with subendothelial connective tissue and serves as a bridge between platelet glycoprotein GPIb/IX and collagen. This activity ensures that platelets can adhere to the exposed subendothelial surfaces at the site of tissue injury. In addition, von Willebrand factor and factor VIII exist in a noncovalently bound complex in the
plasma. The interaction of factor VIII and von Willebrand factor greatly stabilizes factor VIII. For example, following infusion of factor VIII into patients with hemophilia A (caused by loss of factor VIII) the protein exhibits a serum half-life of around 12 hours. Conversely, when infused into patients with severe von Willebrand disease, VWD (lack of von Willebrand factor), the half-life of factor VIII is less than 2 hours. Therefore, individuals suffering from VWD will also have significantly reduced levels of circulating factor VIII. This fact results in the observation that patients with VWD exhibit symptoms of both platelet dysfunction and hemophilia. Deficiency in any of the other coagulation factors (choices A–D) would not result in decreased stability of factor VIII observed as a reduction in circulating levels of this protein.

84. (E) Zellweger syndrome is the most severe of a group of diseases that result from defective assembly of the peroxisomes, leading to the characteristic symptoms observed in the patient. This syndrome is apparent at birth and leads to death within the first year. The cause of Zellweger syndrome is a failure to import newly synthesized peroxisomal proteins into peroxisomes. Hyperpippecolic acidemia (choice A), infantile Refsum disease (choice B), and neonatal adrenoleukodystrophy (choice C) are all much less severe disorders of the group that result from peroxisome dysfunction. Affected individuals with these latter disorders can survive into the third or fourth decade, albeit with deficits in vision, hearing, and cognitive function. It is suspected that the reduced severity of these three disorders, relative to Zellweger, relates to retention of partial gene function as opposed to complete loss. RCDP (choice D) is related to peroxisomal dysfunction at the level of their distribution and structure. The phenotype of RCDP differs from that of Zellweger syndrome in that patients have striking shortening of the proximal limbs, coronal clefts of vertebral bodies, and severely abnormal endochondral bone formation.

85. (B) Apo B_{48} is found exclusively associated with chylomicrons and no other lipoprotein particle. Apo B_{48} is synthesized from an mRNA that is transcribed from the apo B_{100} gene. Following transcription, the mRNA is edited within the intestinal epithelium yielding the apo B_{48} transcript. Apo(a) (choice A) is an apoprotein found disulfide bonded to apo B_{100}. This then forms a complex with LDL, generating a novel lipoprotein particle identified as lipoprotein(a), Lp(a). Lp(a) has a strong resemblance to plasminogen and its presence in the circulation is highly correlated with premature coronary artery disease. Apo CII (choice C) is present in chylomicrons, VLDLs, LDLs, IDLs, and HDLs and is necessary for the activation of endothelial cell LPL. Apo D (choice D) is found exclusively with HDLs and is also associated with cholesterol ester transfer protein (CETP) activity. Apo E (choice E) is found in chylomicrons, VLDLs, LDLs, IDLs, and HDLs. It is necessary for interaction of lipoprotein with the LDL-receptor (which is also referred to as the apo B_{100}/apo E receptor).

86. (B) Jaundice is caused by an elevation in the circulating levels of bilirubin, the heme degradation by-product. Bilirubin, which is toxic, is rendered harmless by binding to albumin in the serum and by conjugation to glucuronate in the liver. Profound hyperbilirubinemia leads to encephalopathy (kernicterus), which results in death if untreated. The hepatic conjugation of bilirubin to glucuronate is catalyzed by bilirubin-UDP-glucurononyltransferase (UGT). The conjugated form of bilirubin is less toxic due to its increased solubility. Hyperbilirubinemia can be of two types, unconjugated or conjugated. Defects in UGT will lead to unconjugated hyperbilirubinemia. The deficiency of UGT in Crigler-Najjar syndrome type I is complete (due to loss of coding exons in the UGT gene) and as a consequence affected individuals will die from the profound kernicterus. AIP (choice A) results from a defect in the activity of the porphyrin biosynthetic enzyme, PBG deaminase. This disorder results in neurovisceral symptoms and signs that can be highly variable and nonspecific, leading to frequent misdiagnosis. Both Dubin-Johnson syndrome (choice C) and Rotor syndrome manifest as conjugated hyperbilirubinemia. Both reflect a defect in biliary excretion and are relatively
benign because the conjugated bilirubin is much less toxic than the unconjugated molecule. Gilbert syndrome (choice D) is caused by an abnormality in the TATA-box of the UGT promoter so expression of functional UGT is reduced, thus the reduced severity of the disorder.

87. (C) Acromegaly results when there is an excess production of growth hormone after epiphysial closure and cessation of long bone growth. Excessive production of corticotropin-releasing hormone (choice A) would result in an increase in ACTH production, which would lead to enhanced glucocorticoid and mineralocorticoid production. Excessive production of GnRH (choice B) would lead to increased production of LH, FSH, and hCG, with consequent effects on the female reproductive system. Excessive production of IGF-II (choice D) could lead to abnormal neonatal development since it is expressed only during this period. Excessive production of thyroid-stimulating hormone (choice E) would lead to increased release of the thyroid hormones, leading to multisystemic involvement such as rapid heart rate, nervousness, inability to sleep, weight loss, excessive sweating, and sensitivity to heat.

88. (C) When glycolysis (a cytoplasmic pathway) is proceeding under anaerobic conditions, the electrons transferred to NAD+ (generating NADH) during the G3PDH-catalyzed step cannot be transferred to mitochondrial NADH nor FADH2, which would regenerate cytoplasmic NAD levels. This would lead to a deficiency in the NAD required by G3PDH and an eventual cessation of glycolysis. Therefore, under anaerobic conditions, tissues such as skeletal muscle reduce pyruvate (the end product of anaerobic glycolysis) to lactate catalyzed by LDH. This reaction requires electrons to be donated from NADH and thereby regenerate NAD, which can be used by G3PDH. If PDH (choice E) were to use any NAD in the oxidation of pyruvate to acetyl-CoA, there would be reduced levels available for G3PDH and glycolysis would cease, hence pyruvate is reduced by LDH. The citric acid cycle enzymes, alpha-ketoglutarate dehydrogenase (choice B) and malate dehydrogenase (choice D), in addition to being in the mitochondria, reduce NAD+ to NADH, therefore, neither would be able to supply glycolysis with NAD+. Although there is a cytoplasmic malate dehydrogenase and glycerol-3-phosphate dehydrogenase (choice A) is cytoplasmic, these enzymes are involved in the transfer of cytoplasmic electrons from NADH into the mitochondria, a process that is restricted by the lack of O2 during anaerobic metabolism.

89. (E) Transferrin is a glycoprotein synthesized in the liver having a central role in the body’s metabolism of iron. Each mole of transferrin can transport 2 moles of Fe3+ in the circulation to sites where iron is required. Free iron is toxic, but when associated with transferrin this toxicity is greatly diminished. When bound to transferrin, iron can be directed to cells where it is needed. Many cells have transferrin receptors and on binding, the transferrin-receptor complex is internalized. The acidic pH of the lysosome causes the iron to dissociate from transferrin. Iron-free transferrin is then recycled to the cell surface along with its receptor, where it then reenters the circulation. Ceruloplasmin (choice A) is the major copper carrier of the body and is also synthesized in the liver. Ferritin (choice B) is an intracellular iron-binding protein. It does not play a role in iron metabolism or transport, and its function is to prevent ionized iron (Fe2+) from reaching toxic levels within cells. Haptoglobin (choice C) is a plasma glycoprotein that binds extracorporeal (free) hemoglobin. This function of haptoglobin is to prevent free hemoglobin from being lost through the kidneys, since the haptoglobin-hemoglobin complex is too large to pass through the glomerulus. Metallothioneins (choice D) are found in many cells and can bind copper, zinc, cadmium, and mercury.

90. (C) During the process of oxidative phosphorylation, electrons from reduced electron carriers enter the pathway at either complex I or complex II. The reduced electron carrier, derived from the oxidation of pyruvate and malate (NADH), enters the oxidative phosphorylation machinery at complex I, NADH-coenzyme Q reductase (also identified as NADH-ubiquinone
oxidoreductase). Whereas, the reduced electron carrier generated during the oxidation of succinate (FADH₂) enters the oxidative phosphorylation machinery at complex II. Thus, a defect in the activity of complex I would inhibit oxygen consumption in the presence of pyruvate or malate but not succinate. The pathway of electron flow through the electron transport assembly has been determined through the uses of compounds termed antimetabolites. Some of these agents are inhibitors of electron transport at specific sites in the electron transport assembly, while others stimulate electron transport by discharging the proton gradient (uncouplers). An important example of an uncoupler is 2,4-dinitrophenol (DNP). Uncoupling agents, such as DNP, act as lipophilic weak acids, associating with protons on the exterior of mitochondria, passing through the membrane with the bound proton, and dissociating the proton on the interior of the mitochondrion. These agents cause maximum respiratory rates but the electron transport generates no ATP, since the translocated protons do not return to the interior through ATP synthase. Cytochrome c (choice A) receives electrons from complex III, cytochrome oxidase (choice B) receives electrons from cytochrome c, succinate dehydrogenase (choice D) is a component of complex II, and ubiquinone (choice E) receives electrons from both complex I and II, therefore, a defect in any of these proteins would not account for the observed phenomena.

91. (A) Phosphorylase kinase (also referred to as phosphorylase/synthase kinase, because it can phosphorylate both glycogen phosphorylase and glycogen synthase) contains calmodulin as a subunit. The presence of calmodulin allows phosphorylase kinase to be activated in the absence of a cAMP-mediated phosphorylation cascade. This is important when muscle is stimulated by epinephrine binding to alpha-adrenergic receptors (this function is diagrammed in Figure 3-4) or by acetylcholine release at the neuromuscular junction. Each of these events leads to increases in intracellular Ca²⁺. Each of the other proteins (choices B, C, D, and E) are independent activities not associated with phosphorylase kinase.

92. (E) Turner syndrome is characterized by phenotypically normal females who are sexually immature and have gonadal dysgenesis and a host of somatic abnormalities. These symptoms arise due to chromosomal abnormalities in one of the X chromosome as well as due to monosomy for the X chromosome. Only around 5% of monosomy X fetuses survive to birth. Some 15% of Turner syndrome females are mosaic for the karyotype 45,X:46,XX and another 15% are mosaic for a 45,X cell line plus a 46,X, abnormal X cell line or a 47,XXX cell line. Achondroplasia (choice A) is the single most common form of dwarfism, which results from two specific defects in the gene encoding fibroblast growth factor receptor 3 (FGFR3). Symptoms of achondroplasia include rhizomelic short stature, midface hypoplasia, short ribs, and trident hand. DMD (choice B) is an X-linked condition whose symptoms occur in affected males in early childhood and only very rarely affects females. DMD is caused by defects in the dystrophin protein, which is involved in the contractile apparatus of muscle cells. Fragile X syndrome (choice C) is the most common form of inherited mental retardation. The symptoms result from the loss of a portion of the X chromosome due to a site of fragility caused by the amplification of a trinucleotide repeat sequence in the FMR1 gene. Symptoms of fragile X are most severe in males (affected females have much milder symptoms) and include severe mental retardation and facial abnormalities such as prominent jaw, forehead, and ears. Kleinfelter syndrome (choice D) is associated with males harboring two or more X chromosomes (e.g., 47,XXY). Symptoms appear in puberty and affected individuals have a greater than expected frequency of social pathology. Although significant mental retardation is not associated with most Kleinfelter patients, the more X chromosomes and individual harbors the higher likelihood of mental retardation.

93. (D) Patients with hereditary fructose intolerance have defective function in hepatic fructose-1-phosphate aldolase (also called aldolase B). This enzyme hydrolyzes fructose-1-phosphate to glyceraldehyde and
dihydroxyacetone phosphate. The reaction is the second in the hepatic pathway of fructose metabolism, the initial one being the phosphorylation of fructose at the 1 position by fructokinase (choice B). When fructose is high in the diet (as in the consumption of large quantities of fruit) the capability to divert the fructose into the glycolytic pathway is severely impaired. Fructose becomes trapped in the liver as fructose-1-phosphate. Due to the lack of aldolase B, the capacity to phosphorylate fructose becomes limiting due to feedback inhibition of fructokinase, resulting in an elevation in serum fructose levels. Hepatic glucokinase (choice C) and aldolase A (choice E) are not involved in the metabolism of fructose. An allergic reaction (choice A) would not manifest with elevated serum fructose, hyperbilirubinemia, or hyperlacticacidemia.

94. (C) The incretins are molecules associated with food intake-stimulation of insulin secretion from the pancreas. Two of the many GI hormones have significant effects on insulin secretion and glucose regulation. These hormones are GLP-1 and glucose-dependent insulinotropic peptide (GIP). Both of these gut hormones represent the incretins. In contrast to activation of gastric emptying (choice A) and repression of pancreatic cell proliferation (choice D), GLP-1 inhibits gastric emptying and promotes a sense of satiety, induces proliferation, and represses apoptosis of pancreatic beta-cells. The incretins do not enhance adipose triacylglycerol synthesis (choice B). Repression of gastric acid secretion, not stimulation (choice E) is one of the additional functions of GIP.

95. (C) Regulation of the PDH complex is effected by both allosteric means and by phosphorylation (see Figure 3-16). Allosteric effectors of the enzyme complex are of both positive and negative type. The complex is phosphorylated by a specific kinase identified as PDH kinase and phosphate is removed by PDH phosphatase. When in the unphosphorylated state the complex is much more active, therefore the activity of PDH phosphatase is important for maintaining the PDH complex in the active state. Acetyl-CoA (choice A) and NADH (choice D) are both allosteric inhibitors of the nonphosphorylated form of the PDH complex and also serves to activate PDH kinase leading to phosphorylated and inhibited PDH. Like acetyl-CoA and NADH, ATP (choice B) allosterically activates the PDH kinase leading to phosphorylated and inhibited PDH. Phosphorylation (choice E) inhibits the activity of the PDH complex.

96. (B) Several enzymes of the blood clotting cascade (e.g., factors II, VII, IX, X, and protein C) bind calcium and are thus activated following cleavage of their zymogen forms. The ability of these proteins to bind calcium requires posttranslationally modified glutamate residues. The modification is a gamma-carboxylation yielding gamma-carboxyglutamate (gla) residue. The carboxylation reaction has an absolute requirement for vitamin K as a cofactor. None of the other amino acid modifications (choices A, C, D, and E) require vitamin K as a cofactor. Hydroxylation of proline (choice E) and lysine (choice C) is carried out by enzymes that require vitamin C as a cofactor.

97. (D) Steroid hormones are lipophilic and hence freely penetrate the plasma membrane of all cells. Within target cells, steroid hormones interact with specific receptors. These receptor proteins are composed of two domains: a hormone-binding domain and a DNA-binding domain. Following hormone-receptor interaction the complex is activated and enters the
nucleus. The DNA-binding domain of the receptor interacts with specific nucleotide sequences termed hormone response elements (HREs). The binding of steroid-receptor complexes to HREs results in an altered rate of transcription of the associated gene(s). The effects of steroid-receptor complexes on specific target genes can be either stimulatory or inhibitory with respect to the rate of transcription. Complexes of steroid with receptor have no direct effect on posttranscriptional processing of RNA (choice A), posttranslational events (choice B), DNA replication (choice C), or translation (choice E).

98. (D) Class I and class II genes of the major histocompatibility locus (MHC), which comprise the HLA genes, are highly polymorphic and express hundreds of different alleles in humans. Many of these polymorphic loci are associated, either positively or negatively, with autoimmune-related disorders. Inheritance of the class II HLA-DQ allele has been highly correlated to resistance to development of Type I diabetes. Conversely, the DR3 allele (choice E) is positively correlated with development of Type I diabetes. Autoantibodies to GAD (choice B) are found in over 80% of patients with Type I diabetes. Different VNTR structure present in the promoter region of the insulin gene (choice A) has been shown to indicate susceptibility to Type I diabetes. The HLA-B27 allele (choice C) is correlated with ankylosing spondylitis.

99. (C) Folic acid is the vitamin component of tetrahydrofolate, THF. Folic acid is reduced within cells (principally the liver where it is stored) to THF through the action of dihydrofolate reductase (DHFR), an NADPH-requiring enzyme. The function of THF derivatives is to carry and transfer various forms of one carbon units during biosynthetic reactions. One of the more important roles for THF is in the conversion of dUMP to dTMP catalyzed by thymidylate synthase, with the methyl group being donated by $N^5,N^{10}$-methylene-THF. Folate deficiency results in complications nearly identical to those described for vitamin B$_{12}$ deficiency. The most pronounced effect of folate deficiency on cellular processes is on DNA synthesis due to an impairment in dTMP synthesis. This leads to cell-cycle arrest in S-phase of rapidly proliferating cells, in particular hematopoietic cells. Deficiencies in ascorbate, vitamin C (choice A), leads to defects in collagen processing and the disorder is identified as scurvy. Deficiencies in biotin (choice B) are extremely rare but would manifest as hypoglycemia following fasting due to the role of biotin in gluconeogenesis at the pyruvate carboxylase step. Deficiencies of niacin, B$_3$ (choice D) are characterized by the “3 Ds”: depression, dermatitis, and diarrhea and are associated with the condition known as pellagra. Deficiencies in thiamin (choice E) cause constipation, appetite suppression, nausea as well as mental depression, peripheral neuropathy, and fatigue. Chronic thiamin deficiency leads to more severe neurologic symptoms including ataxia, mental confusion, and loss of eye coordination. The severe thiamin deficiency disease known as beriberi is the result of a diet that is carbohydrate rich and thiamin deficient. An additional thiamin deficiency related disease is known as Wernicke-Korsakoff syndrome. This disease is most commonly found in chronic alcoholics due to their poor dietetic lifestyles.

100. (B) CF affects a number of organ systems including the lung and upper respiratory tract, liver, pancreas, and sweat glands. Classical symptoms of individuals with CF are chronic airway infection with $P$. aeruginosa and Staphylococcus aureus. CF results from deficiencies in the gene encoding the CFTR. The protein encoded by this gene is a member of the ATP-binding cassette (ABC) transporter family of proteins. Although multiple organ systems are affected by defects in the CFTR gene, morbidity and mortality results primarily from impairment of the pulmonary defense system. Congenital adrenal hyperplasia, CAH (choice A) constitutes a group of diseases whose common features result from defects in the pathway leading to cortisol synthesis. The most frequent defects occur in the 21-hydroxylase gene (CYP21) that catalyzes the conversion of progesterone to 11-deoxycorticosterone and 17-hydroxyprogesterone to 11-deoxycortisol.
Deficiency in CYP21 leads to loss of cortisol and aldosterone secretion and maximal secretion of the adrenal androgens. The effect on female development is masculinization of the external genitalia. Renal Fanconi syndrome (choice C) is acquired either through exposure to toxic agents or due to various inborn errors in metabolism that lead to generalized dysfunction of the proximal renal tubules. Affected individuals exhibit a characteristic vitamin D-deficient metabolic bone disease, polyuria, polydipsia, hypokalemia, and acidosis. Sickle cell anemia (choice D) results from a mutation in the beta-globin gene and is characterized by lifelong hemolytic anemia, an increased propensity to infection, and complications resulting from repeated vascular occlusions that result during cycling crises. Tay-Sachs disease (choice E) is a fatal disease of early childhood resulting from a deficiency in the hexosaminidase A enzyme. Hexosaminidase A is required for the catabolism of complex sphingolipids (GM2 gangliosides) and defects in the enzyme lead to severe neurologic impairment.

101. (C) PAF is a unique complex lipid of the plasmalogen family. PAF functions in hypersensitivity, acute inflammatory reactions, and anaphylactic shock by increased vasopermeability, vasodilation, and bronchoconstriction. Excess production of PAF production may be involved in the morbidity associated with toxic shock syndrome and strokes. Arachidonic acid (choice A) is the precursor lipid for the eicosanoids, which includes the prostaglandins, thromboxanes, and leukotrienes. Leukotriene B4 (choice B) induces leukocyte chemotaxis and aggregation. Prostaglandin E2 (choice D) increases vasodilation, enhances effects of bradykinin and histamine, induces uterine contractions and platelet aggregation. Thromboxane A2 (choice E) induces platelet aggregation and vasoconstriction.

102. (C) The major substrates of gluconeogenesis are pyruvate and lactate. During gluconeogenesis lactate is oxidized to pyruvate. For pyruvate to be converted back to glucose, it must first be carboxylated to oxaloacetate, since a reversal of the PK reaction of glycolysis cannot occur to convert the pyruvate to phosphoenolpyruvate. The carboxylation of pyruvate is catalyzed by the mitochondrial enzyme pyruvate carboxylase. The activity of pyruvate carboxylase is absolutely dependent on the presence of acetyl-CoA, which allosterically activates the enzyme. Of the enzymes listed, only pyruvate carboxylase and PEPCK (choice B) are involved in gluconeogenesis. ACC (choice A) is involved in fatty acid synthesis and is not regulated by acetyl-CoA. PDH (choice D) is the entry point for pyruvate into the TCA cycle. It is also inhibited by acetyl-CoA via the acetyl-CoA-mediated activation of PDH kinase, an enzyme that phosphorylates and inactivates PDH. PK (choice E) is a glycolytic enzyme and is inhibited by acetyl-CoA, not activated by it.

103. (C) The normal flow of electrons, through the proteins of the oxidative phosphorylation machinery, is coupled with the establishment of a proton gradient across the inner mitochondrial membrane. The establishment of this pH gradient is the chemiosmotic potential that is coupled with the production of ATP. If the process of proton movement is uncoupled from the normal pathway through the ATP synthase complex, oxygen can be consumed but no ATP will be synthesized. This is the effect of uncoupling agents such as DNP, which act to discharge the proton gradient. Antimycin A (choice A) is an antibiotic that functions by inhibiting cytochrome b of complex III. Azide (choice B) inhibits cytochrome oxidase of complex IV. Oligomycin (choice D), a streptomyces antibiotic, inhibits ATP synthase. Rotenone (choice E) inhibits complex I.

104. (D) Myotonic dystrophy is the most common muscular dystrophy affecting adults. Apart from the clinical manifestations of the disease described in the question, myotonic dystrophy affects cardiac and smooth muscles, is associated with immune disorder, minor mental retardation, and cataracts. Myotonic dystrophy results from defects in the myotonin gene. These defects are associated with the expansion of a trinucleotide repeat sequence in the 3'-untranslated region of the gene. BMD (choice A)
and DMD (choice B) both result from mutations in the DMD gene, but the symptoms of BMD are milder than those of DMD. Transmission of these two diseases is X-linked. Marfan syndrome (choice C) and osteogenesis imperfecta are disorders of connective tissue. Marfan syndrome results from defects in the fibrillin gene and osteogenesis imperfecta from defects in collagen. None of the other four diseases exhibit the inheritance phenomenon of anticipation.

105. (C) The lac operon in bacteria is a group of three coordinately regulated genes whose functions are to allow the bacterium to survive when glucose is low or absent as an energy source. The major non-glucose source of energy is from lactose, a disaccharide of glucose and galactose. The control of expression from the lac operon by glucose is exerted through the level of cAMP, whereas, control by lactose is exerted through induced inhibition of the repressor of the operon. When glucose levels are plentiful, the level of cAMP is low. The role of cAMP in the regulation of the lac operon is to bind to the catabolite activator protein (CAP), which is a DNA-binding factor that stimulates the activity of RNA polymerase. As glucose levels drop, cAMP levels rise with a concomitant increase in CAP-mediated activation of polymerase. In the presence of lactose, the lac operon repressor protein is prevented from binding to the operator region of the operon resulting in an increase in the rate of transcription. Therefore, maximal activity would be seen with no glucose in the presence of lactose. With both glucose and lactose present (choice A), the level of cAMP would be low so there would be no activation of polymerase via CAP, but some level of transcription would occur due to the lactose-mediated inhibition of the repressor activity. With glucose and no lactose present (choice B) the lac operon would be maximally repressed since CAP would be inactive and repressor would be uninhibited. With no glucose or lactose (choice D), the level of cAMP would be high so activation of CAP would be evident leading to transcription, but due to the presence of the repressor the rate of transcription would not be maximal.

106. (E) Epigenesis refers to the phenomenon where phenotypic differences are present in the same species, but this difference is not due to differences in the genotype of the organism. None of the other examples (choices A–D) define epigenesis.

107. (A) RNA editing in mammals involves the deamination of adenine (A) to produce inosine (I) in pre-mRNAs. The process of A to I editing is catalyzed by ADARs (ADAs acting on RNA). In some pre-mRNAs this alters splicing; in some it alters codon(s). RNA editing also occurs to convert C to U. A C to U edit in the gene for apo B leads to tissue-specific generation of apo B_{48} in intestines, whereas the nonedited mRNA makes apo B_{100} in liver. None of the other gene products (B–E) result from RNA editing, although the generation of the CGRP is the result of another posttranscriptional phenomenon: alternative splicing and alternative polyadenylation site usage.

108. (D) Fatty acids are activated to the CoA derivatives at the outer mitochondrial membrane (catalyzed by enzyme 1 in Figure 3-5), but are oxidized inside the mitochondria. Long-chain fatty acyl-CoA molecules do not cross the mitochondrial membrane. A special transport system involving carnitine is used for movement of the activated fatty acids into the mitochondria. The fatty acyl moiety is transferred from the CoA to carnitine in a reaction catalyzed by carnitine acyltransferase I (enzyme 2 in Figure 3-5). Acyl carnitine thus formed is shuttled across the inner mitochondrial membrane (via enzyme 3 in Figure 3-5), where the fatty acyl group is transferred back to a CoA molecule within the mitochondrial matrix. The latter reaction is catalyzed by carnitine acyltransferase II (enzyme 4 in Figure 3-5). Medium-chain fatty acyl-CoAs can cross the mitochondrial membrane and do not require the carnitine transport system for entry into the mitochondria. The compound(s) at point A are ATP and CoA, point B is carnitine, point C is acylcarnitine, point D is carnitine, and E is acylcarnitine. Therefore, the requirements for carnitine occur on either side of the inner mitochondrial membrane at points B and D, which
occur during the translocation process. All other combinations (choices A, B, C, and E) have a compound or compounds other than or in addition to carnitine.

109. **(A)** Major reactions, that involve the regulation of plasma pH as well as the level of circulating ammonia, involve the heptatic and renal enzymes GDH, glutamine synthase (GS), and glutaminase. The liver compartmentalizes GS and glutaminase in order to control the flow of ammonia into glutamine or urea. Under acidic conditions the liver diverts ammonia to glutamine via the GS reaction. The glutamine then enters the circulation. In fact, glutamine is the major amino acid of the circulation and its role is to ferry ammonia to and from various tissues. In the kidneys, glutamine is hydrolyzed by glutaminase (yielding glutamate) releasing the ammonia to the urine. There the ammonia ionizes to ammonium ion, $\text{NH}_4^+$, which reduces the circulating concentration of hydrogen ion resulting in an increase in the pH. Additionally, the glutamate can be converted to alpha-ketoglutarate yielding another mole of ammonia, which is ionized by hydrogen ions further increasing the pH. Incorporation of ammonia into alpha-ketoglutarate (choice B) would deplete the ammonia ionization reaction and lead to further acidification. Glutamine conversion to glutamate (choice C) will occur in the kidneys but not in the liver under acidic conditions. Glutamine is not directly converted to alpha-ketoglutarate (choice D); a two-step process is required and would take place in the kidneys not in the liver under acidic conditions as in choice C. Conversion of ammonia into urea (choice E) is the process of ridding the body of waste nitrogen, but it is not a means to regulate the pH of bodily fluids.

110. **(D)** Refsum disease is the result of defects in the oxidation of phytanic acid, a lipid requiring an alpha-oxidation pathway. As a consequence, phytanic acid accumulates in the blood and tissues. The hallmark symptoms of the disease are retinitis pigmentosa, cerebellar ataxia, chronic polyneuropathy, and an elevation in protein in the cerebrospinal fluid with no increase in cell count. A deficiency in carnitine palmitoyltransferase I (choice A) primarily affects the liver and results in reduced fatty acid oxidation and ketogenesis. Fragile X syndrome (choice B) is the most common form of heritable mental retardation worldwide. MCAD deficiency (choice C) is one of the most frequently inherited defects in metabolism. Clinical crisis is characterized by an infant presenting with episodes of vomiting and lethargy, seizures, and coma associated with a period of fasting. On presentation, the infant may be comatose and blood glucose will be low with low to no ketones in urine. RCDP (choice E) is caused by a disorder in peroxisome biogenesis. Rhizomelia refers to striking shortening of the proximal limbs. Patients also have severely disturbed endochondral bone formation. In addition, RCDP patients have profound psychomotor retardation.

111. **(C)** The molar ratio of adenosine in any molecule of double-stranded DNA will be equivalent to that of thymidine, since these two nucleotides hydrogen bond to form base pairs. Therefore, the total amount of the DNA accounted for in A-T base pairs would be 40%. Since guanosine and cytidine hydrogen bond to form base pairs, they too contribute an equivalent molar ratio in double-stranded DNA. In double-stranded DNA with 40% A-T composition, the molar ratio of cytidine would be half of the remaining 60% of the DNA, or 30%. No other molar ratio (choices A, B, D, and E) could account for the amount of cytidine in a double-stranded DNA with 20% adenosine.

112. **(E)** In cardiac and skeletal muscle, high-energy phosphate is stored through the transfer of a
phosphate from ATP to creatine-generating creatine phosphate. Creatine is synthesized in liver from guanidoacetate. Guanidoacetate is derived from the amino acid arginine in the kidneys (Figure 3-17). In muscle cells, creatinine is a nonenzymatic metabolite of creatine phosphate. When measured in the serum, levels of creatinine are remarkably constant from day to day and are proportional to muscle mass. In renal dysfunction, the clearance of creatinine will be impaired and its levels will therefore rise in the serum. Although creatine is synthesized in the liver (choice C) from guanidoacetate, which is produced in the kidneys (choice B), it is not used by these two tissues, nor by the lung (choice D) or adipose tissue (choice A). Once synthesized, creatine is transported to cardiac and skeletal muscle where it is phosphorylated and stored for future energy needs.

114. (D) LFS is a rare inherited form of cancer that involves breast and colon carcinomas, soft-tissue sarcomas, osteosarcomas, brain tumors, leukemia, and adrenocortical carcinomas. These tumors develop at an early age in LFS patients. The tumor suppressor gene found responsible for LFS is p53. Mutant forms of p53 are found in approximately 50% of all tumors. The normal p53 protein functions as a transcription factor that can induce either cell-cycle arrest or apoptosis (programmed cell death) in response to DNA damage. CJD (choice A) encompasses three forms: infectious, sporadic, and inherited, with the vast majority of cases being sporadic. Clinical abnormalities of CJD are confined to the CNS and result from a pathogenic protein identified as prion protein (PrP). Crouzon syndrome (choice B) is characterized by craniosynostosis (midface hypoplasia and ocular proptosis) and is the result of a mutation in one of the receptors for fibroblast growth factor (FGFR2). HD (choice C) is an autosomal-dominant disorder resulting from expansion of the triplet CAG within the huntingtin gene. The exact function of the huntingtin protein is still unclear. Symptoms of HD include personality changes, memory loss, and involuntary
leg and arm movements (chorea). The average age of onset is 37 years. PWS (choice E) is a relatively common cause of genetic obesity and mental retardation. Symptoms of severe hypotonia and poor suckling are evident at birth. PWS is caused by a deletion of a portion of the long arm of chromosome 15 [del(15q11–q13)].

115. (E) Hereditary orotic aciduria results from a defect in the de novo synthesis of pyrimidines. The defect is in the bifunctional enzyme that catalyzes the last two steps in the de novo pathway, conversion of orotic acid to OMP and OMP to UMP. Administration of uridine allows afflicted individuals to produce sufficient levels of cytidine nucleotides via the salvage pathways. Treatment with uridine leads to a return of normal blood hemoglobin levels, and bone marrow will become normoblastic. Treatment with cytidine (choice B) has some limited ability to ameliorate symptoms of the disease, but not to the extent of uridine administration. None of the other nucleosides (choices A, C, and D) can be salvaged into cytidine or uridine nucleotides, and are therefore of no clinical value in the treatment of hereditary orotic aciduria.

116. (A) Transcription occurs in the 5’–3’ direction, and during this process RNA polymerase will move in the 3’–5’ direction relative to the template DNA strand. Therefore, the correct transcriptional product from the DNA template begins with its 5’ ribonucleotide corresponding to the complementary deoxyribonucleotide of the 3’ end of the template. None of the other RNA strands (choices B, C, D, and E) could be products generated from the template shown.

117. (C) Translation in a eukaryotic in vitro translation system would begin at an AUG codon residing near the 5’-end of the mRNA. Therefore, translation of the correct RNA product would begin two nucleotides from the 5’ end at the first AUG codon. This would result in the translation of a protein of four amino acids. None of the other choices (A, B, D, and E) translate into a four-unit amino acid chain.

118. (B) When epinephrine stimulates adipocytes (by interaction with beta-adrenergic receptors), the immediate response is the activation of adenylate cyclase, which in turn leads to an increase in cAMP. Increased levels of cAMP lead to activation of PKA, which in adipocytes will phosphorylate and activate hormone-sensitive lipase. When hormone-sensitive lipase is active, it removes fatty acids in a step-wise manner from stored triacylglycerides. The released fatty acids then enter the blood and are bound by albumin for transport to peripheral tissues including the liver. LPL (choice C) is present on the surfaces of vascular endothelial cells and is activated by apo CII present in VLDLs and chylomicrons. Epinephrine is a stimulus that leads to energy consumption and therefore would not lead to an increase in triacylglyceride synthesis (choice A). When triacylglyceride breakdown is activated in adipocytes, the glycerol backbone is released as free glycerol, not glycerol-3-phosphate (choice E) to the blood and delivered to the liver for gluconeogenesis. Fatty acids released from adipose tissue are transported in the blood bound to albumin, not within any lipoprotein particle (choice D).

119. (B) Numerous cancers are caused by the loss of function of tumor suppressor genes. LFS is a rare form of inherited cancer that involves breast and colon carcinomas, soft-tissue sarcomas, osteosarcomas, brain tumors, leukemia, and adenocortical carcinomas. These tumors develop at an early age in LFS patients. The tumor suppressor gene found responsible for LFS is p53. Mutant forms of p53 are found in approximately 50% of all tumors. The normal p53 protein functions as a transcription factor that can induce either cell-cycle arrest or apoptosis (programmed cell death) in response to DNA damage. FAP (choice A) is a rare inherited form of colon cancer. Germline mutations in the APC gene are responsible for FAP. All cases of neurofibromatosis (choice C) arise by inheritance of a mutant allele. Roughly 50% of all affected individuals carry new mutations, which appear to arise paternally, possibly reflecting genomic imprinting. The gene responsible for type 1 neurofibromatosis is termed NF1. Germline mutations at the NF1 locus result in multiple abnormal melanocytes
(café au lait spots) and benign neurofibromas. Some patients also develop benign pheochromocytomas and CNS tumors. A small percentage of patients develop neurofibrosarcomas, which are likely to be Schwann cell derived. Retinoblastoma (choice D) is a tumor of retinal cells, which develops in children between birth and 4 years of age. The gene responsible is termed the retinoblastoma susceptibility gene (RB) and the protein product pRB. Wilms’ tumor (choice E) is a form of childhood kidney cancer. The gene responsible for this disease has been identified and is called WT1 (Wilms’ tumor 1).

120. (B) The extrinsic pathway (see Figure 3-18) is initiated at the site of injury in response to the release of tissue factor (factor III). Tissue factor is a cofactor in the factor VIIa-catalyzed (lower case alpha refers to the active form of the coagulation factors) activation of factor X. The formation of a complex between factor VIIa and tissue factor is believed to be a principal step in the overall clotting cascade. Evidence for this stems from the fact that persons with hereditary deficiencies in the components of the contact phase of the intrinsic pathway do not exhibit clotting problems. Factor VIIa, a gamma-glutamate (gla residue) containing serine protease, cleaves factor X to factor Xa in a manner identical to that of factor IXa of the intrinsic pathway. The activation of factor VII occurs through the action of thrombin or factor Xa. The ability of factor Xa to activate factor VII creates a link between the intrinsic and extrinsic pathways. An additional link between the two pathways exists through the ability of tissue factor and factor VIIa to activate factor IX. Fibrinogen (choice A) is cleaved by thrombin (factor IIa), yielding fibrin monomers that polymerize to form a fibrin clot. The activation of factor VIII (choice C) to factor VIIIa occurs in the presence of minute quantities of thrombin. Factor VIIIa is required for the activation of factor X, which represents the convergence of the intrinsic and extrinsic pathways. The activation of factor X to Xa requires assemblage of the tenase complex (Ca²⁺ and factors VIIa, IXa, and X) on the surface of activated platelets. As the concentration of thrombin increases, factor VIIIa is ultimately cleaved by thrombin and inactivated. This dual action of thrombin on factor VIII acts to limit the extent of tenase complex formation, and thus the extent of the coagulation cascade. Factor IX (choice D) functions only in the intrinsic cascade. When activated, factor IXa aids in the activation of factor X by functioning in the tenase complex as described above. Protein S (choice E) is a cofactor for protein C. Protein C is itself activated by thrombin and when active, cleaves factors VIIIa and Va, thus limiting the extent of the coagulation cascade.

121. (D) Doxorubicin is a drug of the class that functions by interfering with topoisomerases. In particular, doxorubicin inhibits topoisomerase II. During the process of DNA replication, the two strands of the DNA helix are separated. As the replication fork progresses toward sites of chromosomal attachment to the scaffold, there is an increase in the torsional stress on the helix due to supercoiling. These torsional stresses are relieved by the action of topoisomerases that introduce nicks into the DNA, which allows the strands to unwind the supercoils. Topoisomerase I introduces single-strand nicks, whereas topoisomerase II introduces double-strand nicks. Interference with the action of topoisomerases would thus impair the rate of DNA replication and this would be detrimental for rapidly proliferating cells such
as cancer. Doxorubicin does not affect the activity of any of the other enzymes (choices A–C, E).

122. (A) Propionyl-CoA is converted to succinyl-CoA in a series of reactions using three different enzymes. It is first carboxylated in an ATP-dependent reaction catalyzed by propionyl-CoA carboxylase, an enzyme that requires biotin as a cofactor. The product of the first reaction, d-methylmalonyl-CoA is then converted to l-methylmalonyl-CoA by methylmalonyl-CoA racemase. Finally, methylmalonyl-CoA is converted to succinyl-CoA by the cobalamin-requiring enzyme, methylmalonyl-CoA mutase. None of the other vitamins (choice B, C, D, and E) are required in this pathway.

123. (E) von Recklinghausen disease (neurofibromatosis, type I), an autosomal-dominant disorder, is one of the most striking disorders that exhibits variable expressivity (phenotypic variation). Symptoms can range from the benign appearance of café au lait spots to severe disfiguring cutaneous neurofibromas, sarcomas, and gliomas. This disorder is caused by disruption in the neurofibromin gene whose protein product functions the catalysis of inactivation of the signaling protein RAS. FAP coli (choice A) is a disorder that results in the generation of numerous small polyps in the colon by the time an individual reaches age 20. Although the polyps are asymptomatic, they are a significant contributory factor to risk and likelihood of colon cancer. This disorder is caused by mutations in the APC gene, is inherited in autosomal-dominant fashion, and its penetrance is 100% in all afflicted individuals. FH (choice B) is caused by mutations in the gene for the LDL receptor. Inheritance is autosomal dominant with 100% penetrance. FH sufferers may be either heterozygous or homologous for a particular mutation in the receptor gene. Homozygotes exhibit grossly elevated serum cholesterol (primarily in LDLs). The elevated levels of LDLs result in their phagocytosis by macrophages. These lipid-laden phagocytic cells tend to deposit within the skin and tendons, leading to xanthomas. A greater complication results from cholesterol deposition within the arteries, leading to atherosclerosis, the major contributing factor of nearly all cardiovascular diseases. LFS (choice C) is a rare form of autosomal-dominant inherited cancer caused by mutations in the tumor suppressor gene, p53. The disruption in the function of p53 leads to aberrant cell-cycle regulation and development of sarcomas, brain tumors, breast cancer, and leukemias. Cancer occurs in 50% of afflicted individuals by the time they are 30 years of age. VHL syndrome (choice D) is an inherited form of renal carcinoma that is caused by mutations in a tumor suppressor gene identified as the VHL gene.

124. (C) The major mechanism for the inhibition of the extrinsic pathway occurs at the tissue factor—factor VIIa-Ca}\textsuperscript{2+}-Xa—complex. The protein, lipoprotein-associated coagulation inhibitor (LACI, formerly named anticonvertin), specifically binds to this complex. LACI is composed of three tandem protease inhibitor domains. Domain 1 binds to factor Xa and domain 2 binds to factor VIIa only in the presence of factor Xa. Antithrombin III (choice A) is the most important of four thrombin regulatory proteins. This is because antithrombin III can also inhibit the activities of factors IXa, Xa, XIa, and XIIa. The activity of antithrombin III is potentiated in the presence of heparin. Heparin binds to a specific site on antithrombin III, producing an altered conformation of the protein, and the new conformation has a higher affinity for thrombin as well as its other substrates. This effect of heparin is the basis for its clinical use as an anticoagulant. The naturally occurring heparin activator of antithrombin III is present as heparan and heparan sulfate on the surface of vessel endothelial cells. It is this feature that controls the activation of the intrinsic coagulation cascade. HMWK (choice B) is important for initiation of the intrinsic pathway. When prekallikrein, HMWK, factor XI, and factor XII are exposed to a negatively charged surface, they become active. This is termed the contact phase. Exposure of collagen to a vessel surface is the primary stimulus for the contact phase. In addition to antithrombin III, thrombin activity is also inhibited by alpha-2-macroglobulin (choice D). Protein C (choice E) is activated by thrombin when
thrombin is bound to thrombomodulin. Active protein C functions with its cofactor, protein S, to degrade factors VIIIa and Xa.

125. (C) Ferritin is an iron-binding protein that prevents toxic levels of ionized iron (Fe$^{2+}$) from building up in cells. As iron levels increase, the need to increase the amount of ferritin also increases. Iron-mediated regulation of ferritin levels occurs through the action of an iron response element-binding protein (IRBP) that binds to specific iron response elements (IREs) in the 5′-UTR of the ferritin mRNA. These IREs form hairpin loop structures that are recognized by IRBP. This IRBP is an iron-deficient form of aconitase, the iron-requiring enzyme of the TCA cycle. When iron levels are high, IRBP cannot bind to the IRE in the 5′-UTR of the ferritin mRNA. This allows the ferritin mRNA to be translated. When iron levels are low, IRBP is free of iron and can therefore, interact with the IRE in the ferritin mRNA preventing its translation. Binding of iron by ferritin does not increase its excretion in the urine (choice A). Ferritin does not exist as a multimeric protein exhibiting iron binding cooperativity (choice B). Iron binding to ferritin does not affect the half-life of ferritin (choice D).

126. (B) The continual alteration of the intracellular sterol content occurs through the regulation of key sterol synthetic enzymes, as well as by altering the levels of cell-surface LDL receptors. As cells need more sterol they will induce their synthesis and uptake, conversely when the need declines synthesis and uptake are decreased. Regulation of these events is brought about primarily by sterol-regulated transcription of key rate-limiting enzymes and by the regulated degradation of HMGR. Activation of transcriptional control occurs through the regulated cleavage of the membrane-bound transcription factor SREBP (there are three SREBP’s). Sterol control of transcription affects more than 30 genes involved in the biosynthesis of cholesterol, triacylglycerols, phospholipids, and fatty acids. Transcriptional control requires the presence of an octamer sequence in the gene termed the sterol regulatory element, SRE-1. It has been shown that SREBP is the transcription factor that binds to SRE-1 elements. All three SREBP’s are proteolytically regulated by sterols. Full-length SREBP’s have several domains and are embedded in the membrane of the ER. The N-terminal domain contains a transcription factor motif of the basic helix-loop-helix (bHLH) type that is exposed to the cytoplasmic side of the ER (see Figure 3-19). When sterols are scarce, cleavage of the full-length SREBP takes place with the result being that the N-terminal bHLH motif is released into the cytosol. The bHLH domain then migrates to the nucleus to direct transcription. Conversely, when sterols are abundant, cleavage of SREBP is inhibited. To control the level of SREBP-mediated transcription, the soluble bHLH domain is itself subject to rapid proteolysis. The cleavage of SREBP is carried out by two distinct enzymes, one of which is regulated by sterols. The regulated cleavage occurs in the lumenal loop between the two transmembrane domains. This cleavage is catalyzed by site-1 protease, S1P. High sterol content blocks the activity of S1P. The second cleavage, catalyzed by site-2 protease, S2P, occurs in the first transmembrane span, leading to release of active SREBP. In order for S2P to act on SREBP, site-1 must already have been cleaved. Additional studies on sterol-regulated gene expression demonstrated that cleavage of SREBP by S1P is controlled by the level and action of an additional protein termed, SREBP cleavage-activating protein, SCAP (see Figure 3-19). SCAP is a large protein also found in the ER membrane and contains at least eight transmembrane spans. The C-terminal

![FIG. 3-19]
portion, which extends into the cytosol, has been shown to interact with the C-terminal domain of SREBP. This C-terminal region of SCAP contains four motifs called WD40 repeats. The WD40 repeats are required for interaction of SCAP with SREBP. The function of SCAP is to positively stimulate S1P-mediated cleavage of SREBP. The function of sterols is to inhibit this positive action of SCAP. The activity of SCAP involves movement from the ER to the Golgi and back. Because the C-terminus of SCAP interacts with SREBP, movement of SCAP takes SREBP along for the ride. When sterols are low, SCAP and SREBP move to the Golgi. This transit is required for SREBP cleavage as S1P is Golgi-localized. When sterols are high, movement of SCAP is halted. Thus, the overall effect of sterols is to regulate the ability of SCAP to present SREBP to S1P. None of the other choices (A, C–E) represent the mechanisms of sterol-mediated regulation of gene expression.

127. (C) AMP-activated protein kinase (AMPK) was first discovered as an activity that inhibited preparations of ACC and 3-hydroxy-3-methylglutaryl-CoA reductase (HMG-CoA reductase, HMGR) and was induced by AMP. AMPK induces a cascade of events within cells in response to the ever changing energy charge of the cell. The role of AMPK in regulating cellular energy charge places this enzyme at a central control point in maintaining energy homeostasis (see Figure 3-20). Once activated, AMPK-mediated phosphorylation events switch cells from active ATP consumption (e.g., fatty acid and cholesterol biosynthesis) to active ATP production (e.g., fatty acid and glucose oxidation). Other important activities attributable to AMPK are regulation of insulin synthesis and secretion in pancreatic islet beta-cells. As shown in Figure 3-20, AMPK inhibits (not activates) both ACC (choice A) and FAS (choice B). Activation (not inhibition) of PFK-2 (choice E) occurs in response to AMPK. Although AMPK does indeed inhibit mTOR (choice D), this inhibition does not have any influence on adipose tissue lipolysis.

128. (A) The protein of the Wnt signaling cascade, to which APC associates, is beta-catenin. Using antibodies specific for the NH2-terminus of APC, it was possible to coprecipitate additional APC-associated proteins leading to the identification
that one of these APC-associated proteins was beta-catenin. The catenins are a family of proteins that interact with the cytoplasmic portion of the cadherins (cell-cell adhesion family of proteins), thus linking the cadherins to the actin cytoskeleton. Catenins are equally important in the signaling cascade initiated by the Wnt family of proteins that are involved in embryonic patterning, development of the nervous system. The Wnt proteins are secreted factors that interact with cell-surface receptors. Wnt-receptor interaction induces the activity of the cytoplasmic phosphoprotein dishevelled. Activated dishevelled inhibits the serine/threonine kinase glycogen synthase kinase-3-beta (GSK-3β). When GSK-3-beta is inhibited, beta-catenin becomes hypophosphorylated. The hypophosphorylated form of beta-catenin migrates to the nucleus and interacts with transcription factors, thereby, inducing expression of various genes. The role of APC in this pathway is to bind phosphorylated beta-catenin. The APC-beta-catenin complex stimulates the breakdown of beta-catenin. Therefore, mutations that lead to a loss of APC, or to a loss of the portion of the APC protein that interacts with beta-catenin, would lead to constitutive activation of several genes that could then promote the transformed phenotype. None of the other proteins (choices B–E) are known to interact with APC.

1. A student has a genetic defect and cannot produce the J chain which is important in the structure of some immunoglobulin molecules. Which of the following will most likely be observed in this individual?

(A) a decrease in mature B cells
(B) a decrease in mature T lymphocytes
(C) a decrease in serum IgM
(D) an increase in IgA in the intestine
(E) an increase in serum IgM and decrease in IgE

2. A 10-year-old boy has a bacterial pneumonia. The etiologic agent had M type-1 protein and grew on blood agar. The patient’s immune system appeared incapable of controlling the infection. A decrease in which of the following is most directly related to the immunological failure?

(A) antibody activity
(B) cytotoxic T-cell function
(C) IL-4 and IL-10 levels
(D) mast cell degranulation
(E) platelet aggregation

3. An emaciated prisoner in a New York prison began coughing up sputum streaked with blood. Examination of the sputum revealed the presence of acid-fast bacilli. Which of the following would be least helpful in establishing a diagnosis of tuberculosis?

(A) agglutination test for antibodies
(B) niacin production test
(C) nitrate reduction test

Questions 4 and 5

4. Following the consumption of fish at a local restaurant, a 17-year-old girl suddenly experiences severe dyspnea. Upon arrival at the local emergency room she is found to be severely hypotensive and in respiratory distress. Urticarial wheals are also noted all over her body. As the resident physician you quickly realize this to be a hypersensitivity reaction. To which of the following immunoglobulins does the allergen bind rapidly during the activation stage of mast cells?

(A) IgA
(B) IgD
(C) IgE
(D) IgG
(E) IgM

5. Physical examination reveals severe laryngeal edema resulting in a marked hoarseness when the 17-year-old girl attempts to speak. Also, her lips and tongue show significant swelling. Which of the following chemicals most likely caused this edematous swelling?

(A) corticosteroids
(B) cromolyn sodium
(C) epinephrine
(D) histamine
(E) 5-lipoxygenase
6. In February, three patients from a nursing home in East Dallas develop an abrupt onset of a febrile upper respiratory tract illness. They have received no immunizations in the last year. Culture of the nasopharynx of one patient shows influenza A virus. To prevent further cases within the next two weeks, which of the following should be administered?

(A) acyclovir  
(B) amantadine  
(C) hyperimmune serum globulin  
(D) influenza A vaccine  
(E) ribavirin

7. Which of the following statements best describes interferon’s suspected mode of action in producing resistance to viral infection?

(A) It alters the permeability of the cell membrane so that viruses cannot enter the cell.  
(B) It stimulates a cell-mediated immunity.  
(C) It stimulates humoral immunity.  
(D) Its action is related to the synthesis of a protein that inhibits mRNA function.  
(E) Its direct antiviral action is related to the suppression of messenger RNA formation.

8. A 25-year-old man with acquired immune deficiency disease (AIDS) has malabsorption, chronic abdominal pain, low-grade fever, and nonbloody diarrhea. In fecal smears, large numbers of oocysts containing four sporozoites were observed. Which of the following organisms is most likely the etiological agent?

(A) Cryptosporidium parvum  
(B) Entamoeba histolytica  
(C) Giardia lamblia  
(D) Microsporidia species  
(E) Taenia solium

9. A 38-year-old sexually-active woman developed symptoms of lower abdominal pain with adjacent tenderness. No gram-negative cocci were observed or isolated. The obligate intracellular organism causing the infection is unable to perform which of the following metabolic functions?

(A) form ATP  
(B) form the intracellular, metabolically active, reticulate body  
(C) produce polypeptides  
(D) reproduce by binary fission  
(E) synthesize DNA gyrase

10. Severe septic infections caused by bacteria possessing capsules often occur following splenectomy. Which of the following statements most accurately explains why this medical complication is able to occur?

(A) The spleen is a source of IgM and IgG antibodies needed to opsonize encapsulated bacteria.  
(B) The spleen is the main source of stem cells.  
(C) The spleen is uniquely equipped to process capsular polysaccharides.  
(D) The spleen rapidly inactivates many antimicrobial agents.  
(E) The spleen readily metabolizes therapeutic doses of antibiotics.

11. A 37-year-old man was immunologically competent but presented to his physician with malaise, fever, lethargy, and back pain. Examination also revealed vertebral osteomyelitis, splenomegaly, and hepatomegaly. He was a PPD-negative farm worker who consumed unpasteurized goat milk. Which of the organisms listed below is the most-likely etiological agent?

(A) Actinomyces israelii  
(B) Aspergillus fumigatus  
(C) Brucella melitensis  
(D) Candida albicans  
(E) Mycobacterium tuberculosis

12. A 45-year-old man was admitted to the hospital because of fever, shortness of breath, and weight loss with edema in the lower limbs. Examination revealed cardiomegaly and arrhythmias, and a diagnosis of myocarditis was made. Bacterial blood cultures were negative. Which of the
Questions 13 and 14

13. A 5-month-old baby presents to the local community clinic with noted oral candidiasis, chronic diarrhea, extensive diaper rash, and an overall failure to thrive. Previously this infant has been seen for multiple severe, recurrent infections from viruses, fungi, bacteria, and protozoa. Chest x-ray reveals an absent thymic shadow. Which of the following immunodeficiencies best explains this baby’s recurrent infections?

(A) Bruton agammaglobulinemia
(B) deficiencies in the C5–C8 components of complement
(C) deficiency in neutrophil NADPH oxidase
(D) DiGeorge syndrome
(E) severe combined immunodeficiency (SCID)

14. Which of the following can most likely restore the immunological competency of this 5-month-old baby?

(A) administration of purine nucleoside phosphorylase
(B) B-cell supplementation
(C) compatible bone marrow transplantation
(D) injection of adenosine deaminase
(E) T-cell treatment

15. A 20-year-old woman with generally normal health and immune capacity visited her doctor complaining of 2 weeks of fever, sore throat, and cough. She had recently seen blood-streaked sputum and had noticeable chest pain. X-rays showed only a moderate amount of pulmonary consolidation, while a cold agglutinin titer of 1:256 was reported. Which organism listed below is the most likely etiological agent?

(A) Chlamydia pneumoniae
(B) Coxiella burnetii
(C) Legionella pneumophila
(D) Mycoplasma pneumoniae
(E) Pneumocystis carinii

16. A medical student has been immunized with hepatitis B virus (HBV) recombinant vaccine. The curve in Figure 4-1 represents the production of protective antibodies to the viral component present in the recombinant vaccine. Which of the following is the known viral component of the HBV vaccine?

(A) nucleocapsid proteins of HBV
(B) RNA genome of HBV
(C) viral core antigen (HBcAg)
(D) viral e antigen (HBeAg)
(E) viral surface antigen (HBsAg)

17. While on a wilderness vacation, a banker develops extensive skin lesions noted for their varying degrees of erythema, edema, and vesiculations. His physician tells him that these lesions are due to delayed type hypersensitivity. If this is actually the case, which of the following statements is accurate?

(A) Delayed-type hypersensitivity can be transferred passively to volunteers by sensitized lymphocytes.
(B) Delayed-type hypersensitivity is suppressed by antihistaminic drugs.
(C) This allergy does not cause tissue damage.
(D) This allergy is due to IgE absorbed on mast cells.
(E) This type of allergy usually occurs after inhalation of grass pollens.
18. A 42-year-old woman had a catheter placed in her urethra. One week later she is experiencing suprapubic flank pain with urinary urgency and frequency. She has also chills and fever. After examining the patient and evaluating the sediment of her centrifuged urine, she is informed by her physician that she has acute ascending pyelonephritis. If the diagnosis is accurate and the patient’s urine is cultured, which of the following organisms will most likely be isolated?

(A) *Clostridium difficile*
(B) *Escherichia coli* with pili
(C) *Pseudomonas aeruginosa*
(D) *Staphylococcus aureus*
(E) streptococci—group B

19. A 25-year-old female executive presents with edema, hematuria, proteinuria, and decreased urination indicative of glomerulonephritis. Three weeks ago she had impetigo on her chest which resolved without treatment. Which of the following organisms is the most likely cause of her renal disease?

(A) *E. coli*
(B) *S. aureus*
(C) *S. saprophyticus*
(D) *Streptococcus agalactiae*
(E) *S. pyogenes*

20. A 22-year-old man complains to his family physician of fatigue, night sweats, and a dry unproductive cough. Until the past few months, he had apparently been in good health. A complete blood count (CBC) and differential blood count reveal that he is lymphopenic. X-ray examination reveals an interstitial pneumonia. Skin test reactions to a battery of materials are normal. Which of the following should be the next step in evaluating this patient’s illness?

(A) CH50 complement assay
(B) chemotaxis assay
(C) identification of the organism that is causing the pneumonia
(D) intracellular killing assay
(E) nitroblue tetrazolium reduction assay

21. A 22-year-old Hispanic man worked for a company that processed animal products and provided no medical coverage benefits. One week after working with wool imported from a Caribbean island, he developed a small lesion on his arm resembling an insect bite. One week later, the lesion was 2.5 cm in diameter with a central, black sloughed-skin area. Two weeks later, he presented at an emergency room with early stages of sepsis. Which of the following microbes is responsible for the infection?

(A) *Bacillus anthracis*
(B) *Bacteroides melanogenicus*
(C) *Hemophilus ducreyi*
(D) *M. scrofulaceum*
(E) *Treponema pallidum*

22. An outbreak of severe, atypical pneumonia occurred in a Southeast Asian community. Symptoms included high fever, chills, headache, and a cough or breathing difficulty. A virus with the structure shown in Figure 4-2 was implicated as the cause of the infections. Which of the viruses listed below caused this outbreak?

(A) arenavirus
(B) filovirus
(C) poxvirus
(D) rabies virus
(E) SARS virus
23. Figure 4-3 depicts an electrophoretic pattern of serum proteins. This electrophoretic pattern is likely to be obtained from a 6-month-old infant suffering from recurrent pyogenic infections. He has which of the following diseases?

(A) Addison disease
(B) Bruton disease
(C) Graves disease
(D) Goodpasture syndrome
(E) Myasthenia gravis

Questions 24 and 25

24. A 20-year-old prostitute presents at a local clinic with fever and abdominal tenderness at day 2 of her menstrual cycle. Gram-negative diplococci are seen in a Gram stain of vaginal secretions with many of the bacteria inside PMNs. Which of the following is likely the most important virulence factor necessary for this organism to initiate infection?

(A) capsule
(B) endotoxin
(C) hyaluronidase
(D) pili
(E) protease

25. Which of the following approaches is likely to prevent future infection of patrons of the sex worker in question 24?

(A) frequent washing of the genital area
(B) immunization with the appropriate toxoid
(C) prophylactic use of 100 units oral penicillin
(D) use of condoms
(E) vaccination with heat-killed germs

26. A boy picked up a grounded bat and was bitten on the hand, suffering a slight wound. In addition to flushing the wound, cleaning it surgically, and giving antitetanus prophylaxis and antibiotics as indicated, the physician should immediately perform which of the following?

(A) observe the boy very carefully
(B) order a search for the attacking bat for autopsy
(C) report the incident to the state epidemiologist
(D) start rabies vaccine
(E) start rabies vaccine and give antirabies serum

27. A 60-year-old male with a chronic cough, bloody sputum, and marked weight loss is diagnosed as having tuberculosis. A “serpentine-like” colonial morphology is noted on Lowenstein-Jensen agar. This latter finding is due to which of the following factors?

(A) coagulase
(B) endotoxin
(C) large “slimy” capsule
(D) trehalose-6,6′-dimycolate
(E) Wax D
28. Darrin is an intern working in the emergency room at the local county hospital. Mr Arnold, a 48-year-old homeless man, comes in complaining of “feeling real bad.” Mr Arnold’s mentation is altered, and is unable to verbalize his past medical history. Darrin is having difficulty examining the patient because his body emits a tremendous odor. While examining him, Darrin discovers that his right leg is red, swollen, sore, and covered with ulcers. The nurse in the emergency room covers the leg with dressings and a plastic bag to contain the smell. By morning, Mr Arnold’s anaerobic blood cultures become positive with gram-positive rods. Darrin observes that the bag is full of air, and when he removes it the smell is overwhelming. What should Darrin do?

(A) Arrange for Mr Arnold to receive hyperbaric oxygen therapy.
(B) Consult with a surgeon, as Mr Arnold will need debridement and IV antibiotics.
(C) Continue the broad spectrum IV antibiotics he has prescribed for Mr Arnold.
(D) Put Mr Arnold in respiratory isolation and confirm his diagnosis with a spinal tap.

29. Which of the following chemical agents is a powerful oxidizing agent used to kill microorganisms?

(A) benzoic acid  
(B) chlorine  
(C) ethyl alcohol  
(D) ethylene oxide  
(E) mercury

30. On November 6, a patient had the onset of an illness characterized by fever, chills, headache, cough, and chest pain. The illness lasted 1 week. On December 5, she had another illness very similar to the first, which lasted 6 days. She had no flu immunization during this period. Her HI titer to swine flu virus is shown in Figure 4-4. (There were no laboratory errors in any of the tests.) Which of the following is the most valid conclusion?

(A) It is impossible to relate either illness with the specific virus.
(B) The patient was ill with swine flu later, and the November 6 illness was due to another pathogen.
(C) The patient was ill with swine flu on December 20.
(D) The patient was ill with swine flu on November 6.

31. Viruses have various ways of entering the human body and producing disease. Which of the following descriptions accurately describe the route and mechanism for the virus indicated?

(A) Coronaviruses enter the gastrointestinal tract through the mouth and move into the stomach, where they proliferate within mucosal cells to produce peptic ulcers.
(B) Enteroviruses enter through the mouth, replicate in the pharynx and bowel, and move via the blood to distant target organs (central nervous system).
(C) HIV is directly injected into the bloodstream by insects requiring blood for egg development.
(D) Influenza viruses enter through the respiratory tract, replicate within lymphocytes in the lung, and move via the lymphatic vessels to joints and the central nervous system to produce muscle aches, stiff joints, and fever.
(E) Mumps virus enters through abraded skin in the genital area and moves into the testicles of males to produce swelling and sterility.

32. What would be the appearance of invasives *C. albicans* in a Gram-stained abnormal vaginal smear?
33. The tetracycline antimicrobials are effective specifically in prokaryotes due to which of the following activities?

(A) They are transported into prokaryotes but not into eukaryotes.
(B) They bind to prokaryotic and not eukaryotic DNA-directed RNA polymerase.
(C) They bind to prokaryotic but not eukaryotic membranes.
(D) They bind to prokaryotic but not eukaryotic aminoacyl-tRNAs.
(E) They inhibit prokaryotic protein synthesis initiation, which specifically requires formylmethionyl tRNA.

34. Figure 4-5 shows a quantitative precipitin curve of an antigen-antibody reaction, where the amount of antibody is kept constant throughout. According to the figure, which of the following statements is correct?

(A) point A shows antigen excess
(B) point B shows that there is no antibody formation
(C) point C indicates that there is little, if any, free antigen and antibody in the reaction tube
(D) point D represents the area of antigen destruction
(E) point E indicates antibody excess

35. A newborn boy appears to be lethargic and septic. A spinal tap was performed, and a Gram stain of the spinal fluid revealed gram-positive bacilli. Cultures of the spinal fluid on sheep blood agar plates, at a temperature of 22–25°C, yielded catalase-positive hemolytic rods that had a tumbling motion. Penicillin cleared the infection. Which of the following is the most likely organism that caused this disease?

(A) Bacillus cereus
(B) Bordetella pertussis
(C) Corynebacterium diphtheriae
(D) Listeria monocytogenes
(E) Neisseria meningitidis
38. A medical student was bitten by infected ticks. In a week, he developed a high fever, headache, muscular aches, nausea, and splenomegaly. Five days later his symptoms subsided. However, 1 week later all his previous symptoms returned. During the next 9 days he went through a recovery and another relapse followed by a final recovery. The overall temperature curve of his illness is shown in Figure 4-6. Which of the following is the most likely etiological agent?

(A) *Borrelia burgdorferi*
(B) *B. recurrentis*
(C) *Leptospira interrogans*
(D) *T. carateum*
(E) *T. pertenue*

40. An 8-month old boy presents to the emergency room in respiratory distress from a recurrent upper respiratory tract bacterial infection. Labs reveal low levels of IgA, IgD, IgE, IgG, and IgM. Suspecting an immune deficiency disorder, genetic testing reveals a defect in a tyrosine kinase gene. Which of the following would be seen in patients with this immune deficiency disorder?

(A) particular susceptibility to viral and fungal infections
(B) profound deficiencies of cell-mediated immunity
(C) depletion of lymphocytes in the para-cortical areas of lymph nodes
(D) normal numbers of B lymphocytes
(E) very low quantities of immunoglobulin in their serum

41. During a pelvic examination, a woman is found to have painful vesicular lesions on the vagina. The patient states that she had similar lesions 12 months previously which lasted for 2 weeks. Which of the following is the most likely causative agent?

(A) cytomegalovirus
(B) herpes simplex virus
(C) papillomavirus
(D) rubella virus
(E) varicella virus

42. Antibodies against acetylcholine neural receptors were measured in a 35-year-old woman and are thought to be involved in the pathogenesis of which of the following?

(A) acute idiopathic polyneuritis
(B) Guillain-Barré syndrome
(C) multiple sclerosis
(D) myasthenia gravis
(E) postpericardiotomy syndrome
43. Which of the following will be observed in a person who is deficient in interleukin-1 synthesis?
(A) difficulty with immunoglobulin isotypic switching
(B) dependence on endotoxin for the induction of febrile responses
(C) effective mediation of acute phase responses
(D) effective regulation of vascular shock
(E) tendency to develop intense inflammatory reactions

44. After an abdominal surgery for removal of ovarian cysts, a 56-year-old female has had low-grade fever for the past 2 weeks. She has a history of rheumatic fever as a child. Three of the blood cultures grew gram-positive cocci. Which of the following is the most likely etiologic agent?
(A) Group A streptococci
(B) group B streptococci
(C) group C streptococci
(D) group D streptococci
(E) S. viridans

45. A urease-positive, spiral-shaped gram-negative rod is found in gastric washings from a 29-year-old stressed-out medical student with gastritis. Which of the following is most likely to be this organism?
(A) Campylobacter jejuni
(B) Helicobacter pylori
(C) Proteus mirabilis
(D) Providencia rettgeri
(E) Vibrio cholerae

46. A 3-year-old child arrives at the hospital in severe respiratory distress. Periorbital edema is also noted. Blood analysis reveals decreased levels of C4 and decreased levels of C1 inhibitor. This complement deficiency is likely to lead to which of the following conditions?
(A) angioedema
(B) an increased susceptibility to pyogenic infections
(C) bacteremia
(D) decreased production of anaphylatoxins
(E) enhancement of antibody production

47. A rabbit is repeatedly injected with a peptide hapten. Two weeks later, its serum is subjected to a gel diffusion assay with the hapten and a carrier protein. Which of the following would be the expected result of the gel diffusion assay?
(A) A line of identity between serum and both the carrier and the hapten will be present.
(B) A line of identity between the serum and carrier protein will be detected.
(C) A line of nonidentity between serum, carrier, and hapten will be detected.
(D) A line of partial identity between serum, carrier, and hapten will be detected.
(E) No precipitin line will be present.

48. A 45-year-old male experiences memory lapses, loss of reasoning ability, ataxia, and myoclonic jerking. His condition steadily deteriorates and finally progresses to stupor, coma, and death. The physician notes that 34 years ago, the patient was given injections of growth hormone prepared from human pituitary glands. Histological sections of brain show widespread neuron loss, vacuolation, and inflammation. Which of the following is the most likely diagnosis?
(A) Creutzfeldt-Jacob disease (CJD)
(B) kuru
(C) meningitis due to herpes simplex virus
(D) progressive multifocal leukoencephalopathy (PML)
(E) subacute sclerosing panencephalitis (SSPE)
49. A 6-year-old girl has been having recurrent pyogenic bacterial infections of the sinus and respiratory tract. The latest one has been caused by *N. meningitidis*. The results of her diagnostic tests are shown in Figure 4-7. These results are consistent with a diagnosis of which of the following?

- (A) chronic granulomatous disease
- (B) deficiency in the opsonization of microbes by phagocytes
- (C) Graves disease
- (D) systemic lupus erythematosus
- (E) Wiskott-Aldrich syndrome

<table>
<thead>
<tr>
<th>TEST</th>
<th>RESULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>White cell count</td>
<td>Normal</td>
</tr>
<tr>
<td>T cell count</td>
<td>Normal</td>
</tr>
<tr>
<td>Production of IgM to ploysaccharides</td>
<td>Normal</td>
</tr>
<tr>
<td>Production of anti-DNA antibodies</td>
<td>Not detected</td>
</tr>
<tr>
<td>Levels of complement components C3 and C5 to C8</td>
<td>Low</td>
</tr>
<tr>
<td>Levels of thyroid-stimulating hormone</td>
<td>Normal</td>
</tr>
<tr>
<td>Levels of immunoglobulins</td>
<td>Normal</td>
</tr>
<tr>
<td>Intracellular killing of microbes by neutrophils</td>
<td>Normal</td>
</tr>
</tbody>
</table>

(C) is a major cause of severe diarrhea in infants in the developing countries

(D) is an important cause of epidemic gastroenteritis in the United States

(E) is diagnosed by isolation and then growth of the virus in tissue culture

50. A primary viral isolate from a suspected case of poliomyelitis was inoculated into cell culture, and a dramatic cytopathic effect (CPE) was noted within 24 hours. The isolate was confirmed as poliovirus by neutralization with polyvalent antibody to poliovirus types I, II, and III; however, monospecific antibody to each type failed to block CPE. This finding suggests that the isolated contained which of the following?

- (A) hybrid virus of type I and type II poliovirus
- (B) mixture of polio and another type of picornavirus mixture
- (C) mixture of two types of poliovirus
- (D) recombinant of type I and type II viruses
- (E) virus that shares a few antigenic determinants with poliovirus

(E) variable region of the heavy chain of IgG

51. Which of the following correctly describes Norwalk virus?

- (A) contains an RNA genome with a single open reading frame
- (B) generally causes a severe chronic gastroenteritis with diarrhea that may persist for several weeks
- (C) is a major cause of severe diarrhea in infants in the developing countries
- (D) is an important cause of epidemic gastroenteritis in the United States
- (E) is diagnosed by isolation and then growth of the virus in tissue culture

52. Which of the following is the best neutrophil and monocyte attractant?

- (A) C5a
- (B) HLA-A
- (C) HLA-B
- (D) J chain
- (E) variable region of the heavy chain of IgG

53. Patients with fungal pneumonias are not isolated from other patients because of which of the following?

- (A) These infections are caused by organisms which multiply in lymph nodes.
- (B) These infections are difficult to transmit from person to person.
- (C) These infections are eliminated quickly by antifungal drugs (ketoconazole).
- (D) These infections are naturally resolved in 24 hours.
- (E) These infections provoke an effective immune response.

54. German measles virus (rubella), a common cause of exanthemas in children is best described by which of the following statements?

- (A) incubation time is approximately 3–4 weeks
- (B) infections routinely fail to cause an immune response
- (C) it can be diagnosed by the presence of Koplik’s spots
- (D) rubeola and rubella are caused by the same virus
- (E) specific antibody in the serum does prevent disease
55. The tolerance of facultative anaerobic bacteria, many of which may be normal flora and opportunistic, to superoxide and hydrogen peroxide is due to which of the following?

(A) absence of catalase  
(B) cytochrome oxidase  
(C) inability to form oxygen  
(D) presence of peroxidase  
(E) presence of superoxide dismutase and catalase

56. An injured firefighter developed a wound infection, and culture of the site indicates a gram-negative rod that is oxidase-positive and produces a bluish-green pigment. The organism was relatively resistant to antibiotics, but susceptible to ticarcillin and tobramycin. The organism is most likely to be identified as which of the following?

(A) E. coli  
(B) Klebsiella pneumoniae  
(C) P. mirabilis  
(D) P. aeruginosa  
(E) Serratia marcescens

57. After extraction of a wisdom tooth, an 18-year-old male student was diagnosed as having subacute bacterial endocarditis. He has a congenital heart disease which has been under control. Which of the following is the most likely organism causing his infection?

(A) Enterococcus faecalis  
(B) S. aureus  
(C) S. epidermidis  
(D) S. pneumoniae  
(E) S. viridans

58. Persistent fever and neutropenia with persistently negative blood cultures is often caused by which of the following?

(A) fungi  
(B) gram-negative organisms  
(C) gram-positive organisms  
(D) viral infections

59. Which of the following immunological assays employs separation of proteins by electrophoresis in polyacrylamide gels and subsequent transfer to nitrocellulose, followed by a reaction with antibodies?

(A) complement fixation  
(B) enzyme-linked immunosorbent assay (ELISA)  
(C) immunoelectrophoresis  
(D) indirect fluorescent antibody test  
(E) Western blot

60. A female patient presents with swollen inguinal lymph nodes and painful lesions on the genitalia and perianal region. Which of the organisms below is the most likely causative agent for this infection?

(A) Group B streptococci  
(B) Haemophilus aegypticus  
(C) H. ducreyi  
(D) Moraxella (Branhamella) catarrhalis  
(E) N. gonorrhoeae

Questions 61 and 62

61. A 34-year-old female patient is sneezing and has a runny nose and watery eyes every summer. Her physician is convinced that the patient is suffering from an allergy and performs some skin tests. The results of these tests are shown below:

<table>
<thead>
<tr>
<th>Allergen used for testing</th>
<th>Response to allergen (wheat diameter in mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>cat dander</td>
<td>1</td>
</tr>
<tr>
<td>house dust</td>
<td>4</td>
</tr>
<tr>
<td>Kentucky blue grass</td>
<td>13</td>
</tr>
<tr>
<td>pollen</td>
<td>7</td>
</tr>
<tr>
<td>fungal spores</td>
<td>6</td>
</tr>
<tr>
<td>solvent-only control</td>
<td>5</td>
</tr>
</tbody>
</table>

Which of the following test allergens is most likely to be inducing the patient’s symptoms?

(A) cat dander  
(B) house dust  
(C) Kentucky blue grass  
(D) mold  
(E) pollen
62. Which of the following substances is most likely to prevent the attachment of the mold allergen to the sensitized mast cells in this patient?
   (A) complement
   (B) corticosteroids
   (C) cromolyn sodium
   (D) epinephrine
   (E) IgG anti-mold

63. A 64-year-old alcoholic man has fever, chills, cough, and pleuritic pain. His sputum is a dark brown color, and upon cultivation on blood agar produces alpha hemolytic colonies, composed of gram-positive, optochin-positive cocci. The microbes are which of the following?
   (A) E. faecalis
   (B) N. meningitidis
   (C) S. aureus
   (D) S. pneumoniae
   (E) S. pyogenes

64. After isolating a pathogen from a patient, you monitor its growth in rich medium. According to Figure 4-8 the rate of growth of the bacterial culture for which it was obtained reaches its maximum rate of growth between which of the following time periods?
   (A) noon and 1:00 p.m.
   (B) 2:00 p.m. and 3:00 p.m.
   (C) 3:00 p.m. and 4:00 p.m.
   (D) 3:00 p.m. and 5:00 p.m.
   (E) 4:00 p.m. and 5:00 p.m.

65. A 30-year-old previously healthy patient has all the gastrointestinal symptoms of infection with hepatitis A virus (HAV), yet all the tests for HAV-IgG and HAV-IgM are negative. Which of the following is the most likely cause of this infection?
   (A) hepatitis B virus
   (B) hepatitis C virus
   (C) hepatitis D virus
   (D) hepatitis E virus
   (E) rotavirus

66. In a quantitative serological test, the results shown below were obtained (+ = antibody detected, 0 = no antibody detected). Which of the following courses of action should be taken?

<table>
<thead>
<tr>
<th>SERUM DILUTION</th>
<th>1:10</th>
<th>1:20</th>
<th>1:40</th>
<th>1:80</th>
<th>1:160</th>
<th>1:320</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Result</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

   (A) choose another test mechanism to measure the antibody
   (B) perform testing on additional dilutions until an end point is reached
   (C) repeat the test because this pattern is impossible
   (D) report “negative” for antibody
   (E) report “positive” for antibody

67. A Gram-stain smear of spinal fluid from a 2-year-old child reveals short gram-negative rods. It grows on enriched chocolate agar, but does not grow on blood agar, except adjacent to a streak of staphylococci. The organism most probably is which of the following?
   (A) H. influenzae
   (B) N. gonorrhoeae
   (C) N. meningitidis
   (D) L. monocytogenes
   (E) S. pneumoniae

68. Clinical laboratory results indicate that an AIDS patient in a county hospital in San Antonio is infected with an acid-fast bacillus. Which of the following bacteria is this organism most likely to be?
Within hours after being bitten by a cat trapped in a flood drain, a member of the rescue team develops redness, swelling, and intense pain at the site of the bite. Laboratory results indicate the presence of mixed flora in the wound, including a gram-negative rod that is frequently associated with cat and dog bites and that often leads to complications such as osteomyelitis if untreated. Which of the following is most likely to be this organism?

(A) B. canis  
(B) C. coli  
(C) Franciscella tularensis  
(D) Pasteurella multocida  
(E) P. aeruginosa

Which of the following immunoglobulins is responsible for passing the placental barrier and attacking the Rh+ fetal red blood cells in hemolytic disease of the newborn (erythroblastosis fetalis)?

(A) IgA  
(B) IgD  
(C) IgE  
(D) IgG  
(E) IgM

A 27-year-old man was treated with penicillin for gonorrhea. Thirty-five days later he was reinfected with the same germ, and his physician administered an intramuscular dose of penicillin. Two minutes following the injection of penicillin, the patient experienced hypotension and shock and became unconscious. This reaction was most likely mediated by which of the following?

(A) activation of the alternate complement pathway  
(B) activation of the classical complement  
(C) IgD

A similar virus was isolated from several students in a day-care school that experienced a respiratory disease outbreak. This virus passes through a 50 nm filter, grows best in human diploid fibroblasts at 33°C, is not inactivated by chloroform, is inactivated at pH 3, and is inhibited by compounds that interact with the interior of grooves on the viral surface that attach to cell receptor molecules. Which of the following is the most likely virus based upon its identifying characteristics?

(A) coronaviruses  
(B) Influenza virus B  
(C) respiratory syncytial virus  
(D) rhinovirus  
(E) rubella virus

Sputum from a patient with a respiratory infection reveals bacteria that resist engulfment by phagocytic WBCs. Which of the following factors is most likely responsible for this virulence?

(A) A capsule  
(B) fimbriae  
(C) flagella  
(D) lipid A  
(E) peptidoglycan
75. A 75-year-old lady is slowly developing a chronic suppurative cervicofacial lesion, thought to be actinomycosis. Which of the following is most likely to promote the progress of this infection?

(A) high levels of oxygen in tissues
(B) presence of a foreign body at the site of infection
(C) production of exotoxin by A. israelii
(D) production of leukocidin by A. israelii
(E) production of pili by A. israelii

76. An X-linked recessive B-cell immune deficiency associated with a defect in the tyrosine kinase gene and low levels of all antibody classes is most likely to present with repeated infections involving which of the following?

(A) extracellular bacteria
(B) fungi
(C) intracellular bacteria
(D) P. carinii
(E) viruses

77. Gene therapy has taken an approach of expressing TNF in tumor-infiltrating lymphocytes (TIL). It is hoped that this approach will induce which of the following events?

(A) allow the TIL to return to the tumor and produce locally high levels of TNF
(B) generate high serum levels of endotoxin
(C) lyse tumor cells due to retrovirus infection
(D) stimulate natural killer (NK) cell activity
(E) stimulate T-cell proliferation

78. A 2-year-old boy who has not been vaccinated against any germ is experiencing severe spasms in the muscles of the jaw and face. These spasms do not allow the child to open his mouth. Laboratory tests established that a bacterial toxin was responsible for this boy’s symptoms. The toxin involved was most likely produced by which of the following organisms?

(A) C. botulinum
(B) C. perfringens
(C) C. tetani

79. A college freshman exhibits symptoms of fever, malaise, sore throat, and fatigue. She also has enlarged lymph nodes and spleen and large, atypical T-lymphocytes. Which of the following tests can be used to confirm which virus is the etiologic agent?

(A) antibody that reacts with Epstein-Barr virus (EBV)-associated nuclear antigen
(B) antibody to hemagglutinin
(C) antibody to neuraminidase (NA)
(D) heterophile antibody that reacts with antigens on sheep erythrocytes
(E) nucleic acid hybridization assays for the presence of Epstein-Barr viral nucleic acid

80. A hemagglutination (HA) assay was performed with influenza virus. A fixed number of chicken red blood cells were mixed with increasing dilutions of the influenza virus. The results of the assay are shown in Figure 4-9. Which of the following represents the HA titer of the virus?

(A) 20
(B) 40
(C) 80
(D) 160
(E) 320

81. HIV isolated from the same patient over time may differ antigenically. HIV also differs from the viruses found in the general class of RNA tumor viruses. Which of the following best explains how HIV differs from most other RNA tumor viruses?

(A) HIV contains the gag gene
(B) HIV contains the pol gene
(C) HIV contains two copies of single-stranded RNA in its virion
(D) HIV does not require T4 receptor protein for adsorption to host cells
(E) HIV lyses the host cells

82. A 24-year-old construction worker who had four injections of the DPT (diphtheria, pertussis, and tetanus) vaccine in his first year of life and boosters at ages 5 and 19 received a deep laceration while excavating a building’s foundation. Which of the following is the preferred treatment?

(A) equine tetanus immune globulin, because it will passively immunize him
(B) human tetanus immune globulin, because it will stimulate his anamnestic response
(C) penicillin, because it will kill the organism
(D) streptomycin, because it will kill the organism
(E) tetanus toxoid, because it will stimulate his anamnestic response

83. A Boy Scout troop camped for 1 week in the woods in the New England area. After arriving home, two experienced an insect bite lesion that was characterized by a clear center surrounded by a flat reddened area that expanded. They also had fever, chills, fatigue, and headache. Which disease listed below was diagnosed?

(A) epidemic typhus
(B) lyme disease
(C) Q fever
(D) rickettsial pox
(E) trench fever

84. A young street person was treated with the drug the structure of which is shown in Figure 4-10. Which of the following correctly identifies the drug?

(A) acyclovir, which inhibits the herpesvirus-encoded DNA polymerase
(B) azidothymidine (AZT), which inhibits the AIDS virus reverse transcriptase
(C) dideoxyinosine, which inhibits poliovirus replication
(D) enviroxine, which inhibits rhinoviruses
(E) idoxuridine, which inhibits herpesvirus thymidine kinase

85. A grandmother undergoing chemotherapy for cancer in a hospital was exposed to a grandchild with chickenpox. In order to prevent a clinical complication of varicella or disseminated zoster in the grandmother, which of the materials listed below should be used as an appropriate medical intervention?

(A) acyclovir
(B) indinavir
(C) killed varicella-zoster virus (VZV) vaccine
(D) live attenuated VZV vaccine
(E) subunit VZV vaccine

86. A young child developed staphylococcal scalded syndrome. Which one of the following toxins is most likely responsible for this syndrome?

(A) alpha toxin
(B) erythrogenic toxin
(C) exfoliative toxin
(D) staphylococcal enterotoxins A through F
(E) toxic shock syndrome toxin (TSST)

87. A 3-year-old child presents at the physician’s office with symptoms of coryza, conjunctivitis, low-grade fever, and Koplik’s spots. The causative agent of this disease belongs to which group of viruses?

(A) adenovirus
(B) herpesvirus
(C) orthomyxovirus
(D) paramyxovirus
(E) picornavirus
88. A 25-year-old woman develops fever, sore throat, headache, and generalized lymphadenopathy, a macular non-pruritic rash over the trunk and limbs, flat papular lesions on her inner thighs. Initial serological tests are positive for *Treponema* species. Which of the following represents the diagnosis for this condition?

(A) condylomata lata
(B) primary syphilis
(C) secondary syphilis
(D) tertiary syphilis
(E) yaws

89. A 58-year-old nurse has a herpetic infection that requires administration of acyclovir. Which one of the following is the known mechanism of action of acyclovir?

(A) degradation of viral RNA
(B) inhibition of reactivation of virus in trigeminal root ganglia
(C) inhibition of viral RNA synthesis
(D) killing of actively dividing cells in which virus replicates
(E) termination of DNA replication of herpes virus

90. A suburban housewife was pricked by a thorn while pruning her roses. Four days later, a pustule that changed to an ulcer developed in the lesion area. Then three nodules formed along the local lymphatic drainage. The most likely agent is which of the following?

(A) *A. fumigatus*
(B) *C. albicans*
(C) *Cryptococcus neoformans*
(D) *Sporothrix schenckii*
(E) *Trichophyton rubrum*

91. A 53-year-old alcoholic man had been experiencing acute episodes of nausea and eventually jaundice. A virus was detected from him, which had a circular molecule of DNA having the structure diagrammed in Figure 4-11. Which virus listed below has this type of genome?

![FIG. 4-11](image)

(A) EBV
(B) hepatitis A virus
(C) hepatitis B virus
(D) JC virus
(E) papillomavirus

92. A Gram stain of pus from the oral abscess of a 62-year-old man with periodontitis shows that the patient’s infection is polymicrobial. Which of the following is the most likely source of this man’s infection?

(A) *A. israelii* following tooth extraction
(B) autoinfection with oral anaerobes
(C) autoinfection with oral *Staphylococcus spp.*
(D) periodontitis is not an infectious process
(E) *P. aeruginosa* following primary viral infection

93. A 30-year-old man presents symptoms and signs consistent with primary syphilis. Which of the following pairs of tests are more likely to provide a definitive confirmation of this diagnosis?

(A) dark-field microscopy followed by Venereal Disease Research Lab (VDRL) test
(B) examination of sample taken from a chancre by dark-field microscopy followed by fluorescent antibody (FA) technique
(C) silver staining of sample taken from the patient followed by VDRL
(D) VDRL followed by FA
(E) VDRL followed by Fluorescent Treponemal Antibody Absorption (FTA-Abs) test
94. A child has conjunctivitis and sore throat. The clinical laboratory has isolated a non-enveloped, icosahedral DNA virus shown in Figure 4-12. Which of the following is likely the infectious agent?

(A) adenovirus
(B) Hepadnavirus
(C) herpesvirus
(D) parvovirus
(E) poxvirus

95. Which of the following colonizes the nasopharynx and produces toxins that kill ciliated epithelial cells, causes edema locally, and induces lymphocytosis systemically?

(A) B. pertussis
(B) Hemophilus influenzae type b
(C) L. pneumophila
(D) N. meningitidis
(E) P. aeruginosa

96. A 21-year-old man has been skin tested and had a positive test to purified protein derivative (PPD). This indicates that he has which of the following?

(A) active tuberculosis
(B) proper B-cell function
(C) provided sound information on his health status
(D) received BCG vaccine
(E) received middlebrook 7H10/7H11 vaccine

97. Oseltamivir is used for the treatment of infections by a virus with a segmented negative strand genome. Which of the following would respond to this treatment?

(A) EBV
(B) herpes simplex virus
(C) influenza virus
(D) rabies virus
(E) rhinovirus

98. A 35-year-old male with end-stage renal disease must undergo a kidney transplant. Which of the following is true of immunologic suppression for transplantation?

(A) It can occur by antilymphocyte globulin.
(B) It cannot be achieved by cyclosporine administration.
(C) It cannot occur by lymphoid irradiation.
(D) It is facilitated by gamma interferon administration.
(E) It is not likely to respond to steroid administration.

Questions 99 and 100

99. A high school student while on a field trip encounters poison ivy and develops a severe contact dermatitis, which is classified as type IV hypersensitivity. Contact dermatitis is differentiated from type III hypersensitivity by which of the following facts?

(A) It is associated with cell bound antigens of human erythrocytes.
(B) It is associated with cytotoxic reactions.
(C) It is encountered in atopic individuals.
(D) It is mediated by antigen-antibody complexes.
(E) It is mediated by cellular immunity.

100. Which of the following mechanisms is responsible for the type IV hypersensitivity reaction in the high school student?

(A) expression of antigen epitopes on B cells
(B) expression of allergen epitopes on CD8+ T cells
(C) IgE reaction with mast cells
(D) reaction of allergen with the Ti and CD4 markers of B cells
(E) T helper cell reaction with the antigen epitope
Questions 101 and 102

101. A retired policeman who received a kidney transplant developed a generalized infection by an enveloped double-stranded DNA virus. This organism formed owl’s eye inclusions in cells found in urinary sediments. Which of the following viruses is the most likely etiological agent?

(A) adenovirus  
(B) coronavirus  
(C) cytomegalovirus  
(D) papillomavirus  
(E) variola virus

102. Which of the following approaches most likely might have prevented the infection of the policeman?

(A) administration of gamma interferon  
(B) injection of alpha interferon  
(C) treatment with methisazone  
(D) treatment with zanamivir  
(E) viral screening of donor and recipient

103. Judging from the graph in Figure 4-13, which microorganism is likely to be the causative agent of food poisoning characterized by diarrhea and severe vomiting related to heat-stable enterotoxins?

(A) C. jejuni  
(B) Salmonella typhimurium  
(C) S. aureus

104. A judge has a fungal infection known as “Tinea cruris.” Which of the following statements concerning this infection is accurate?

(A) It cannot be transmitted from person to person.  
(B) It involves a fungus that produces aflatoxins.  
(C) It is associated with athlete’s foot.  
(D) It is caused by a fungus that forms tuberculate macroconidia.  
(E) It occurs primarily in immunocompromised individuals.

105. Poliovirus type 2 has been isolated from the stool of a 55-year-old patient who has experienced malaise, fever, nausea, and vomiting. An infant grandchild was vaccinated about 3 weeks prior to onset of the disease. What should the laboratory do to determine whether the isolated virus is related to the vaccine strain or a wild-type virus?

(A) determine the cytopathic effects of the virus  
(B) do neutralization studies using the infant’s serum  
(C) do oligonucleotide mapping of the wild-type and vaccine strains  
(D) inoculate the virus into mice to determine whether it kills them  
(E) stain the virus with fluorescent antibody

106. Two days following surgery to repair a defective valve, a patient developed an acute infection caused by a penicillin-resistant strain of S. aureus. Figure 4-14 shows the penicillin molecule. Which numbered bond in the structure is the site of action of penicillinase?

(A) O  
(B) 1  
(C) 2  
(D) 3  
(E) 4  
(F) 5
107. A 37-year-old male patient presents with a necrotizing skin lesion on the trunk of the body subsequently identified as *Blastomyces dermatitidis*. Which is the most likely route of entry for this organism?

(A) contaminated water  
(B) illicit drug use  
(C) lung inhalation  
(D) skin prick  
(E) spoiled food

108. A 25-year-old male patient comes to your office experiencing inability to swallow and speech difficulty. The patient was in perfect health prior to the consumption of home-canned green beans. Which of the following is the most likely method of treatment?

(A) administration of staphylococcal enterotoxin antiserum  
(B) administration of trivalent botulinum antitoxin  
(C) immunization with *S. aureus* enterotoxin toxoid  
(D) penicillin administration  
(E) placement of the patient in a hyperbaric oxygen chamber

109. Antibiotic therapy is a critical step in the proper management of many patients infected with various types of bacteria. Infection with which microorganism listed below would not benefit from even prompt antimicrobial treatment?

(A) *B. anthracis*  
(B) *C. botulinum*  
(C) *C. difficile*  
(D) *C. perfringens*  
(E) *C. tetani*

Culture grew both aerobic and anaerobic gram-negative bacteria. Which of the following represent the cultured organisms?

(A) *A. israelii* and *E. coli*  
(B) *B. fragilis* and *L. monocytogenes*  
(C) *B. fragilis* and *N. gonorrhoeae*  
(D) *C. difficile* and *B. fragilis*  
(E) *E. coli* and Peptostreptococcus spp.

111. A 33-year-old male who practices veterinary medicine in Fresno (central California) is seen in the emergency room with chills, high fever, persistent unproductive cough, and generalized malaise. Physical examination reveals no evidence of pharyngitis, sinusitis, or otitis media. The patient does not have a rash and vehemently proclaims that he has not been bitten by any vectors. On his 10-acre farm, he raises sheep, chickens, turkeys, ostriches, and emus. A complement fixation assay for Coxiella is negative. Given the PE and history, which of the following is the most likely etiologic agent?

(A) *C. pneumoniae*  
(B) *C. psittaci*  
(C) *C. trachomatis*  
(D) *Ehrlichia canis*  
(E) *Rickettsia typhi*

112. Small, “fried-egg” colonies are produced in agar medium by which of the following pairs of agents?

(A) *Acinetobacter* and *Legionella* species  
(B) *Legionella* and *Mycoplasma* species  
(C) *Mycoplasma* and *Acinetobacter* species  
(D) *Mycoplasma* and *Gardnerella* species  
(E) *Mycoplasma* and L-form bacteria

113. Transovarian passage of an obligate intracellular agent is associated with which of the following rickettsial diseases?

(A) Brill-Zinsser disease  
(B) Epidemic typhus  
(C) Human monocytic ehrlichiosis  
(D) Q fever  
(E) Rocky Mountain spotted fever
114. A 27-year-old graduate student, upon her return from vacation in a tropical area with poor sanitary conditions, became ill. She experienced lower abdominal pain, colitis, tenesmus, flatulence, and bloody diarrhea caused by an RBC-containing parasite. Which of the following represents the most likely diagnosis?

(A) acute amoebic dysentery  
(B) malaria  
(C) toxoplasmosis  
(D) trichomoniasis  
(E) trypanosomiasis

115. The etiological agent of the graduate student’s disease is usually transmitted by the ingestion of which of the following?

(A) cysts  
(B) gametocytes  
(C) larvae  
(D) ova  
(E) sporozoites

116. Which of the following is the drug(s) of choice for the treatment of the graduate student’s illness?

(A) chloroquine  
(B) metronidazole and iodoquinol  
(C) stibogluconate  
(D) sulfonamide and pyrimethamine  
(E) trimethoprim and sulfamethoxazole

117. A 26-year-old management consultant has recently eaten raw oysters on three occasions. The patient has always been healthy, but suddenly developed fatigue, loss of appetite, nausea, vomiting, abdominal pain, and fever. Following a careful evaluation, his doctor informed him that he is suffering from a viral infection. This infection was caused by a small (20–30 nm), non-enveloped, single-stranded RNA virus. This virus is most likely which of the following?

(A) adenovirus  
(B) hepatitis A virus  
(C) hepatitis B virus  
(D) rhinovirus  
(E) rotavirus

118. Diagnosis of the causative agent of the patient’s illness can best be made by which of the following means?

(A) a positive Tzanck smear  
(B) assays for specific viral cytopathic effects  
(C) detection of IgA antibodies against the specific virus  
(D) detection of IgM antibodies against the specific virus  
(E) detection of Negri bodies in the patient’s tissues

119. The patient’s viral infection can best be prevented by which of the following treatments?

(A) administration of human gamma globulin  
(B) immunization with HBcAg  
(C) immunization with the specific inactivated virus  
(D) immunization with the specific subunit vaccine  
(E) interferon

Questions 117–119

120. A 3-year-old child with a history of recurrent staphylococcal infections arrives at the emergency department at the local hospital. His neutrophils show normal chemotaxis, degranulation, and phagocytosis. However, intracellular killing of staphylococci by the neutrophils is severely impaired. Myeloperoxidase activity of his neutrophils is normal. The child has no history of streptococcal infection. Which of the following is the most likely disease affecting this patient?

(A) chronic granulomatous disease  
(B) Graves disease  
(C) rheumatoid arthritis  
(D) severe combined immunodeficiency disease (SCID)  
(E) systemic lupus erythematosus (SLE)
121. Which of the following explains the reason why the child described in question 530 has no history of streptococcal infection?

(A) he has been administered antistreptolysin O
(B) he has been immunized with CRP
(C) he has been injected with pooled human gamma globulin
(D) phagocytosis plays a minor role in the killing of streptococci
(E) streptococci are catalase negative

122. Several *Neisseria* species are part of the normal flora (commensals) of the human upper respiratory tract. Which of the following statements accurately describes the significance of these bacteria?

(A) As a part of the normal flora, neisseriae provide a natural immunity in local host defense.
(B) As a part of the respiratory flora, they are the most common cause of acute bronchitis and pneumonia.
(C) Commensal bacteria stimulate a cell-mediated immunity (CMI).
(D) Commensal neisseriae in the upper respiratory tract impede phagocytosis by means of lipoteichoic acid.

123. *S. pyogenes*, Group A, is subdivided into specific antigenic types principally on the immunologic differences in which of the following?

(A) hyaluronic acid capsule
(B) M protein
(C) streptolysin O
(D) streptolysin S
(E) TSST

124. A 39-year-old man with normal sexual practices saw his doctor, complaining of a mild (38.5°C) but persistent fever. His physician observed pharyngitis and a bilateral conjunctivitis that the patient claimed was recent and painful. Which of the following microbes most likely caused the infection?

(A) adenovirus
(B) *C. pneumoniae*

125. An elderly patient was hospitalized with severe flu. An enveloped virus was isolated from this patient. Which of the following pertains to this RNA virus with a segmented, negative-sense genome?

(A) can have direct viral genome and host cell ribosome interaction
(B) cannot possess a lipid envelope
(C) must contain a DNA-dependent RNA polymerase
(D) must contain an RNA-dependent DNA polymerase
(E) must contain an RNA-dependent RNA polymerase

126. Autoantibody testing of a patient with an autoimmune disorder reveals high titers of antibodies against the core proteins of small nuclear ribonucleoprotein particles (Smith antigen). Based on this finding, detection of which of the following is the most important initial clinical feature of this autoimmune disorder?

(A) a lesion known as *erythema chronicum migrans*
(B) a rash in a butterfly distribution on the face
(C) antibody to single-stranded RNA
(D) carditis
(E) pneumonitis

127. A newborn has a temperature of 103°F. Blood culture grows out gram-positive cocci in chains. Which of the following is the causative agent?

(A) Group A *Strep* (*S. pyogenes*)
(B) Group B *Strep* (*S. agalactae*)
(C) *N. meningitidis*
(D) *Salmonella* species
(E) *S. pneumoniae*
A specimen of thick, bloody sputum from a hospitalized 80-year-old patient with chronic obstructive pulmonary disease is sent for laboratory analyses. The tests yield heavy growth of a lactose-positive, nonmotile, gram-negative rod with a large gelatinous capsule. Which of the following is this bacterium most likely to be?

(A) E. coli
(B) Enterobacter aerogenes
(C) K. pneumoniae
(D) P. aeruginosa
(E) Y. pseudotuberculosis

A 14-year-old boy presents with acne with inflamed follicles and sebaceous glands. Gram stain of a pustule from his face reveals pleomorphic gram-positive bacilli. Which of the following is the organism implicated in this condition?

(A) C. durum
(B) Erysipelothrix rhusiopathiae
(C) L. monocytogenes
(D) S. aureus
(E) S. epidermidis

A Gram stain smear of spinal fluid from a 2-year-old child reveals short gram-negative rods. Which of the following most likely is the organism?

(A) A. israelii
(B) B. fragilis
(C) E. coli
(D) H. influenzae
(E) L. monocytogenes

Which pair of organisms below can be routinely responsible for food poisoning?

(A) C. botulinum and B. anthracis
(B) C. difficile and C. botulinum
(C) C. perfringens and B. cereus
(D) C. tetani and B. anthracis
(E) C. tetani and B. cereus

A number of children are hospitalized with bloody diarrhea and severe hematological abnormalities. A 4-year-old girl dies of kidney failure shortly after admittance. Epidemiological investigation establishes that all of the patients developed symptoms soon after consuming hamburgers from the same fast-food restaurant chain. Which of the following organisms is most likely to be responsible for the outbreak?

(A) C. jejuni
(B) non-01 serogroup of V. cholerae
(C) O157:H7 serotype of E. coli
(D) S. typhimurium
(E) Shigella dysenteriae

A small gram-negative pleomorphic organism was isolated from the nasal secretion of a toddler who later had paroxysms of coughing and post-tussive vomiting lasting at least 2 weeks. Which of the following culture media should be used to culture the suspected organism?

(A) blood agar
(B) Bordet Gengou agar
(C) MacConkey agar
(D) Thayer Martin agar
(E) Tryptic soy agar

Mumps virus accounts for 10–15% of all cases of aseptic meningitis in the United States. Which of the following is most true of infection with mumps virus?

(A) It is apt to recur periodically in many affected persons.
(B) It is maintained in large canine reservoir.
(C) It is preventable by immunization.
(D) It usually produces severe systemic manifestations.
(E) It will always cause mumps orchitis in postpubertal males.
135. A 60-year-old man arrives at the emergency room with chills, high fever, headache, and muscle pain. He is a slaughterhouse worker. Believing he had a flu, the man had stayed at home for 9 days after the onset of the symptoms. You suspect a diagnosis of leptospirosis. What body fluid should the clinical laboratory check for the presence of *L. interrogans*?

(A) blood  
(B) saliva  
(C) serum  
(D) spinal  
(E) urine

136. A 10-year-old boy living in a wooded area of northern California is taken to the emergency room after developing a typical erythema migrans (EM) rash around what appears to be a tick bite, and complaining of severe headache. Which of the following is the most likely diagnosis?

(A) Lyme disease caused by *B. afzelii* and transmitted by the hard-bodied tick *Ixodes pacifica*  
(B) Lyme disease caused by *B. burgdorferi* and transmitted by the hard-bodied tick *I. pacifica*  
(C) Lyme disease caused by *B. burgdorferi* and transmitted by *Anopheles* mosquitoes  
(D) relapsing fever caused by *B. dudonii* and transmitted by a soft-body tick of the *Ornithodoros* species  
(E) relapsing fever caused by *B. recurrentis* and transmitted by a body louse (*Pediculus humanus*)

137. A 48-year-old man had a long history of alcoholism (including alcoholic hepatitis and hallucinations) and was admitted to the ICU with hypotension and GI bleeding. He was given IV fluid and transfused with packed RBCs. He remained intubated and ventilator dependent for several weeks. He developed a high fever and was treated with broad-spectrum antibiotics. Culture of his tracheal aspirate initially grew *S. aureus*. After more antibiotic treatment, Gram stain of his aspirate showed PMNs and gram-negative rods. A chest x-ray demonstrated an infiltrate with possible small abscesses. Tracheal aspirate then yielded a heavy growth of a gram-negative, nonfermenting rod that produced a greenish hue in the culture plates. Which of the following is the most likely organism causing this patient’s problem?

(A) *H. influenzae*  
(B) *L. pneumophila*  
(C) *M. pneumoniae*  
(D) *P. aeruginosa*  
(E) *S. pneumoniae*
1. (C) Deficiency in production of J chains for immunoglobulins could result in a decrease in serum IgA and IgM levels. These antibodies are dimers and pentamers, respectively, of the basic immunoglobulin molecule, and require a J chain to join the immunoglobulin chains. There is no evidence which indicates that a deficiency in the production of J chains of IgA or IgM will cause a decrease in mature B cells, or T lymphocytes, an increase in serum IgM and decrease in IgE, or a decrease in IgA (choices A, B, D, and E).

2. (A) A deficiency in immunoglobulin production or activity is directly related to susceptibility to common extracellular microbes such as streptococci. Cytokines such as the interleukins, IL-4 and IL-10 (choice C), the function of T cells (choice B) or mast cells (choice D), and nonantibody factors (choice E) are not directly involved in increased susceptibility to bacterial infections.

3. (A) Molecular amplification techniques provide fast diagnostic results when they are compared to traditional cultural procedures for *M. Tuberculosis*, which often has to be incubated for several weeks. The rod-shaped, aerobic bacteria do not stain readily, but once stained they resist decoloration by acid or alcohol (hence, acid-fast bacilli). Cellular immunity is most important in how a host controls the growth and spread of the tubercle bacteria. There is evidence that mononuclear phagocytes ingest the organisms and even destroy them. The tuberculin skin test is based on cellular immune mechanisms, with the PPD causing a positive skin reaction in a person who has encountered the mycobacterium in the past. As a result, humoral immunity reactions are of little use diagnostically (choice A). Other mycobacteria are capable of accumulating niacin (choice B) and reducing nitrate (choice C). The development of rough, non-pigmented colonies on media (choice D) and slow growth on L-J medium (choice E) are also not specific for *M. tuberculosis* since slow growth (weeks) and colony morphology (rough, no pigment) are characteristic of other species of *Mycobacterium*.

4. (C) Within seconds after the allergen encounters human tissue, it binds to IgE antibodies which are attached to mast cells. When it engages at least two IgE molecules it forms a bridge between them. This cross-linking, in turn, draws the attached IgE receptors close to one another. Such aggregation of receptors activates mast cells to release histamine and other vasoactive substances that generate the allergic reaction. IgA, IgG, IgM, or IgD are not the germane antibodies to which allergens bind (choices A, B, D, and E).

5. (D) Histamine is among the class of preformed (primary) mediators released from mast cells upon degranulation and is classified as a biogenic amine. It is a potent pharmacologically active substance that can dilate small blood vessels and increase vascular permeability, allowing fluid to leak into tissues. These vascular changes can give rise to swelling and redness. Histamine can stimulate production of mucus from the epithelium, thus contribute to congestion of airways. It can cause smooth muscles around the bronchial airways and the intestine to contract. Prostaglandins and leukotrienes like histamine can also cause constriction of the bronchial tubes and vascular dilation. Corticosteroids are anti-inflammatory drugs that are used for the treatment of asthma, autoimmune diseases, or graft rejection (choice A). Epinephrine and cromolyn sodium counteract the action of histamine or other mediators of type I hypersensitivity reaction and are used for the treatment of anaphylactic reactions (choices B and C). 5-lipoxygenase retards production of several leukotrienes (choice E).
6. (B) Influenza viruses are helical viruses with a segmented, negative-sense RNA genome. A, B, and C types are determined by the protein coat of the virus. The infections are characterized by short (1–2 days) incubation periods and are efficiently transmitted in respiratory secretions. While most RNA viruses grow only in the infected cell cytoplasm, influenza viruses have growth steps in both the cytoplasm and nucleus of the host cell. The patient’s humoral immune system is most important in controlling virus growth. The important antibodies are made against the viral hemagglutinin (early viral attachment) and the NA (release of mature viruses) enzymes. Amantadine (choice B) and rimantadine block viral uncoating and must be given prophylactically. Oseltamivir (Tamiflu) inhibits NA activity and must also be given before viral infection for best results. Acyclovir (choice A) is an antiviral drug. Passive immunity (choice C) does not play a significant role in influenza control. Ribavirin (choice E) is used to treat RSV, a paramyxovirus. Active immunity (choice D) is the most effective mechanism of controlling influenza on a population basis and probably would not be as effective as prophylactic antivirals in the nursing home arena.

7. (D) Interferons are produced by most nucleated cells in the body, and inhibit the translation of viral proteins. There are three major types of interferons, that is, alpha, beta, and gamma. Interferons are active against many viruses and are not specific. Virus infection in one cell induces interferon production which moves to an adjacent, uninfected cell and causes an antiviral protein (AVP) to be produced by the second cell. This AVP inhibits viral mRNA activity and thereby inhibits viral protein production. Interferons do not destroy viruses, but probably result in fewer virions that need to be eliminated by the host’s immune system. Interferons do not affect host cell membranes (choice A) or directly suppress mRNA function (choice E). Interferons do not directly stimulate either cellular (choice B) or humoral (choice C) immunity to enhance an antiviral effect.

8. (A) All five organisms are protozoa. There are two intestinal protozoa specifically associated with AIDS that can cause transient diarrhea in immunocompetent individuals, but can cause debilitating, and potentially life-threatening, chronic diarrhea in AIDS patients. These organisms are C. parvum with no effective drug therapy, and Isospora belli treated with folate antagonists, such as trimethoprim-sulfamethoxazole. Microsporidia may cause severe, persistent, watery diarrhea in AIDS patients, but they produce spores rather than oocysts (choice D). T. solium is the pork tapeworm which occasionally may cause diarrhea (choice E). E. histolytica and G. lamblia may cause diarrhea, but they are not closely associated with AIDS (choices B and C).

9. (A) Chlamydiae are obligate intracellular parasites because they cannot synthesize ATP. They are classified as bacteria because they divide by binary fission (choice D), form polypeptides (choice C), produce RNA, DNA, and DNA gyrase (choice E). Finally, they synthesize two unique morphological forms. That is, the extracellular infective, metabolically inert elementary body, and the intracellular, metabolically active reticulate body (choice B).

10. (A) The spleen is important for the production of IgM and IgG antibodies needed to opsonize encapsulated bacteria. Involvement of the spleen in metabolizing (choice D), inactivating of antimicrobial agents (choice E), or processing of capsular polysaccharides (choice C) is not considered important. The main source of stem cells is the bone marrow not the spleen (choice B).

11. (C) B. melitensis is a gram-negative aerobic bacillus that grows well in the presence of 10% CO₂ as a coccobacillus. This microbe has a predilection for the cells of the reticuloendothelial system. This explains the frequent splenomegaly or hepatomegaly, which when present provide useful clues for the diagnosis of brucellosis. M. tuberculosis (choice E) is a strictly aerobic acid-fast rod. It can cause tuberculosis and vertebral osteomyelitis. In these cases and in the absence of immunosuppression, the Mantoux test (PPD-based) is positive. A. israelii (choice A)
is a gram-positive branching rod that causes actinomycosis. *A. fumigatus* (choice B) is a branching, filamentous fungus that has been associated with invasive infections in immunocompromised hosts. *Candida albicans* (choice D) is a yeast that causes disseminated disease in immunosuppressed individuals.

12. (C) Myocarditis is most commonly caused by Coxsackie group B viruses, and may be preceded by gastrointestinal or respiratory symptoms. The mumps virus (choice D), coronaviruses (choice B), adenovirus (choice A), and rhinovirus (choice E) may be associated with influenza like, or gastrointestinal symptoms, but they are not common causes of myocarditis.

13. (E) The most serious immunodeficiency is severe combined immunodeficiency disease (SCID). This occurs as a result of a defect in early stem differentiation resulting in an acute deficiency in both T and B cells. Severe and recurrent infections occur early in life from bacteria, viruses, fungi, and protozoa. DiGeorge syndrome (choice D) is due to poor development of thymus that leads to a pronounced deficiency of T cells. In Bruton agammaglobulinemia (choice A) there is virtual absence of B cells and extremely low levels of immunoglobulins. Deficiencies in complement components C5 through C8 (choice B) are associated with enhanced susceptibility to *N. gonorrhoeae* and *N. meningitides*. In chronic granulomatous disease (CGD) there is increased susceptibility to infection by *S. aureus*, or enteric rods. CGD is due to a deficiency in neutrophilic NADPH oxidase, which is associated with the microbicidal activity of neutrophils (choice C).

14. (C) In patients with combined B- and T-cell immunodeficiencies, compatible bone marrow transplantation, from an HLA-identical sibling, can restore immunological competence for bacteria, viruses, fungi, and protozoa. Administration of adenosine deaminase or purine nucleoside phosphorylase may sometimes reduce the number and severity of microbial infections by a slight, temporary stimulation of the production of B and T cells, but it does not restore immunity to microorganisms (choices A and D). Treatment with compatible B or T cells may provide very brief humoral or cellular immunity (choices B and E).

15. (D) “Walking” primary atypical pneumonia caused by *M. pneumoniae* can lead to formation of IgM antibodies called cold agglutinins, because they agglutinate type O human erythrocytes at 4°C. *L. pneumophila* (choice C), *C. burnetii* (choice B), *P. carinii* (choice E), and *C. pneumoniae* (choice A) may produce symptoms of pneumonia similar to those induced by *M. pneumoniae*, but normally these microbes are not associated with cold agglutinin formation.

16. (E) The envelope of hepatitis B virus contains an antigen known as HBsAg (hepatitis B surface antigen). This antigen is of importance because production of antibodies to HBsAg indicates immunity against hepatitis B virus, which resulted either from infection or vaccination with HBsAg. Treatment of HBV with a nonionic detergent removes the envelope and produces the viral core, which contains the hepatitis B core antigen (HBcAg). Antibodies to HBcAg are not protective (choice C). Treatment of the viral core with strong detergents results in the release of a soluble core antigen called hepatitis virus antigen e (HBeAg). Production of antibody to HBeAg signals active disease during which the patient is infectious (choice D). The DNA genome (choice B), or the nucleocapsid proteins of HBV (choice A) are not protective.

17. (A) Delayed-type hypersensitivity is mediated by helper CD4 lymphocytes, not antibody (choice D). Thus it can only be transferred by sensitized CD4 helper lymphocytes. Sensitization occurs via such substances as poison ivy, poison oak, some cosmetics, topically applied sulfonamides, or other drugs and simple chemicals, such as nickel, formaldehyde, and others, but not inhalation of grass pollen (choice E). Part of the tissue destruction seen in tuberculosis is due to delayed-type hypersensitivity, so this type of hypersensitivity reaction may lead to tissue damage (choice C). Administration of antihistaminic drugs, epinephrine, or cromolyn
sodium is used for the treatment of anaphylactic reactions resulting from type I hypersensitivity, but not delayed-type hypersensitivity (choice B).

18. (B) Piliated strains of E. coli move up the urethra to infect the bladder and kidney. Infections of the kidney cause pyelonephritis. The vast majority of cases of bacterial pyelonephritis, cystitis, and other urinary tract infections are caused by E. coli. Introduction of catheters into the urethra has been associated with the occurrence of urinary tract infections. C. difficile is the cause of pseudomembranous colitis (choice A). S. aureus is usually the cause of boils, skin sepsis, postoperative wound infections, scalded skin syndrome, food-borne infection, septicemia, endocarditis, toxic shock syndrome, osteomyelitis, and pneumonia (choice D). P. aeruginosa is usually the cause of infections of skin and burns. It is also the major pathogen in cystic fibrosis, and can cause urinary infections, but not as commonly as E. coli (choice C). Group B streptococci (choice E) are usual vaginal flora, not pathogenic to the host but may be opportunistic to newborns.

19. (E) Acute glomerulonephritis appears as a complication after pharyngeal or skin infections with Group A S. pyogenes. Patients with post-streptococcal glomerulonephritis develop high levels of antibodies against streptolysin O of S. pyogenes. While S. aureus (choice B) may also cause impetigo, it is seldom, if ever, found to be the cause of postinfectious glomerulonephritis. None of the other organisms (choices A, C, or D) have been identified with this postinfectious complication either.

20. (C) The patient described in the question probably has AIDS. Such individuals will be lymphopenic and have greatly reduced immunity. AIDS victims commonly develop P. carinii pneumonia. The most important evaluative procedure for the patient described is determining the cause of the pneumonia so the problem can be corrected. Identifying the infecting organism may assist in the overall diagnosis. Choices A, B, D, and E involve innate immunity; either complement activity or phagocytic cell functions, and thus, would not be of much diagnostic assistance.

21. (A) A patient with cutaneous anthrax usually presents with a pruritic macule or papule that enlarges into a round ulcer in several days. Then 1–2 mm vesicles that discharge clear or sanguinous fluid might appear. Purulent drainage ordinarily does not occur. This is followed by the development of a painless, depressed, black-colored eschar. If it is not treated early, dissemination of the disease in about 10% of cases results in septicemia and meningitis. H. ducreyi (choice C) produces a disease called chancreoid or soft chancre, which is not associated with the formation of black eschars. T. pallidum (choice E) produces hard chancres without black eschars. B. melanogenicus (choice B) causes abscesses. M. scrofulaceum (choice D) is associated with scrofula which is cervical adenitis.

22. (E) It has recently been shown that severe acute respiratory syndrome or SARS is caused by a corona-associated virus. This virus is a positive, single-stranded RNA, enveloped virion which has petal-like projections called corona, and is shown in Figure 4-2. The structure of rabies virus is bullet-shaped (choice D). Poxvirus is a very large, brick-shaped, very complex virus (choice C). Filovirus, such as the Ebola, or Marburg virus is very long and filamentous (choice B). Arenaviruses, like the lymphocytic choriomeningitis, or Lassa fever virus are circular, and have granules (arena) of nonfunctional ribosomes on their surfaces (choice A).

23. (B) Bruton disease is an X-linked congenital agammaglobulinemia. Thus, electrophoresis of the serum of infants, after the passively transferred maternal antibodies have been eliminated, reveals the absence or very low levels of gamma globulin. In contrast to Bruton disease all the other diseases listed will reveal a gamma globulin peak. Goodpasture syndrome (choice C) and Addison disease (choice A) are caused by autoantibody production to basement membrane of kidney and adrenal cortex, respectively. Myasthenia gravis (choice E) involves autoantibody production to acetylcholine receptor of the neuromuscular junctions. Graves disease (choice D) is caused by autoantibody production to thyroid-stimulating hormone receptors.
24. (D) The most important presumptive diagnostic test for gonorrhea is the demonstration of gram-negative, kidney-shaped diplococci inside PMNs obtained from thick, creamy urethral exudates. Outside the human host, *N. gonorrhoeae* is fragile and usually do not survive well and are rapidly killed by drying, heat, and many disinfectants. Inside the host, however, the cocci possess virulence factors that enhance the organism’s ability to establish mucus membrane infections. Pili (choice D) are hair-like appendages that extend out several micrometers. They enhance attachment to host cells and resistance to phagocytosis and are the most significant virulence factor. Polysaccharide capsules (choice A) do not appear to be as significant for gonococci infection as they do for *N. meningitides* infections. *N. gonorrhoeae* endotoxin (choice B) or LPS is a significant factor for toxicity once infection is established. A protease (choice E) can split IgA molecules, inactivating those antibodies, as do the meningococci. Hyaluronidase (choice D) can be an important virulence factor for gram-positive cocci.

25. (D) Prevention of gonorrhea rests on the use of safe, properly worn condoms, and immediate treatment of symptomatic patients as well as their sexual partners. Ceftriaxone is the best treatment for uncomplicated cases of gonococcal infections. Since 1976, penicillinase-producing strains of *N. gonorrhoeae* have been isolated that show a high level of resistance to penicillin. Thus, use of 100 units of penicillin will be of little if any value for the prevention of gonorrhea (choice C). There are no vaccines composed of either killed germs (choice E) or toxoids (choice B) available for the prevention of gonorrhea. Frequent washing of the genital areas is not likely to prevent gonorrhea (choice A).

26. (E) If exposure to rabies virus appears definite, as in this case, treatment with human diploid cell live-derived vaccine and hyperimmune antirabies gamma globulin should be started immediately. Serum antibodies provide an immediate barrier to the growth of virus; meanwhile, antibodies are elicited by the vaccine. If the level of exposure is minimal (e.g., no skin puncture) and the animal probably is not rabid, vaccine is not recommended. Ordering a search for the attacking fox for autopsy to determine if it has rabies is like searching for a needle in a haystack, and thus not the best approach to address a possible rabies infection, which requires immediate actions (choice B). Initiation of rabies vaccine will lead to production of antibodies against the rabies virus, but it will require approximately 2 weeks to develop protective antibodies. By that time, severe damage may have already occurred (choice D). Postexposure immunization and human rabies immunoglobulin is the best approach. Observation of the patient (choice A) or reporting of the incident to the state epidemiologist (choice C) do not address the real needs of an individual running the risk of rabies.

27. (D) Mycobacteria are rich in lipids. These include mycolic acids, waxes, and phosphatides. In the cell, the lipids are largely bound to proteins and polysaccharides and are, to some extent, responsible for acid-fastness. Virulent strains of tubercle bacilli form microscopic “serpentine cords” in which acid-fast bacilli are arranged in parallel chains. Cord formation is correlated with virulence and a “cord factor” (trehalose-6, 6-dimycolate choice D) has been extracted from virulent bacilli. It inhibits leukocyte migration, causes chronic granulomas, and may serve as an immulogical adjuvant. Virulent mycobacteria do not have endotoxin (choice B) as do the enteric bacteria which may cause inflammation. Nor do mycobacteria produce coagulase (choice A). Mycobacteria colonies are usually rough and dry, not “slimy” from a capsule (choice C). Wax D (choice D) is present in mycobacteria, but is not associated with cord factor.

28. (B) Darren’s patient is most likely suffering from an infection that is caused by toxin-producing clostridia. *C. perfringens* and related clostridia can produce invasive infection (myonecrosis and gas gangrene) if they are introduced into damaged tissue. These organisms produce a large variety of toxins that may be lethal, necrotizing, and/or hemolytic. Clostridia are
anerobic bacteria and can only grow well in conditions of low oxygen contact, such as necrotic tissue. In such an infection, within a few days there is foul-smelling discharge, fever, hemolysis, toxemia, shock, and death. Treatment includes immediate surgery and antibiotic administration. Hence, choice B would be the next appropriate medical intervention. Hyperbaric oxygen (choice A) has no proved effect in this situation. Antibiotics only (choice C) would provide only partial resolution and not in a timely manner. Choice D has nothing to do with the medical management of Darren’s patient.

29. (B) Chlorine (choice B) is a halogen that is often used for microbial disinfection and antisepsis. Many compounds can release various forms of chlorine (OCl\(^-\), HOCl, Cl\(_2\)) that can kill microorganisms by oxidation. These include sodium hypochlorite, chlorine dioxide, and sodium dichloroisocyanate, oxidizing agents that destroy the cellular activity of proteins. Hypochlorous acid is the active ingredient for bactericidal and virucidal effects. Such compounds may be sporocidal. Iodine (I\(_2\)) may also be bactericidal, fungicidal, tuberculocidal, virucidal, and sporocidal. Mercury (choice E) is antimicrobial but dangerous to humans. Ethanol (choice C) has limited killing ability for bacteria. Benzoic acid (choice A) has limited antimicrobial use, which ethylene oxide (choice D) is able to sterilize (completely kill all organisms) materials, but is very dangerous to humans as well.

30. (B) Influenza viruses are classified into three main groups (A, B, and C) based on proteins in the ribonucleoprotein capsid. Each virus can be further subdivided into various groups when the hemeagglutinin (HA) and NA glycoproteins are examined. So far, 15 subtypes of HA (H1–H15) and 9 subtypes of NA have been identified, and these can be found in many different combinations for influenza virus types or strains. Influenza viruses also have the ability to attach to and to agglutinate various types of red blood cells, including chicken RBCs. Antibodies made against HA antigens will neutralize HA activity and inhibit HA. This HI data can be used clinically to determine whether the same or different flu viruses have caused single or multiple outbreaks. In our clinical episode in this question and Figure 4-4, an HI titer of 10 (or 1:10 dilution of the patient’s serum) represents little or no specific antibody against the specific virus, (swine flu virus) used in the HI test. Infection may have occurred in the past, with only small amounts of specific antibody remaining. The 160 (1:160) titer indicates a large amount of specific anti-swine flu immunoglobulins are now present. A positive diagnosis for swine flu infection by December 20 is stated because it is fourfold or higher than the November 30 serum sample. As a result, choice B is the proper interpretation of these serological test results. Choice A is incorrect because we have specifically measured antibodies against swine flu on December 20. Choice C is partially correct but does not interpret results for November 6 and 30. Choice D is specifically incorrect since only swine flu was used in this HI test and the November 6 data is essentially negative.

31. (B) It is important that physicians have a good understanding of how pathogens, including viruses, enter into the human host and know what symptoms may be caused by the microorganism. Such knowledge and interpretations may have significant value in making a meaningful differential diagnosis. Enteroviruses do enter through the mouth, replicate in the pharynx and bowel before using the blood system (viremia) to access final target organs (choice B). Coronavirus (choice A) are inhaled or ingested (small number of strains), but do not produce peptic ulcers. Insects have been shown not to be important for HIV transmission (choice C). Influenza viruses (choice D) do not replicate in lung lymphocytes. Mumps virus (choice E) is most often inhaled from respiratory secretions from infected individuals who make large numbers of the viruses in the upper respiratory tract during the prodromal period.

32. (C) Candida species are considered to be opportunistic microorganisms. They are normal or usual members of the skin, mucus membranes, and the GI tract. The risk of endogenous
opportunistic infection is ever-present. In culture or tissue, candida species grow as oval, budding yeast cells (3–6 μm) which stain blue in the Gram-stain procedure. They also form pseudohyphae when the buds grow, but fail to detach. *C. albicans* is dimorphic, being also able to produce true hyphae. Diagnostically, *C. albicans* will begin to form true hyphae (germ tubes) in serum at 37°C in the laboratory. With these characteristics in mind, choice C is correct. Alternating filled and empty arthrospores (choice A) is characteristic of coccidioides. Branching mycelia (choice B) is a general characteristic seen in any mold colony on agar and is not specific for candida. Endosporulating spherules (choice D) are also seen in tissue with coccidioides. Single yeast cells (choice E) may be occasionally seen with candida, but most candida spores will be associated with buds and pseudohyphae.

33. (A) The specificity of the tetracycline antibiotics is attributable to an energy-dependent transport system present in prokaryotes, but not in eukaryotic cells. This transport system results in accumulation of the drug inside the bacterial cell, where it binds to the ribosome and interferes with binding of aminoacyl tRNA to the acceptor site. Tetracyclines bind to the bacterial ribosome, but not to DNA-directed RNA polymerase, or prokaryotic membranes (choices B and C). Tetracyclines do not inhibit initiation of protein synthesis, which specifically requires formylmethionyl tRNA (choice E). Both prokaryotic and eukaryotic cells bind tetracyclines. However, the prokaryotic cells have much more effective tetracycline transport systems than eukaryotic cells. Thus, prokaryotic cells accumulate higher intracellular concentrations of tetracyclines than eukaryotic cells, which induce a significant inhibition of protein synthesis only in prokaryote cells (choice D).

34. (C) Point C represents the zone of equivalence, that is, that point of the antigen-antibody reaction when optimal concentrations of antigen and antibody combine. Thus, there is little, if any, free antigen and antibody, and as a consequence maximal amounts of antigen and antibody will be found in the precipitate resulting from the antigen-antibody reaction. Points A and B represent areas in the antigen-antibody precipitin curve where there is an excess of antibody (choices A and B). Points D and E show areas in the precipitin curve where there is an antigen excess in the antigen-antibody reaction mixture (choices D and E).

35. (D) *L. monocytogenes* causes meningitis and sepsis in newborns and patients whose immune systems have been compromised by irradiation or chemotherapy. When this microbe is growing at a temperature of 22–25°C on blood agar, it yields gram-positive rods, which move with a characteristic tumbling motion. A slight zone of hemolysis surrounds the colonies of *L. monocytogenes*. These characteristics are not applicable to *B. cereus* (choice A), *B. pertussis* (choice B), *N. meningitides* (choice E), or *C. diphtheriae* (choice C).

36. (E) SLE is characterized by development of auto-antibodies against double-stranded DNA, and other components of the nucleus. These auto-antibodies are involved in the production of immune complexes that lead to activation of complement, tissue damage, including vasculitis, glomerulonephritis, or arthritis. Rheumatoid arthritis (choice D) is due to production of auto-antibodies (of the IgM type) against IgG. In multiple sclerosis (choice B), auto-activated T cells and macrophages cause demyelination of the white matter of the brain. Goodpasture syndrome (choice A) is caused by the development of auto-antibodies to the collagen component of the basement membrane of the lungs and kidneys. In myasthenia gravis (choice C), auto-antibodies are generated against the acetylcholine receptors of the neuromuscular junction.

37. (D) Prednisone alone or in combination with methotrexate and azathioprine is commonly used for the treatment of systemic lupus erythematosus. The cytokines TNF (choice E), interleukin-1 (choice B), or gamma interferon (choice A) have not been shown to be effective against SLE. Plasmapheresis (choice C) has been used for the treatment of Guillain-Barre syndrome and myasthenia gravis.
38. (B) The endemic form of relapsing fever is transmitted by ticks infected by *B. recurrentis*. Relapsing fever begins with headache, high fever, muscle aches, and splenomegaly. It has a unique fever curve due to the emergence of various antigenic types of *B. recurrentis*. *B. burgdorferi* (choice A) causes a distinct spreading circular rash with a clear center, which is called *erythema chronicum migrans*. *L. interrogans* (choice C) is transmitted by rat urine and causes leptospirosis. This disease is associated with jaundice, uremia, and aseptic meningitis. *T. carateum* (choice D) is the cause of pinta, which is characterized by hyperpigmentation of the skin. *T. pertenue* (choice E) is transmitted by contact with infected persons and is characterized by the development of cauliflower-like skin lesions.

39. (C) A physician is justified in giving antitoxin on clinical evidence, or suspicion of diphtheria, without waiting for laboratory confirmation. The antitoxin dosage should be adjusted according to the weight of the patient and the severity of the infection. The antitoxin is given to neutralize free diphtheria exotoxin in the body fluids and timeliness is of extreme importance. Once the exotoxin has been bound by the body cells and exerted its influence, diphtheria antitoxin is of little value. *C. diphtheriae* localizes in the throat, and thus spinal taps are useless (choice E). Tellurite agar, not blood agar, is used for the isolation of *C. diphtheriae* from throat swabs, because it is a selective medium for this germ, inhibiting the growth of other bacteria present in throat swabs (choice B). *C. diphtheriae* is not an acid-fast microbe. Methylene blue is used to stain smear for the bacteriological diagnosis of diphtheria (choice A). This initial treatment of choice for diphtheria is antitoxin. Treatment with penicillin G or erythromycin, but not sulfonamides, may be used. Penicillin G or erythromycin are not substitutes for diphtheria antitoxin (choice D).

40. (E) Bruton hypogammaglobulinemia is a B-cell immunodeficiency disorder that is X-linked recessive and thus only affects males (boys). Affected patients are deficient in B cells in the peripheral blood and in B-dependent areas of lymph nodes and spleen. Most of the serum immunoglobulins are absent, and the IgG level is <200 mg/L. Recurrent pyogenic infections usually begin to occur at 5–6 months of age, when maternal IgG has been depleted. Individuals with Bruton syndrome have normal T-cell-mediated immune responses (choice B). Patients suffering from X-linked hypogammaglobulinemia do not have normal numbers of B lymphocytes, because the pre-B cells from which B cells are produced fail to differentiate into B cells. This is due to a gene mutation in pre-B cells, which does not allow pre-B cells to form tyrosine kinase (choice D). The number of lymphocytes in the paracortical areas of lymph nodes of patients with Bruton syndrome is normal (choice C). Individuals with X-linked hypogammaglobulinemia have normally functioning T cells, and thus are not particularly susceptible to viral or fungal infections, which are dependent on proper T-cell-mediated immune responses (choice A).

41. (B) Recurrent vesiculating lesions in the genital region suggest human herpesvirus type II, although type I is seen in some cases. Choice B would be the correct answer. Cytomegalovirus (choice A) and rubella virus (choice D) will commonly form latent infections but would not appear as vesicular lesions in the genital area if reactivated. Rubella may occur as a macular rash on the skin, but only in the initial infection episode. Papillomaviruses (choice C) are highly tropic for epithelial cells of the skin and mucus membranes. Papilloma lesions (warts) are benign except for certain strains and are never presented as vesicular. Warts contain lesion parts known as the horny layer and the granular layer. Varicella (choice E) or chickenpox will usually have all stages of a lesion (macule, papule, vesicle, and pustule) present and would be skin lesions, not in the genital mucus membrane area of the body.

42. (D) Anti-acetylcholine receptor antibodies are found in more than 90% of myasthenia gravis patients. If the clinical symptoms are suggestive of myasthenia gravis, this finding alone is often considered diagnostic. Multiple sclerosis patients tend to have high levels of measles...
virus antibodies in their spinal fluid. However, the role of this agent in the disease is undetermined (choice C). Guillain-Barr syndrome (also called acute idiopathic polyneuritis) is a demyelinating disease of peripheral nerves. It commonly occurs after a viral infection or an injection, such as influenza immunization. The disease seems to be caused by a T-cell response to nervous tissue (choices A and B). Postpericardiotomy syndrome is a term used to describe a disorder following surgery of the pericardium to remove cysts or tumors or to correct a malformation (choice E).

43. (B) Interleukin-1 (IL-1) is a protein generated primarily by macrophages. The cytokine is called endogenous pyrogen because it acts on the hypothalamus to produce fever during infections and inflammatory conditions. Thus individuals who are unable to produce IL-1 most likely will have to depend on endotoxin, the exogenous pyrogen, to induce febrile reactions. Mediation of immunoglobulin isotypic switching (choice A) requires IL-4 and IL-5. Acute-phase responses (choice C) and shock (choice D) are mediated by IL-6 and TNF-alpha, TNF-alpha. Intense inflammatory reactions are produced by IL-1 (choice E).

44. (D) There are at least 12 species of enterococci, and all are classified as group D streptococci (choice D). E. faecalis is the most common and causes 85–90% of enterococcal infections. As long as enterococci remain in the intestinal tract, they are seldom involved in disease. Yet, they are extremely efficient opportunists. The enterococci are among the most frequent causes of nosocomial infections, especially in intensive care units. They are commonly found in complications of intra-abdominal surgery, often as part of a mixed culture of microorganisms. Antibiotic therapy (cephalosporins, etc) is often a selective feature since enterococci are resistant to many of the antimicrobials in common use. Group A streptococci (choice A) would be represented by S. pyogenes and is the group which causes about 95% of human infections (skin, sepsisemia, organs, etc), but would seldom be found in intra-abdominal complications. Streptococci B (choice B) are most often found in infections of infants since type B streptococci are found routinely in the vaginal flora. Group C streptococci (choice C) usually occur in the nasopharynx and may cause sinus, blood, or heat infections. S. viridans (choice E) are usually found in the oral cavity and may be opportunists involving blood and heart infections.

45. (B) H. pylori is a spiral-shaped gram-negative motile rod that is associated with antral gastritis and duodenal (peptic) ulcer disease. It is oxidase-positive, catalase-positive, and a strong producer of urease. Antimicrobial therapy that clears H. pylori results in improvement of gastritis and duodenal ulcer disease. Hence, choice B is the correct answer. C. jejuni (choice A) infections are widespread and usually cause abdominal pain and profuse bloody diarrhea, not gastritis and ulcer manifestations. Urease-positive P. mirabilis (choice C) and other Proteus species produce infections in humans when the bacteria leave the intestinal tract, being very significant in urinary tract and bacteremia infections. P. retteri (choice D) is a member of the normal intestinal flora, often resistant to antimicrobial therapy, and is seen in urinary tract infections. V. cholerae is a comma-shaped curved rod and is widely distributed in marine and surface waters in nature. It is oxidase positive and many species are salt tolerant. V. cholerae (choice E) produces a heat-labile enterotoxin whose action increases cAMP in intestinal cells, resulting in prolonged hypersecretion of water and electrolytes.

46. (A) Deficiency in the inhibitor of the first component of complement (C1) is associated with angioedema, because this condition leads to the production of anaphylatoxins C3a, C4a, and C5a. These anaphylatoxins act on mast cells, which release large amounts of histamine. Production of histamine increases capillary permeability resulting in edema. Enhanced susceptibility to pyogenic infections has been attributed to C3 and C5–C8 components of complement. Bacteremia is a term used to indicate the presence of bacteria in the blood. Thus it has nothing to do with the first component of complement (choice C). Inherited deficiencies of C3 and C5–C8 have been associated with
increased susceptibility to pyogenic infections, but not the first component of complement (choice B). Complement can act synergistically with antibody to modify its action, but not its production (choice E). The conversions of the third (C3) and fifth (C5) components of complement by the C3 and C5 convertases to C3a and C5a anaphylatoxins lead to the increased production of anaphylatoxins (choice D) seen with C1 inhibitor deficiency.

47. (E) By definition, a hapten is a substance of low molecular weight that by itself does not elicit the formation of antibodies. However, when attached to a carrier protein, antibody production becomes possible. The hapten-carrier approach has been employed to produce antibodies against penicillin, steroids, nucleotides, lipids, and even 2,4-dinitrophenol. Since the rabbit has been repeatedly injected with the hapten only, the serum cannot be expected to have antibodies against the hapten. It is clear that when the serum is subjected to a gel diffusion assay with the hapten and a carrier protein not used to complex the hapten during immunization, no antigen-antibody precipitin lines of either identity, partial identity, or nonidentity can be expected to form (choices A, B, C, and D).

48. (A) CJD (choice A) is caused by a prion, a protein agent with no detectable nucleic acid for a genome. It is considered to be one of a group of degenerative central nervous diseases called transmissible spongiform encephalopathies. Its incubation period most often lasts for years. CJD in humans begins gradually, with progressive dementia, ataxia, twitching of muscles (myoclonus), and leading to death within a year. While cases are rare, there may be some type of familial association. Kuru (choice B) is similar to CJD but was confined to New Guinea. Once consumption of dead relatives was outlawed, the disease disappeared. Herpes simplex meningitis (choice C) results in a fairly rapid onset of symptoms caused by destruction of brain tissue, followed by a mortality rate of 75–80%. Acyclovir treatment is usually beneficial. PML (choice D) is caused by JC Virus (JCV), a polyomavirus. It is considered a slow virus disease. Several polyomaviruses are important DNA tumor viruses. PML is seen in about 5% of patients with AIDS. Clinically, demyelization of the CNS results in oligodendrocyte infection with polyomaviruses. SSPE (choice E) is another slow virus disease, caused by a defective variant of the measles virus. This slowly progressive demyelization of the CNS results in death.

49. (B) The diagnostic tests ordered by the physician are consistent with a deficiency in the C3, C5–C8 components of complement. Individuals with these deficiencies have recurrent pyogenic infections, and show enhanced susceptibility to meningococcal infections. All other choices are not consistent with the laboratory findings. Chronic granulomatous disease (choice A) entails a defect in the intracellular killing of microbes by neutrophils. Graves disease (choice C) involves autoantibody production to thyroid-stimulating hormone receptors. Systemic lupus erythematosus (choice D) involves production of anti-nuclear antibodies (ANA). Wiskott-Aldrich syndrome (choice E) is associated with recurrent pyogenic infections, but is due to an inability of plasma cells to produce IgM against bacterial polysaccharides, and it occurs only in male infants.

50. (C) Polioviruses 1, 2, and 3 are enteroviruses that belong to the picornavirus group. Even though wild-type polioviruses have not been detected in North America for many years, both the live-attenuated and killed vaccines are currently used in pediatric vaccinations. It is fairly easy to isolate and identify poliovirus strains. In this case, poliovirus was isolated and neutralized by a polyvalent antibody against all three polio strains, prompting a presumptive diagnosis of poliomyelitis in the patient. A follow-up study using separate monovalent antibodies failed to duplicate the viral identification that was indicated by the trivalent serum product. The most logical reason for this would be that two types of polioviruses were isolated and neutralized by the polyvalent reagent but not the monovalent reagents (choice C). While work is being reported on attempts to create a recombinant
virus with 1, 2, and 3 antigen markers (choice D),
this has not yet become successful. Neither have
any hybrid polio viruses (choice A) been
reported. A mixture of poliovirus and another
picornavirus (choice B) would not explain the
situation described because there is little to no
cross reactivity of poliovirus antisera to the
other members of the picornavirus group.
Choice E would not be appropriate either
because no other picornavirus shares only some
antigenic determinants with the polioviruses.

51. (D) Many outbreaks of intestinal disease and
diarrhea occur in crowded conditions like
cruise ships, where hundreds of tourists
become ill in a short time and the cruise must
be terminated early so that treatment may be
obtained and the ship sanitized. Norwalk virus
belongs to the calicivirus classification and is an
important cause of outbreaks of vomiting and
diarrheal illness in families, communities, and
institutions. It is widespread in the United
States and is the most important cause of epi-
demic viral gastroenteritis in adults (choice D).
Caliciviruses do have a single-stranded RNA
genome which is positive-sense and non-
segmented. It has multiple open reading
frames for translation (choice A). The gas-
troenteritis caused by Norwalk virus has a
24–48 hour incubation, rapid onset, and a brief
time course (12–60 hours), not several weeks
(choice B). Rotaviruses are the major cause of
severe diarrhea in infants in developing and
developed countries (choice C). Reverse tran-
scriptase—PCR is the most widely used
method to diagnose Norwalk and other cali-
civiruses in outbreaks since the virus cannot
be isolated, grown, and identified in diagnos-
tic laboratories (choice E).

52. (A) C5a is a component of complement.
Activation of complement by endotoxin, or
antigen-antibody complexes produces C5a,
which is a powerful neutrophil, monocyte,
eosinophil, and basophil attractant. C5a along
with C3a are anaphylatoxins which mediate
histamine release from mast cells leading to
increased vascular permeability and vasodila-
tion. The variable region of the heavy chain of
IgG is not known as the best neutrophil or
macrophage attractant (choice E). The J moiety
of IgM and IgA does not possess chemotactic
properties for neutrophils and macrophages
(choice D). HLA-A and HLA-B are genes for
the human leukocyte antigens (HLA), and they
control the synthesis of class I antigens (choices
B and C).

53. (B) In general, with the exception of some
superficial infections, mycoses are not readily
transmitted from person to person. Thus,
patients with fungal pneumonias are not iso-
lated, and hospital personnel are not generally
required to wear masks. Fungal pneumonias
are not resolved in 24 hours, they can become
chronic, and they need long-term treatment
with antifungal drugs (amphotericin B) due to
the high percent of cases that relapse (choices C
and D). Fungi that cause pneumonias are
phagocytized by pulmonary macrophages and
multiply in them (choice A). Most of the fungal
pneumonias occur in immunosuppressed
patients who do not mount an effective immune
response (choice E).

54. (E) Rubella virus causes German measles or
3-day measles. Rubella virus is a stable RNA
virus classified in the Togavirus group, but is
not spread by any insect vector. The route of
infection of rubella virus is the respiratory tract,
with spread to the lymphatic tissue and then to
the blood (viremia). Maternal viremia is fol-
lowed by infection of the placenta, which leads
to congenital rubella. Many organs of the fetus
support the multiplication of the virus, which
does not seem to destroy the cells, but reduces
the rate of growth of the infected cells. Viremia
develops in 7–9 days, not 3–4 weeks (choice A).
Viremia lasts until the appearance of antibody
on about day 13–15. Rubella virus is an excel-
lent antigen which produces an excellent, and
possibly life-long, immune response (choice B).
Koplik’s spots (choice C) are buccal lesions that
are seen in rubeola (measles) infections. Rubeola
is a paramyxovirus while rubella virus, as men-
tioned, is a togavirus (choice D). There is an
excellent live-attenuated vaccine for rubella that
has been given to most children in the United
States, and we have seen the number of cases
drop from approximately 70,000 in 1969 to a
few hundred today. Obviously, a specific antibody in the serum does prevent disease (choice E).

55. (E) Superoxide, which is bactericidal, is generated during electron transport and in the autoxidation of hydroquinones, leukoflavins, ferredoxins, and flavoproteins. Superoxide dismutase, however, forms oxygen and hydrogen peroxide from superoxide radicals. When catalase is present, it destroys the bactericidal hydrogen peroxide, because catalase hydrolyzes hydrogen peroxide to water and oxygen. Thus, the presence of both enzymes allows aerobes, facultative anaerobes, and aerotolerant microbes to survive when they grow in the presence of oxygen. Obligate anaerobic bacteria generally lack superoxide dismutase or catalase or both and thus cannot grow in the presence of oxygen. Oxidase is an enzyme that oxidizes a substrate by the addition of oxygen or the removal of hydrogen. It cannot oxidize the bactericidal radical superoxide (choice B). Catalase is an enzyme that converts the bactericidal substance hydrogen peroxide to water and oxygen. It has no effect on the microbiocidal action of superoxide. Bacteria that lack catalase are likely to be suppressed by hydrogen peroxide (choice A). Peroxidase is an enzyme which catalyzes the dehydrogenation of a substrate in the presence of hydrogen peroxide, which acts as hydrogen acceptor and becomes converted into two molecules of water. Thus, possession of peroxidase in a given microbe will allow it to grow in the presence of hydrogen peroxide, but not in the presence of superoxide (choice D). There are no known pathogenic bacteria that cannot form oxygen (choice C).

56. (D) P. aeruginosa is a gram-negative, oxidase-positive, aerobic rod that produces a green-blue pigment called pyocyanin. This microorganism has been associated frequently with wound infections in burn patients, and it is the second leading cause of burn infections after S. aureus. P. aeruginosa tends to develop resistance to various antibiotics. However, it may respond to ticarcillin, gentamycin, tobramycin, piperacillin, or azlocillin. E. coli (choice A), K. pneumoniae (choice B), P. mirabilis (choice C), and S. marcescens (choice E) may cause urinary or pulmonary tract infections, but are not considered leading causes of burn infections. Furthermore, these bacteria are oxidase negative and do not produce blue-green pigments.

57. (E) The viridans streptococci include S. mitis, S. mutans, S. salivarius, S. sangus, and others. They make up a major part of oral normal flora and are alpha hemolytic. They reach the bloodstream as a result of trauma and are a principal cause of endocarditis on abnormal heart valves (choice E). They produce large amounts of polysaccharides and contribute to dental caries. S. aureus (choice B) and S. epidermidis (choice C) are usually found on the skin and may be opportunistic, but they are not as significant for endocarditis as the alpha hemolytic streptococci. E. faecalis (choice A) are usually found in the intestinal tract flora and are opportunistic if they escape that location. The major lesion for enterococci is an abscess. S. pneumoniae (choice D) is primarily found in lung infections (pneumonias) and are pathogenic primarily due to their polysaccharide capsules which inhibit phagocytosis.

58. (A) Most fungi reside in nature and are essential in breaking down and recycling organic matter. About 90% of human infections by fungi can be traced to a few dozen species. Most pathogenic fungi are exogenous, their natural habitats being water, soil, and organic debris. The mycoses with the highest incidence—candidiasis and dermatophytosis—are caused by fungi that are part of the usual or normal microbial flora of humans. Most fungal growth is kept at low levels by bacteria that are more successful at using available nutrients, but fungi are efficient opportunists. Often, hosts who become infected with fungi have some serious metabolic or immune disability. Pathogenic fungi do not produce patent toxins, and the mechanisms of fungal pathogenicity are complex and multifocal, often making these infections hard to treat. The relatively low numbers of fungi in the infection and medium requirements make fungi (choice A) more difficult to isolate, identify, and relate to a medical
condition. Gram-positive (choice C) and gram-negative (choice B) bacteria will usually be isolated from clinical specimens. Viral isolation (choice D) is routinely performed successfully today. The symptoms of persistent fever and neutropenia (small number of PMNs) reflect a probable infectious disease process. Failure to associate bacteria and/or viruses with an infectious disease process and clinical history might justify consideration of a fungal etiology.

59. (E) In Western blots proteins are separated on the basis of molecular weight in polyacrylamide gels by electrophoresis. Then, they are transferred electrophoretically to nitrocellulose membranes and reacted with antibodies and substrate for detection. The Western blot assay is used as a confirmatory test in the determination of the HIV status of an individual. Electrophoretic transfer of proteins or antigens to nitrocellulose membranes followed by antibody reaction is not a part of complement fixation (choice A), indirect fluorescent antibody test (choice D), ELISA (choice B), or immunoelectrophoresis (choice C).

60. (C) *H. ducreyi* (choice C) causes chancroid (soft chancre), a sexually transmitted disease. Chancroid consists of a ragged ulcer on the genitalia, with marked swelling and tenderness. The regional lymph nodes are usually enlarged and painful. Differential diagnosis must consider syphilis, HSV infection, or lymphogranuloma venereum. The organisms can usually be obtained from the lesions and often are part of a mixed infection. Scrapings from the lesion base are inoculated on to chocolate agar with X factor and vancomycin. No permanent immunity develops from chancroid infection, but the organism is treatable with ceftriaxone, TMS, or erythromycin. Group B streptococci (choice A) are usually a component of normal vaginal flora, but do not tend to be pathogenic to the host. Group B streptococci are most significant in new-born infections. *H. egypticus* (choice B) is most often found to be associated with conjunctivitis and Brazilian purpuric fever in children. *M. catarrhalis* (choice D) is a usual oral cavity organism and is considered to be an opportunist, although it has not been associated with genital infections. *N. gonorrhoeae* (choice E) will usually present as a mucus membrane infection with a discharge and not present as genital lesions.

61. (C) Ms Y is suffering from allergic rhinitis. The diagnosis of this allergy is made on the basis of clinical symptoms and the performance of a skin test, as well as a radioallergosorbent test (RAST). In a skin test, a battery of potential allergens is injected separately subcutaneously, and the area of the wheal and flare reaction is measured. The allergen which induces the greatest wheal and flare reaction when compared to solvent is usually the one which causes the allergy. In this case injection of Kentucky blue grass yielded the biggest wheal and flare reaction, and thus this is the allergen which caused rhinitis in the patient. Allergens such as mold (choice D), cat dander (choice A), house dust (choice B), and pollen (choice E) gave wheal and flare reactions which were either below or slightly above the skin test values of the allergen solvent. Therefore, they are not likely to be causing allergy in the patient.

62. (E) The IgG anti-mold-blocking antibody will combine with the mold allergen and will not permit the mold allergen to reach the IgE antimold on the surface of the mast cells, thus inhibiting the allergic reaction. Corticosteroids suppress inflammation, but will not prevent the attachment of the mold allergen to the sensitized mast cells by the patient (choice B). Complement is not fixed by IgE allergen complexes and plays no role in the attachment of mold allergen to sensitized mast cells (choice A). Epinephrine reverses constriction of bronchioles and bronchi, and also has no effect on the attachment of mold allergen to sensitized mast cells (choice D). Cromolyn sodium stabilizes the membrane of mast cells and thus prevents release of histamine from mast cells (choice C).

63. (D) The main symptoms of pneumonia caused by *S. pneumoniae* are fever, chills, and cough that produce a dark brown sputum. Alcoholism predisposes an individual to pneumonia
because it reduces phagocytic activity, and promotes aspiration of microbes. In addition to \( S.\ pneumoniae \) (choice D), \( S.\ pyogenes \) (choice E), \( S.\ aureus \) (choice C), and \( N.\ meningitidis \) (choice B) can cause pneumonia. However, these other microbes do not produce alpha hemolysis and are not sensitive to optochin.

64. (B) By definition, the rate of growth of bacteria represents the change in the bacterial cell numbers over the change in time. From the choices given, the maximum rate of growth occurs between 2 p.m. and 3 p.m., where within 1 hour the number of bacteria has increased approximately threefold. Between noon and 1 p.m., 3–4 p.m., and 3–5 p.m., there is no increase in the number of cells and the rate of growth is zero.

\[
\frac{2 \times 10^7 - 2 \times 10^7}{5 - 4} = 0
\]

65. (D) Hepatitis E virus (choice D) has been tentatively placed in the calicivirus grouping. It has been found to be the cause of another form of hepatitis and is spread by the oral-fecal route, resembling hepatitis A epidemiology. This virus, like HAV, appears to cause only acute disease and is especially dangerous to pregnant women. This cohort experienced a 20% mortality rate in an Indian outbreak in 1955. No specific diagnostic tests are currently available for HEV diagnosis. Hepatitis B (HBV—choice A) and hepatitis C (HCV—choice B) are usually spread by means of blood and excellent diagnostic tests exist for these to diagnose specifically or rule out these agents. Hepatitis D virus (HDV—choice C) contains delta-Ag surrounded by HBV surface antigen. HDV must exist in a coinfection with HBV and may present as an acute or chronic infection. Diagnostic tests for HDV also exist. Rotaviruses (choice E) are double-stranded RNA viruses that are usually found in pediatric infections.

66. (B) Quantitative serological tests are being replaced by newer testing procedures, such as ELISA, which is not quantitative. Understanding how quantitative data is used diagnostically is still important clinically. For best results for interpretation, an acute and convalescent serum from the patient should be tested at the same time. If a 4-fold (1:2 dilutions) or 100-fold (1:10 dilutions) increase in Ab titer is found, that would be a positive diagnostic result. Often, as in this case, only a single serum sample was tested. Positive results through the highest dilution of serum could represent a very high Ab level or some problem with the test procedure, giving a false-positive interpretation. The most effective way to solve this problem is to dilute the serum further and repeat the test (choice B). Once an end-point is reached, this information may confirm or deny a possible diagnosis. An alternative test mechanism (choice A) may be available, but one must remember not to use results from two test mechanisms as a direct comparison for diagnostic purposes. This pattern is not uncommon (choice C) because high antibody titers may exist in some infections (EBV, for example). Negative (choice D) or positive (choice E) would be inappropriate reports without repeating the test as described above.

67. (A) The organisms of the genus \textit{Haemophilus} are small, gram-negative, nonmotile, nonspore-forming bacilli with complex growth requirements. \( H.\ influenzae \) requires a heat-stable factor found in blood (X factor), which can be replaced by hematin, and nicotinamide adenine dinucleotide (V factor), which can be added to the medium as a supplement, or can be supplied by other microorganisms, such as staphylococci (satellite phenomenon). \( N.\ meningitides \) (choice C), \( N.\ gonorrhoeae \) (choice D), \( S.\ pneumoniae \) (choice E), and \( L.\ monocytogenes \) (choice B) are able to synthesize hematin and nicotinamide adenine dinucleotide, and thus they will grow in culture media which do not contain these nutrients. They also do not need to rely on the production of hematin and nicotinamide adenine dinucleotide by \( S.\ aureus \) to grow. In contrast to \( H.\ influenzae \), \( S.\ pneumoniae \) is a gram-positive, lancet-shaped diplococcus, not a gram-negative bacterium. \( L.\ monocytogenes \) is a gram-positive rod.

68. (A) \( M.\ avium-intracellulaire \) (choice A) is often called the MAC or MAI (\( M.\ avium-intracellulaire \))
complex. They are ubiquitous in the environment (water, soil, food, animals). MAC organisms seldom cause disease in immunocompetent humans but are efficient opportunists in those immunocompromised, especially in AIDS patients in the United States. In fact, it is one of the most common opportunistic infections of bacterial origin in that situation. Environmental exposure can lead to MAC colonization of either the respiratory or GI tract. A transient bacteremia is usually followed by tissue invasion. Any organ may be affected. A wide variety of clinical presentations may occur, but patients often present with nonspecific symptoms of fever, night sweats, abdominal pain, and diarrhea and weight loss. Diagnosis is made by culturing the organism. Treatment may involve multiple drugs and last from 6 months to 1 year or even for life. M. fortuitum-cheloni (choice B) are soil/water saprophytes and may cause superficial or systemic disease only rarely. M. marinum (choice C) occurs in water and may cause skin lesions in humans. Infections are relatively rare. M. scrofulaceum (choice D) is also found in water and may be a rare saprophyte in adults with chronic lung disease. M. tuberculosis (choice E) causes tuberculosis in humans and is a very important human pathogen. Host to host transmission is the usual method observed.

69. (D) Pasteurella species are primarily animal pathogens, but they can produce a range of human diseases. All yersiniae and francisellae were formerly classified under this genus. P. multocida (choice D) occurs worldwide in the respiratory and GI tracts of many domestic and wild animals. It is the most common organism in humans inflicted by bites from cats and dogs. It may produce human infections in many systems and may, at times, even be part of the normal/usual human flora. A history of animal bite, pain and pus drainage at the bite site, gram-negative bipolar rods, and culture of the organism would confirm the diagnosis. B. canis (choice A) may cause mild reticuloendothelial disease in humans. F. tularensis (choice C) can be transmitted by direct contact with infected animal tissues or by inhalation or ingestion, seldom if ever by bites. C. coli (choice B), along with C. jejuni, are common human pathogens, causing mainly enteric infections. P. aeruginosa (choice E) is widely distributed in nature and in moist environments in hospitals. It can cause opportunistic diseases in immunocompromised humans. Such infections may present with blue–green pus and are difficult to treat with antimicrobials.

70. (D) There are five known classes of immunoglobulins: IgG, IgA, IgM, IgD, and IgE. IgG is the major immunoglobulin that is found in human serum and the only one that has been shown to pass the placental barrier in humans. IgM possesses higher agglutinating and complement-fixing capacity than IgG. IgM has a molecular weight of 900,000. Carbohydrates constitute 7–11% of the total weight of IgM (choice E). IgD constitutes a minor portion of serum immunoglobulins (1%). It contains higher amounts of carbohydrate (13%) than the other immunoglobulins, but it is an important B-cell receptor. No other biological functions have been described for IgD (choice B). IgE is the immunoglobulin that has been associated with anaphylactic hypersensitivity. IgE has a molecular weight of 190,000–200,000, contains 11–12% carbohydrate, and constitutes 0.002% of the total serum immunoglobulin (choice C). IgA is the major immunoglobulin of extracellular secretions. It has a molecular weight of 160,000–440,000, has modest agglutinating capacity, and its carbohydrate content is two to three times higher (7.5%) than that of IgG (choice A).

71. (D) Anaphylaxis triggered by penicillin is an immediate hypersensitivity reaction, which is typically mediated by IgE antibodies. IgE antibodies bind to specific Fc receptors on the surface of mast cells and basophils. Upon cross-linking of the IgE antibodies with their specific antigen (penicillin in this case), mast cells and basophils release histamine within minutes along with other pharmacologically active shock mediators which produce the characteristic symptoms of anaphylaxis. Activation of either the classical (choice B) or the alternate complement pathway (choice A) does not play
any meaningful role in anaphylaxis. IgD (choice C) and IgG (choice E) are not involved in anaphylactic reactions.

72. (E) *Proteus* species (choice E) produce disease in humans only when the bacteria leave the intestinal tract. *P. mirabilis* routinely causes urinary tract infections and produces urease. In such urinary tract infections, the urine becomes alkaline, promoting stone production. The organism is rapidly mobile, resulting in swarming on agar plates and may be a virulence factor in the urinary tract invasion. *Proteus* species are resistant to many antimicrobials. *E. coli* (choice B) is urease negative, and while motile, does not swarm on agar. *H. pylori* (choice C) is motile and a strong producer of urease, which is used to modify gastric mucus for more efficient growth in the intestinal tract. Gastritis and peptic ulcers are produced by *H. pylori*. *Morganella morganii* (choice D) is similar to *proteus* but observed only in occasional infections. *E. faecalis* (choice B) are gram-positive cocci which are urease negative and form colonies on blood agar, not swarming.

73. (D) Rhinoviruses (choice D) are common cold viruses that belong to the picornavirus group. They are small (28–30 nanometers), have a positive-sense linear RNA genome, and no lipid envelope. The viral receptor is located in a groove or canyon in the capsid coat where the cellular receptor (ICAM-1) attaches in the initial cell infection process. The incubation period is brief (1–2 days), allowing many infections to occur in a crowded or closed living situation. Coronaviruses (choice A) are also common cold viruses but larger than 50 nm and has a lipid envelope. The viral receptor is located in a groove or canyon in the capsid coat where the cellular receptor (ICAM-1) attaches in the initial cell infection process. The incubation period is brief (1–2 days), allowing many infections to occur in a crowded or closed living situation. Influenza viruses (choice B) are also larger than 50 nm and possess lipid envelopes. RSV (choice C) and rubella virus (choice E) are similar, being larger than 50 nm with lipid envelopes.

74. (A) Capsules (choice A) are usually made of polysaccharides and allow bacteria to resist phagocytosis by PMNs and macrophages. Since the capsule contributes to the invasiveness of pathogenic bacteria, it is considered a virulence factor. If the host produces an antibody against the capsule materials, phagocytosis and destruction of the organism can occur. Fimbrae (choice B) are also called pili and attach to cell surfaces to promote microbial colonization. While some bacteria (*N. gonorrhoeae*, for instance) produce pili and are able to resist phagocytosis if firmly attached, fewer kinds of bacteria produce pili than those capable of producing capsules. Flagella (choice C) are organelles of locomotion and do not resist phagocytosis. Lipid A (choice D) is a component part of endotoxin from gram-negative cell walls. It is considered to be the toxic component of endotoxin, capable of causing inflammation, but does not resist phagocytosis. Peptidoglycan (choice E) is part of gram-positive cell walls. Peptidoglycans do not resist phagocytosis directly but do contain teichoic acid residues that allow bacteria to adhere to cells.

75. (B) *A. israelii* is an opportunistic microorganism that does not produce any known virulence factor. It seems that its pathogenesis is related to the ability of this organism to survive the host’s inflammatory responses. Devitalized tissues, presence of foreign bodies, broken mucous membranes, and immunosuppression promote development of actinomycosis. *A. israelii* is an anaerobic organism. Thus high levels of oxygen will kill this microbe (choice A). This bacterium does not produce leukocidin (choice D), exotoxin (choice C), or pili (choice E).

76. (A) Individuals who have been diagnosed as X-linked agammaglobulinemic lack B lymphocytes and are not able to produce immunoglobulins. The lack of immunoglobulins in X-linked agammaglobulinemia renders individuals susceptible to a succession of infectious diseases caused by extracellular bacteria. These infections may be partially controlled by the injection of specific gamma globulin as a supportive therapy. X-linked agammaglobulinemic patients have T cells that are the key players in cell-mediated immunity associated with graft rejection, intracellular parasites (choice C), viruses (choice E), and fungi (choice B). *P. carinii* (choice D) is now considered a fungus, causing infections in immunocompromised patients, such as those with AIDS.
77. (A) TNF is cytotoxic to certain tumor cells. Recent experiments in gene therapy have taken the approach of expressing TNF in TIL, with the hope of allowing the TIL to return to the tumor and produce a high concentration of TNF and kill the tumor cells. TNF is a mediator of endotoxin-induced shock and is involved in inflammation, but does not generate high levels of endotoxin (choice B). There is no evidence to support that TNF stimulates T-cell proliferation (choice E). TNF is cytotoxic to certain tumor cells, but it does not lyse tumor cells by retroviral participation (choice C). NK cells can destroy tumor cells; however, they cannot be stimulated by TNF (choice D).

78. (C) Tetanus toxin produced by \( C. \text{tetani} \) is a protease that often first affects the masseter muscles. Patients so affected cannot open their mouths and have what is called trismus. Trismus provides an explanation for the term lockjaw used to describe tetanus. Cholera toxin (choice E—\( V. \text{cholerae} \)) causes fluid and electrolyte loss that leads to severe diarrhea. The clostridial alpha toxin (choice B—\( C. \text{perfringens} \)) kills cells and produces necrosis. Diphtheria toxin (choice D—\( C. \text{diphtheriae} \)) is an inhibitor of protein synthesis affecting heart, kidney, and other cells. Protein synthesis is inhibited because diphtheria exotoxin catalyzes the polyADP-ribosylation of eukaryotic elongation factor 2 (eEF2). Botulinum toxin (choice A) cleaves the proteins involved in the release of acetylcholine. This leads to paralysis of ocular, pharyngeal, and respiratory muscles.

79. (E) Infectious mononucleosis is caused by EBV, which is a member of the herpesviruses. Nucleic acid hybridization assays for EBV DNA are the most sensitive means of diagnosing infectious mononucleosis. Hemagglutinins (choice B) and NAs (choice C) are associated with orthomyxoviruses and paramyxoviruses. The majority of infectious mononucleosis patients develop what is known as a heterophile antibody, antibodies that cross-react with unrelated antigens, such as those found on sheep and horse erythrocytes. The heterophile antibody test (choice D) is used for the diagnosis of infectious mononucleosis, but since it is not a very specific test, it is not as good as the nucleic acid hybridization assays for the presence of Epstein-Barr viral nucleic acid. Important antigens that also may be used, but which are less sensitive for diagnostic purposes, include the viral capsid protein (VCA), the early proteins (EA), and the EBV-associated nuclear antigen (EBNA). Infectious mononucleosis patients develop antibody titers exceeding 1:320 and 1:20 against VCA and EA, respectively, during the acute phase of infectious mononucleosis. Antibodies to EBNA develop 1–2 months after acute infection (choice A).

80. (C) The ability of certain viruses, such as influenza, mumps, and parainfluenza viruses, to agglutinate red blood cells is used to diagnose these viruses. In general, chicken or human type O red blood cells are employed for the identification of influenza and other viruses. Red blood cells have receptors for the surface component of the influenza virus called hemagglutinin. This hemagglutinin is a glycoprotein. In an HA assay, a fixed number of red blood cells is mixed with increasing dilutions of the influenza virus. Following incubation at 4°C for 2 hours, the tubes containing the red blood cells and the virus are examined for HA. Cells agglutinated by the virus form a lattice that covers the entire bottom of the test tube (virus dilutions 1:20; 1:40; 1:80). The HA titer of the virus is the highest dilution of virus that forms a lattice. In this case, the HA titer is 1:80. Unagglutinated cells form a dark bottom (virus dilutions 1:160; 1:320) (choices D and E).

81. (E) An important difference between the AIDS (HIV) virus and the RNA tumor viruses is that HIV lyses the host cells, while RNA tumor viruses transform the cells they invade, but they lack cytolytic activity. The tropism of the HIV for T4 lymphocytes depends on the presence of the T4 protein on the surface of the lymphocytes. This protein serves as the receptor for the adsorption of the HIV to T4 lymphocytes. The HIV is a member of the retroviruses (choice D). The genomic RNA molecule of HIV contains the \( \text{gag}, \text{pol}, \text{and env} \) genes. Thus, the HIV does not differ from RNA tumor retroviruses (choices A and B). HIV contains one
copy, not two, of single-stranded RNA in its virion (choice C).

82. (E) Since there are memory lymphocytes primed by a previous tetanus toxoid injection, booster immunization with tetanus toxoid will lead to rapid production of adequate levels of protective antibody. This is the routine procedure followed by physicians for trauma patients, who have been vaccinated against tetanus and received booster immunization within the last 5–7 years. The antibody titer to tetanus toxoid remains at protective levels for 5–10 years. Aminoglycosides such as streptomycin (choice D) or penicillin (choice C) will not be effective against the spores or vegetative cells of \( C. \) tetani. Human tetanus immune globulin will only provide antibodies to tetanus exotoxin for a short time and cannot induce an anamnestic response because an injection of tetanus exotoxin or toxoid is required (choice B). Individuals who have been vaccinated against tetanus require injections of the tetanus toxoid to induce rapid production of adequate levels of protective antibody. Treatment with equine tetanus immunoglobulin, which will only provide antitetanus antibody for a short time, is not the preferred method of treatment for this patient (choice A).

83. (B) This patient’s symptoms point to a diagnosis of Lyme disease, caused by \( B. \) burgdorferi, and transmitted to humans by ticks that harbor this organism. The initial symptoms of Lyme disease are fever, chills, fatigue, and headache, but the pathognomonic feature is a spreading, circular rash with a clear center. The rash begins 3–18 days after the tick bite and is called \( erythema chronicum migrans \). Q fever (choice C), epidemic typhus (choice A), rickettsial pox (choice D), and trench fever (choice E) do not produce \( erythema chronicum migrans \).

84. (B) The antiviral drug currently used against the immunodeficiency virus is AZT, or 3-azido-3-deoxthymidine (azidothymidine). Its structure is shown in Figure 4-11. The structures of related compounds idoxuridine (choice E) and dideoxyinosine (choice C) are shown below in Figure 4-15. Acyclovir (choice A) and enviroxine (choice D) differ chemically from the structure depicted in Figure 4-11.

85. (A) Prevention of varicella and disseminated zoster rests on the administration of acyclovir. Killed varicella-zoster virus (VZV) vaccine has not been shown to be effective. Furthermore, if the immunological system has been compromised the immune responses will be very weak and of questionable value (choice C). Live attenuated VZV vaccines cannot be given to immunocompromised individuals because vaccination can be lethal (choice D). Subunit VZV vaccines are not available, and will be of little value to persons with suppressed immunological responses (choice E). Indinavir is a protease inhibitor used for the treatment of AIDS, not for varicella or zoster (choice B).

86. (C) Exfoliation toxin is produced by certain strains of \( S. \) aureus belonging to phage group II. This exotoxin divides the epidermis between the stratum granulosum and the stratum spinosum. The end result of exfoliation action is the exfoliation of the skin, known as the staphylococcal scalded skin syndrome. The TSST (choice E) causes multisystem involvement with shock which can be lethal. TSST is a super antigen that releases large concentrations of IL-1, IL-2, and TNF. Erythrogenic toxin (choice B) is produced by \( S. \) pyrogenes and is associated with scarlet fever. Alpha toxin (choice A) is produced by \( S. \) aureus and causes necrosis and hemolysis of blood cells. Staphylococcal enterotoxins A through F (choice D) are responsible for food poisoning.

87. (D) Measles or rubeola belongs to the paramyxovirus group (choice D). Measles is
an acute, highly infectious disease characterized by fever, respiratory symptoms, and a maculopapular rash. Complications are common and serious. Humans are the only natural host for measles virus, which is spread by respiratory secretions. The virus grows first in the respiratory tract and then to the local lymphatics. Koplik’s spots can be observed in the buccal mucosa. The virus replicates in the RE system and is then spread to the skin and other epithelial surfaces. The incubation period can be up to 3 weeks and the rash can last up to 2 weeks (hard measles). The rash appears to be a T-cell interaction with virus-infected cells. The main complication involves the CNS and lungs. A rare complication is SSPE. An excellent live-attenuated virus vaccine has been widely used and has decreased measles presence in the population greatly. Immunity (natural or artificially acquired) is lifelong. Adenovirus (choice A) is most often seen as respiratory infections, although significant eye and enteric diseases are caused by different strains of adenovirus. Herpesvirus (choice B) produces crops of vesicular lesions, not a maculopapular rash. Orthomyxovirus (choice C) is influenza, which has no rash presentations. Picornaviruses (choice E) consist of polioviruses, coxsackieviruses and ECHO viruses. Koplik’s spots do not appear in these infections although macular rashes may occasionally be observed.

88. (C) Natural infections with *T. pallidum* are limited to the human host, usually by sexual contact. The infectious lesion is on the skin or mucus membranes of the genitalia. Spirochetes multiply locally at the site of entry and spread to the local lymph nodes and the blood stream. Several weeks later, a papule develops at the site of infection and develops into a lesion (hard chancre). This primary lesion (choice B) “heals” spontaneously, but “secondary” lesions appear 2–3 months later. These include a red maculopapular rash and moist, pale papules (condylomas) in the genital region, axillas and mouth (choice C). Syphilitic meningitis, chorioretinitis, hepatitis, nephritis, or periostitis may occur. Both primary and secondary lesions are filled with infectious spirochetes. The infection goes subclinical. About 30% of cases cure spontaneously, while another 30% remain latent. In the rest, the disease progresses to the tertiary (choice D) stage characterized by the development of granulomatous lesions (gumma) in the skin, bones, and liver. Degenerative changes can occur in the CNS or cardiovascular system. Spirochetes are rare at this stage. *T. pallidum* cannot be cultured, and the disease is usually confirmed by serological tests. Penicillin remains the treatment of choice, but prolonged follow-up is essential. Yaws (choice E) is a disease that is usually seen as ulcerating papules on the skin of arms or legs and is caused by a variant of *T. pallidum*. Direct contact is the usual transmission mechanism. Condylomata lata (choice A) refer to eroded papules that fuse together and are highly infectious during secondary syphilis.

89. (E) Acyclovir is a guanosine analogue which inhibits viral DNA synthesis. It is activated in cells by the virus-encoded thymidine kinase, which phosphorylates this drug. Only viruses that produce thymidine kinase, such as herpes simplex 1 and 2 or the varicella-zoster virus are susceptible to acyclovir. This antiviral agent has not been shown to inhibit reactivation of herpes virus in trigeminal ganglia (choice B), to kill actively dividing cells in which virus replicates (choice D), to degrade (choice A), or to inhibit viral RNA synthesis (choice C).

90. (D) *S. schenckii* is found on thorns, and it is introduced into the skin of extremities through trauma. A regional lesion begins as a pustule, abscess, or ulcer, and then nodules and abscesses are formed along the lymphatics. The history and the symptoms described in this patient are consonant with a diagnosis of sporotrichosis. *A. fumigatus* (choice A) and *C. albicans* (choice B) are associated with deep opportunistic infections in immunocompromised patients such as AIDS patients. Aspergillosis is basically a pulmonary infection. Candidiasis can be associated with pathological conditions of the mucous membranes of the respiratory, genital, and gastrointestinal tract, where it is found as a normal inhabitant. *C. neoformans* (choice C) is the cause of meningitis. *T. rubrum* (choice E) is the cause of dermatophytosis ringworm of skin, scalp, and
especially nails. The nails thicken and are discolored.

91. (C) The genome of hepatitis B virus is composed of a circular, double-stranded DNA. It has a negative strand of 3200 nucleotides and another positive, incomplete strand of 1700–2600 nucleotides. Papilloma (choice E) and polyomaviruses belong to the family of Papoviridae, which lacks envelopes and have a double-stranded, circular DNA genome. Both strands are complete and thus differ from the genome of hepatitis B virus that has one incomplete positive strand. Hepatitis A virus (choice B), the cause of infectious hepatitis, has a linear single-stranded RNA genome, and as such it is a member of the enteroviruses. EBV (choice A) is a member of the herpesviruses and as such has a double-stranded, linear DNA genome. EBV has been associated with infectious mononucleosis, Burkitt lymphoma, and nasopharyngeal carcinoma. JC virus (choice D) is a member of the polyomaviruses.

92. (B) Medically important infections due to anerobic bacteria are common. The infections are often polymicrobial, anerobes being mixed with other anerobes, facultative anerobes, and aerobes. Anerobic bacteria are found throughout the body’s normal or usual flora. They comprise part of the bacteria on the skin, on mucosal surfaces, in the mouth, and in the intestinal tract. Infection occurs when anerobes contaminate body sites that are normally sterile. Such conditions may also arise with the use of broad spectrum antimicrobials. In the oral cavity, anerobes are present in small numbers. Bacteroides, Fusobacterium, Prevotella, and Porphyromonas make up the most common genera. The main etiological agents of periodontitis (soft oral tissue infections) and endodontic (root canal infections) belong to those four genera. Therefore, choice B represents a situation where low numbers of endogenous, normal anerobic bacteria were introduced into a lesion area and made the infection worse. Such oral infections will respond to dental manipulations and antibiotics. Periodontitis (choice D) is definitely an infectious process. Another important factor is the polymicrobial etiology from endogenous sources can be found in the lesions. Choices A (Actinomyces), C (Staphylococcus), and E (Pseudomonas) would be incorrect since they present a single genus in each case for etiology.

93. (E) The fluorescent treponemal antibody absorption test (FTA-ABS) is the confirmatory test of choice for syphilis. This is a standard indirect fluorescent antibody test. It uses killed T. pallidum as a specific antigen, the patient's serum which has been absorbed with an extract of nonpathogenic spirochetes to remove cross-reacting antibodies, and the fluorescein isothiocyanate-labeled anti-human antibody versus the regular fluorescent antibody (FA) alone. This test is positive earlier in primary syphilis, and remains positive in more patients with latent syphilis than the VDRL, RPR, or other tests for syphilis. The VDRL and the RPR tests are known as the nontreponemal tests for syphilis, and they are used for screening large groups of people. They measure nonspecific IgG and IgM called reagins, which are directed against a cardiolipin extracted from normal mammalian tissues. The silver stain (choice C) is used to detect P. jroveci cysts in specimens from AIDS patients. The correct procedure for primary syphilis diagnosis confirmation would be to screen a serum with a general screening test (VDRL) and confirm a positive VDRL with a more specific FTA-Abs test specific for anti-syphilis antibodies (choice E).

94. (A) Adenoviruses are the only ones that produce spikes extending from each one of the vertices of the capsid. These microbes are DNA, non-enveloped, icosahedral viruses. Adenoviruses cause upper respiratory infections associated with coryza, sore throat, fever, and conjunctivitis.

95. (A) B. pertussis (choice A) is a highly communicable small gram-negative coccobacillus that causes whooping cough (pertussis). It is isolated on Bordet-Gengou medium. B. pertussis produces a number of factors involved in the pathogenesis of the disease. A hemeagglutinin mediates attachment of the bacteria to ciliated epithelial cells. The pertussis toxin promotes lymphocytosis, histamine sensitization, and a mechanism of action similar to cholera toxin.
A tracheal exotoxin inhibits DNA synthesis in ciliated cells. *B. pertussis* survives only briefly outside the human host. During the catarrhal stage, large numbers of infectious bacteria are released in respiratory secretions. It is during the paroxysmal stage that the cough develops its explosive character and the “whoop” upon inhalation. Infants are especially at risk with persistent coughing in older children and even adults. An excellent vaccine is available to control this disease. The other choices (B, C, D, and E) are also upper respiratory pathogens capable of causing serious disease episodes. None of them produce the toxic products that are made by *B. pertussis* that are directly responsible for the action on cells and symptoms observed in whooping cough.

96. **(D)** A positive PPD skin test indicates that the individual has experienced mycobacterial infection at some time. A positive PPD skin test is usually obtained in individuals who have been vaccinated with the attenuated strain of *M. bovis* produced by Calmette-Guerin, who named the vaccine bacillus-Calmette-Guerin (BCG). However, as has been indicated above, any individual who had contact with *M. tuberculosis* usually gives a positive PPD test. The PPD skin test does not necessarily indicate current disease (choice A) or give any information on the health status of the individual (choice C). The PPD skin test may be used to assess proper T-cell function, but not B-cell function (choice B). Middlebrook 7H10/7H11 (choice E) refers to media, not vaccines.

97. **(C)** The NA inhibitors zanamivir and oseltamivir (tamiflu) were approved in 1999 for the treatment of influenza A and influenza B. Amantadine (generic name) or Symmetrel (trade name) inhibits an early event in the multiplication cycle of influenza virus, as well as arenaviruses. It blocks the uncoating process. Mutations in the M protein genes result in the development of drug-resistant mutants. The drug is not used extensively in the United States because it seems impractical to control this type of infectious disease that is not ordinarily fatal. To protect individuals at high risk, and in those in whom the infection is potentially dangerous, the choice is between this drug and the influenza vaccine. In most cases, the vaccine is usually preferred. Acyclovir is used to shorten the duration of herpes simplex virus episodes and also to limit the duration of viral shedding (choice B). There are no antiviral drugs for rabies (choice D). Acyclovir has slight antiviral action for EBV (choice A). There is no antiviral agent against rhinovirus (choice E).

98. **(A)** There are various ways by which immunologic suppression for transplanted tissue can occur. One of these ways is administration of antilymphocyte globulin. Other means used to obtain immunologic suppression for transplantation include destruction of B and T lymphocytes by irradiation (choice C). Cyclosporin is also used to achieve immunologic suppression for transplantation. It is thought to inhibit interleukin-2, which drives antigen-activated cells to proliferate (choice B). Steroid administration is an effective means to suppress the immune system (choice E). Suppression of transplanted tissue cannot be obtained by interferon administration, because interferon inhibits translation of viral mRNA (choice D).

99. **(E)** Type IV hypersensitivity, such as contact dermatitis, is a delayed-type allergic reaction that is differentiated from immediate type III hypersensitivity by the fact that it is mediated by a T-cell response. Type III, II, or I allergic reactions are mediated by humoral antibody. Atopic individuals exhibit type I hypersensitivity (choice C). Type II allergic reactions involve production of antibody (IgG, IgM) to cell-bound antigens of erythrocytes. Transfusion reactions are good examples of type II hypersensitivity (choice A). Cytotoxic reactions are type II allergic reactions (choice B). Immune complex reactions represent type III hypersensitivity. Here antigen-antibody (IgG or IgM) complexes accumulate on blood vessels or kidney glomeruli and cause tissue damage. Examples of type III allergy is the Arthus reaction or serum sickness (choice D).

100. **(E)** The major event associated with IV hypersensitivity is a helper T-cell reaction with the
antigen epitope and class II antigen via Ti and CD4 respectively. IgE reacts with mast cells in type I hypersensitivity (choice C). The major event associated with type IV allergy has nothing to do with the expression of antigen epitopes on B cells (choice B), the reaction of allergen with the nonexistent Ti and CD4 markers of B cells (choice D), or the expression of antigen epitopes on CD8+ of T cells (choice A).

101. (C) Cytomegalovirus (CMV) is an enveloped, double-stranded DNA virus, which causes formation of giant cells with intranuclear inclusion bodies that have an oval owl’s eye shape. CMV can cause a generalized infection, which is associated with immunosuppression. This can occur with organ transplantation or AIDS and result in central nervous system involvement, pneumonia, retinitis, colitis, and organ rejection. Adenoviruses (choice A) are also double-stranded DNA viruses but do not have an envelope. Coronaviruses (choice B) contain an RNA genome and do have an envelope. Papillomaviruses (choice D) contain double-stranded DNA and have no envelope. Variola virus (choice E) is a poxvirus, having double-stranded DNA. The largest virus group by size, poxviruses, does contain an “envelope” but it is constructed of multiple membranes closely attached to the virions, unlike lipid envelopes seen in herpes viruses, for example.

102. (E) In this case, prevention of infection most likely involves careful prescreening of the kidney donor and the recipient for CMV presence by antibody detection, isolation, or PCR. For treatment, ganciclovir is moderately effective for CMV pneumonia and retinitis in AIDS patients. Alpha interferon is used for patients with chronic hepatitis caused by B or C virus. However, only some genotypes appear to be susceptible (choice B). Gamma interferon, like alpha, has been shown to have viral replicative inhibitory activity, and also to be able to activate macrophages as well as other immune cells (choice A). Zanamivir inhibits the release of influenza virus from infected cells and thus limits the infection (choice D). Methisazone inhibits protein synthesis of vaccinia and smallpox viruses (choice C).

103. (C) The short incubation of 4 hours indicates staphylococcal food poisoning. This is a situation arising from the ingestion of preformed staphylococcal enterotoxin, which induces symptoms within 1–6 hours following consumption of contaminated food, including diarrhea, abdominal cramps, and severe vomiting. These symptoms last for 6–12 hours, and complete recovery usually occurs in less than 1 day. The incubation periods for *S. typhimurium* (choice B), *V. parahaemolyticus* (choice D), *Y. enterocolitica* (choice E), and *C. jejuni* (choice A) are 8–12, 24–96, 24–48, and 72–168 hours, respectively. These longer incubation periods in comparison to the incubation period of staphylococcal food intoxication are due to the need for these bacteria to invade the human intestinal tract, and then multiply and form the toxins responsible for the infective form of food poisoning.

104. (C) Tinea cruris or as commonly known “Jock itch” is typically found in young men, especially in macerated or occluded areas. It is also associated with tinea pedis (athlete’s foot) and the causative agent (*T. rubrum* or *T. mentagrophytes*) may be easily seen in skin scrapings. Tinea cruris occurs in healthy and immunosuppressed persons (choice E). *Histoplasma capsulatum*, the causative agent of histoplasmosis, forms septate hyphae with tuberculate macroconidia (choice D). In contrast to other fungal infections, tinea cruris is transmitted from person to person (choice A). *Aspergillus flavus*, not *T. rubrum* or *T. mentagrophytes*, produces aflatoxins, which can cause liver damage (choice B).

105. (C) To determine whether the poliovirus is a wild-type virus or if it is related to that used for vaccination, it will be necessary to prepare oligonucleotide maps of the isolated virus and compare them to those of the wild-type and vaccine strains. Many viruses may kill mice; thus, one cannot determine whether poliovirus strains are related or unrelated by mouse lethality studies (choice D). Cytopathology cannot be used for definitive diagnosis of poliovirus strains or other types of viruses (choice A). Viral neutralization assays using the grandchild’s serum will only indicate whether the grandchild has been exposed to and vaccinated.
for the polioviruses in question, but will not establish whether the poliovirus isolated from the stool of the grandfather is related to the poliovirus used to vaccinate his grandchild (choice B). Staining of the virus with fluorescent antibody may detect the presence of poliovirus, but will not establish whether the poliovirus is a wild-type virus or if it is related to that used for vaccination (choice E).

106. (B) An important part of the penicillin molecule is the beta-lactam group. This group is composed of two carbon and two hydrogen atoms at the top of the group. The bottom part of the group contains one carbon, which is linked to one nitrogen atom and one oxygen atom. Penicillinase breaks the bond between the bottom carbon and nitrogen atom, and destroys the antibacterial activity of penicillin, along with that of cephalosporin, which also possesses a beta-lactam group.

107. (C) B. dermatiditis is a dimorphic fungus, producing hyphae and conidia at room temperature but large, singly budding yeast cells at 37°C. Blastomycosis is a chronic infection with granulomatous and suppurative lesions that is initiated in the lungs. Inhalation (choice C), therefore, would be the mechanism of entry for this organism. It can disseminate to any organ, but the skin and bones appear to be the most common site. Interestingly, while B. dermatiditis is endemic for humans and dogs in the United States, it is not directly transmitted from either of these sources. It is thought to be derived from the environment, perhaps with some factor associated with rivers. It can be treated with amphotericin B. No reports of transmission have been reported from consuming contaminated water (choice A), drug use (choice B), skin penetration (choice D), or ingestion of food (choice E), spoiled or otherwise.

108. (B) The patient described in this question is showing the typical symptoms of botulism, which is commonly caused by types A, B, or E C. botulinum toxin. Therefore, early administration of potent botulinum antitoxin-containing antibodies to toxins A, B, and E constitutes the most appropriate type of treatment. Administration of staphylococcal enterotoxin antiserum could have been helpful if the patient was suffering from staphylococcal food poisoning, but he is not (choice A). Immunization with staphylococcal enterotoxin toxoid (choice C), administration of penicillin (choice A), or placing this patient in a hyperbaric chamber (choice E) are all useless.

109. (B) Botulism is worldwide in distribution and is caused by C. botulinum (choice B). C. botulinum is an anaerobic, spore-producing gram-positive organism. During the growth of the vegetative form of the organism, toxins (types A–G) are liberated into the environment, especially when the bacteria undergo autolysis. Illness in humans is most often caused by ingestion of foods contaminated with the toxin. Botulism toxin is absorbed from the gut and binds to receptors of presynaptic membranes of motor neurons of the peripheral nervous system and cranial nerves. This inhibits the release of acetylcholine, producing a flaccid paralysis. Use of antibiotics would be inappropriate and useless since no living bacteria are involved in this presentation of disease. Use of antitoxins would be the method of choice for intervention. B. anthracis (choice A) causes anthrax by bacterial spores entering small abrasions in oral mucosa and germinating into vegetative bacteria. Antibiotics would be the treatment of choice in a clinical situation, although vaccines are available for domestic animals. The other three choices (C, D, and E) all include clostridial organisms that cause diseases where antibiotic treatment is necessary.

110. (C) Medically important infections due to anaerobic bacteria are common. The infections are often polymicrobial, being mixed with other anerobes, facultative anerobes, and aerobes. Anerobes are found in all parts of the body including skin, intestinal tract, oral cavity, and urogenital mucosa. Infection usually occurs when anerobes contaminate usually sterile body sites or are heavily inoculated with anerobes. Most of the B. fragilis bacteria contain small amounts of catalase and SOD, allowing them to survive oxygen toxicity. Their usual
clinical manifestation is an abscess. Anaerobes produce an extremely foul odor from abscess pus or growth on media. In this scenario, choice C could be the proper answer. A. israelii (choice A) is anerobic but not usually involved in intra-abdominal/pelvic abscess formations. L. monocytogenes (choice B) enters the GI tract by ingestion of contaminated food (cheese or vegetables). L. monocytogenes is usually found in intrauterine infections, bacteremias, and CNS infections. C. difficile (choice D) is usually present in small numbers and increases when broad-spectrum antibiotics have been used with the patient. C. difficile produces toxins that act on the intestinal lining, producing severe diarrhea. Peptostreptococci (choice E) are anerobic streptococci, usually found in the intestine. These and E. coli would not likely to be routinely found as etiologic causes of pelvic abscesses.

111. (B) The term “psittacosis” is applied to the human disease acquired from contact with birds. “Ornithosis” is applied to infections associated with all types of domestic and free-living birds. In humans, C. psittaci (choice B) produces a range of clinical manifestations ranging from severe pneumonia and sepsis to mild, inapparent infection. A sudden onset of illness taking the form of influenza or nonbacterial pneumonia in a person exposed to birds is suggestive of psittacosis/ornithosis. Such infections will respond to tetracycline treatment. C. trachomatis (choice C) is transmitted person to person and is associated with ocular, genital, and some respiratory infections. C. pneumoniae (choice A) is the newest chlamydia species which usually presents with asymptomatic or mild illnesses. Ehrlichiae (choice D) are small, gram-negative bacilli (similar to rickettsiae) that cause nonspecific disease symptoms, fever, chills, headache, vomiting, weight loss, with few reports of respiratory problems. R. typhi (choice E) causes endemic typhus with symptoms similar to those of choice D. Rickettsiae are usually transmitted by insect vectors.

112. (E) Mycoplasma are cell-wall-free bacteria, as are L-form (L=Lister Institute) bacteria who temporarily lose their cell wall due to antibiotic treatment. Mycoplasma never possesses a cell wall but L-form bacteria will regain their cell walls when the antimicrobial affecting cell wall synthesis is removed. L-form bacteria have been a suggested mechanism for maintenance of some chronic infections, a controversial concept. All other genera (Acinetobacter, Legionella—choice A, Gardnerella—choice D) form regular colonies on agar medium. Mycoplasma and L-form bacteria have very small colonies on the agar surface and substantial growth down into the agar medium in the colony center, giving the perception of “fried-egg” morphology to the colony.

113. (E) The human pathogens in the family Rickettsiaceae are small bacteria of the genera rickettsiae, coxiella, and ehrlichia. They are obligate intracellular parasites and mostly transmitted to humans by insect vectors (excepting Q fever). Rickettsial infections are typically manifested by fever, rashes, and vasculitis (excepting Q fever and the Erhlichioses). Rickettsia rickettsii, the cause of Rocky Mountain spotted fever (choice E) is passed transovarially in the tick vector. Epidemic typhus (choice B) is caused by R. prowazekii and is not transmitted transovarially in its flea host. Brill-Zinsser disease is a recurrence of epidemic typhus (latent infection). Human monocytic ehlichiosis is caused by Ehrlichea chaffeenes (choice C) which is not transmitted transovarially in its deer tick vector. Q fever (choice D) is a respiratory infection in which the etiologic agent (Coxiella burnetii) is transmitted in dust contaminated with rickettsiae from placenta, dried feces, urine, or milk from infected animals. Aerosols from slaughterhouses may also be a source of infection for Q fever.

114. (A) The most likely diagnosis of the patient’s illness is acute amoebic dysentery, because the classical symptomatology of acute amoebic dysentery is lower abdominal pain, cramping, colitis, tenesmus, flatulence, and bloody diarrhea. Malaria is characterized by periodic fever, fatal cerebral episodes, lysis of red blood cells, and nephritis due to immune complex formation, and is transmitted by mosquito bites (choice B). Trypanosomiasis is transmitted by
bites of the tsetse fly and the trypanosomes initially cause ulcers at the site of the bite. Then the trypanosomes reach the central nervous system, and the patient has lassitude, develops sleeping episodes, and tissue wasting or even death may occur (choice E). Trichomoniasis is limited to the vagina and is associated with a watery, foul smelling, abundant greenish-gray discharge (choice D). Toxoplasmosis is a mild influenza-like disease with possible lymph node enlargement, and may be severe in immunocompromised patients. Congenital infections can damage the eyes or brain and may be fatal (choice C).

115. (A) Cysts are the infective form of *E. histolytica* and are transmitted by ingestion of infected food or drink. The gametocyte (choice B) is the infective stage of malaria parasites for mosquitoes. Larval penetration of the skin is the mode of transmission for hookworms, *Strongyloides* and *Schistosoma* (choice C). Ingestion of ova (choice D) is the mode of transmission of such organisms as *Enterobius vermicularis*, *Ascaris lumbricoides*, *Trichuris trichiura*, and others, but not *E. histolytica*. Sporozoites (choice E) are the infective stage of malaria parasites spread to humans by mosquito bites.

116. (B) The drugs of choice for acute amoebic dysentery are metronidazole and iodoquinol. Chloroquine (choice A) is normally used for the treatment of malaria. Stibogluconate (choice C) is recommended for the treatment of leishmaniasis. Sulfonamide and pyrimethamine (choice D) is used for the treatment of toxoplasmosis. Trimethoprim and sulfamethoxazole (choice E) are the drugs of choice for the treatment of pneumonia caused by *P. carinii*.

117. (B) Hepatitis virus A is a small (20–30 nm), non-enveloped, single-stranded RNA virus. The virus is transmitted via the fecal–oral route, usually by eating contaminated foods, such as oysters grown in polluted waters. The symptoms of hepatitis A infection include fatigue, loss of appetite, nausea, vomiting, abdominal pain, fever, and jaundice. The urine excreted from patients with jaundice may be dark and the feces pale. Adenovirus is a non-enveloped, double-stranded, linear DNA virus. It is transmitted by respiratory secretions, and it causes pharyngitis, conjunctivitis, keratoconjunctivitis, pneumonia, and gastroenteritis (choice A). Hepatitis B is an enveloped, partially double-stranded DNA virus with a circular genome. It is transmitted by infected blood or blood products, sexually, or congenitally (choice C). Rhinoviruses are members of the picornaviruses. Rhinoviruses cause the common cold, and are isolated from people with mild upper respiratory tract infections (choice D). Rotavirus is a member of the reoviruses. Its genome is quite unusual in that it is composed of double-stranded RNA consisting of 10 segments. Rotavirus causes diarrhea in children mostly under the age of 6 (choice E).

118. (D) Diagnosis of the patient’s infectious hepatitis can best be made by the demonstration of a fourfold rise of IgM against hepatitis A virus. Patients with hepatitis virus A do not show any meaningful rise of IgA (choice C). Hepatitis virus does not induce any pathognomonic cytopathic effects (choice B). The detection of Negri bodies is useful in the diagnosis of rabies, not hepatitis virus A (choice E). A positive Tzanck test is useful for the diagnosis of herpes virus, not hepatitis virus A (choice A).

119. (C) Hepatitis virus A infection can best be prevented by immunization with the intact inactivated virus. Interferons act only in the early phase of a viral infection, limiting the spread of virus, and are not recommended for long-term protection against viral diseases (choice E). Immunization with a subunit vaccine is used to prevent hepatitis virus B infection, not hepatitis virus A infection (choice D). Hepatitis B core antigen (HbcAg) is not effective for vaccination, even against the hepatitis B virus from which it is derived (choice B). Administration of human gamma globulin may provide only passive immunity, which will be of short duration, and thus it is not the best way to prevent hepatitis A viral infection (choice A).

120. (A) This patient has chronic granulomatous disease. Children with this disease suffer chronic suppurative infections caused most
frequently by *S. aureus*. The cause of chronic granulomatous disease is most commonly an X-linked disorder related to a genetic defect in NADPH oxidase, leading to a deficiency of NADPH oxidase. Neutrophils contain myeloperoxidase, which utilizes hydrogen peroxide and halide ions to produce hypochlorite, which is highly microbicidal. Because of the defective NADPH oxidase, the patient’s phagocytes cannot generate sufficient hydrogen peroxide, thus the myeloperoxidase-hydrogen peroxide-halide system cannot function normally. Neutrophils from these patients can phagocytize bacteria and fungi normally, but they cannot kill them because of the defective myeloperoxidase-hydrogen peroxide-halide system. Also, laboratory analysis reveals an absent respiratory burst as demonstrated by a negative nitroblue tetrazolium test in patients with chronic granulomatous disease. Severe combined immunodeficiency disease (SCID) is characterized by the absence of T and B cells, absence of thymus, and a lack of lymphocyte proliferative response to mitogens, antigens, and allogeneic cells in vitro (choice D). Systemic lupus erythematosus is an autoimmune disease (type III hypersensitivity or immune-complex disease). Patients with lupus erythematosus produce anti-DNA antibodies (choice E). Rheumatoid arthritis is another autoimmune disease. Patients with this disease produce IgM autoantibodies to the Fc moiety of IgG (choice C). Patients with Graves disease produce autoantibodies to thyroid-stimulating hormone receptors (choice B).

121. (E) Streptococcal infections in chronic granulomatous disease are rare, because the defective myeloperoxidase-hydrogen peroxide-halide system can use hydrogen peroxide accumulated by phagocytized streptococci, which are catalase negative and cannot convert hydrogen peroxide to water and oxygen. Administration of pooled gamma globulin (choice C) or antistreptolysin (choice A) is likely to provide only brief, but not chronic, protection against streptococci. C-reactive protein (CRP) is a beta serum globulin which reacts with the C carbohydrate of the cell wall of *S. pneumoniae*. It is not an antibody and thus will not provide even brief protection against streptococci (choice B). Phagocytosis plays a major, not a minor, role in the killing of streptococci (choice D).

122. (A) The term normal or usual microbial flora denotes the microorganisms on the skin and mucus membranes of healthy individuals. This resident flora consists of relatively fixed types of organisms that promptly reestablishes itself if disturbed. If normal flora is altered due to use of broad-spectrum antimicrobials, for instance, transient microorganisms may colonize, proliferate, and cause disease. The resident flora are commensals (symbiotic, not harmful; one may benefit from the other). Normal flora may become opportunistic pathogens if they become established in some other part of the human host. Since normal flora microorganisms are antigenic, it has been proposed that normal flora (like these Neisseriae) help to provide a natural immunity in local host defense (choice A). While there is a normal respiratory flora (choice B), most respiratory diseases (bacterial and/or viral) are usually transmitted from the environment or from other people. Bacteria, in general, affect the humeral (antibody) immunity (choice C). Some non-commensal bacteria may stimulate the CMI (mycobacteria, for example). *Neisseria* pathogens (gonococci and meningococci) possess capsules and produce mucoid colonies (evidence of capsules), while normal flora colonies are opaque and wrinkled, indicating no capsules (choice D). Techoic acids and lipotechoic acid residues are usually associated with gram-positive bacteria.

123. (B) M protein (choice B) is a major virulence factor of Group A *S. pyogenes*. M proteins appear as hair-like projections of the cell wall which resist phagocytosis by PMNs. Group A Streptococci are nonvirulent, and antibodies to specific M proteins will protect against reinfection. There are, however, more than 80 types of M protein, with little cross-protection observed. M protein may well have an important role in the pathogenesis of rheumatic fever. Purified streptococcal cell wall membranes induce antibodies that cross-react with human cardiac sarcolemma.
A component of the cell wall of selected M types induces antibodies that react with cardiac muscle tissue. The M protein serotypes are used to subdivide Group A streptococci into 80 different serotypes. The other choices (A, C, D, and E) are all virulence factors of Group A streptococci, but do not form the basis of identifying antigenic different subgroups or serotypes.

124. (A) Adenoviruses are a frequent cause of infection characterized by a triad of symptoms, namely, pharyngitis, conjunctivitis, and fever. *S. pyogenes* (choice D) causes 25% of cases of pharyngitis. However, the disease is often accompanied by tonsillitis. The infection is usually associated with fever which is higher than 39°C. *N. gonorrhoeae* (choice C) normally causes gonorrhea. *C. pneumoniae* (choice B) causes generally primary atypical pneumonia which is not usually associated with conjunctivitis. *T. gondii* (choice E) in AIDS patients, or other immunosuppressed individuals can cause disseminated disease and encephalitis (choice E).

125. (E) The patient was hospitalized due to severe influenza symptoms, and an influenza virus was isolated from clinical specimen. Isolation of the etiologic virus would not change the way medical care was being given to the individual. Influenza viruses have an RNA genome comprising of eight segments, each coding for one or more viral components. Influenza viral genomes are also negative-sense, meaning that within the virus particle, there must be an RNA-dependent RNA polymerase to allow the virus growth cycle to make viral mRNA and viral genomic RNA (choice E). There would be no use for a DNA-dependent RNA polymerase (choice C) or an RNA-dependent DNA polymerase (choice D). Since the influenza virus uses the host cell as a factory to produce new viral progeny, host cell ribosomes would be utilized for viral protein production (choice A) but by definition, negative-sense RNA cannot act as mRNA. Therefore, RNA from the virion could not directly interact with host cell ribosomes. Influenza viruses possess a well-defined lipid envelope (choice B), where the HA and NA glycoproteins are found.

126. (B) The autoimmune disease described here by the presence of anti-Sm antibodies is Systemic lupus erythematosus (SLE). This autoimmune disease is initially recognized clinically by a rash on the face with a “wolf”-like shape and thus the name lupus. Such a butterfly rash (over the malar eminences of the face, hence a malar rash) is considered a distinctive manifestation of SLE. The development of *erythema chronicum migrans* is a pathognomonic feature of Lyme disease (choice A). Detection of antibodies to double-stranded DNA are pathognomonic for SLE (choice C). Arthritis, but not carditis (choice D) or pneumonitis (choice E), occurs frequently.

127. (B) The streptococci were divided into multiple groups based upon different soluble carbohydrates isolated from the cell walls. This CHO was antigenic, and R. Lancefield produced antibodies against each of them. She initially identified Groups A–G. Almost 95% of streptococcal infections in humans are caused by Group A, *S. pyogenes* (choice A). *S. agalactiae* is a representative member of the Group B streptococci (choice B). They are members of the normal flora of the female genital tract and an important cause of neonatal sepsis and meningitis. They produce beta (clear zone) hemolysis, like the Group A members. They can be identified as Group B on the basis of the CAMP test (positive) and monoclonal antibody screening tests. It is important to identify and treat such neonatal infections properly to avoid mortality of the small patients. While *N. meningitidis* (choice C) may affect infants, most cases of meningitis caused by the organism would be in 5-year-old to young adult patients. *Salmonella* species (choice D) is an inappropriate choice for this age and disease. *S. pneumoniae* (choice E) can affect all age groups, but the highest incidence for meningitis is in the elderly population.

128. (C) *K. pneumoniae* (choice C) is present in the respiratory tract and feces of about 5% of normal individuals. It causes a small proportion (about 1%) of bacterial pneumonias. It is a gram-negative rod with a well-defined capsule that helps to resist phagocytosis by PMNs. It can produce extensive hemorrhagic necrotizing
consolidation of the lung in debilitated patients and can cause nosocomial (hospital acquired) infections. Elderly patients with COPD are particularly at risk with this organism. Other enterics (choices A and B) may also produce pneumonia but do not have the well-defined capsule that K. pneumoniae possesses. P. aeruginosa (choice D) is a widely distributed gram-negative bacillus that can also be quite opportunistic for individuals with abnormal host defenses. P. aeruginosa produces pigments that produce blue–green pus and is especially a problem with cystic fibrosis patients where the organism resides in a well-defined biofilm within the patient. Y. pseudotuberculosis (choice E) resides in domestic farm animals and is the source of human infections.

129. (A) The non-spore forming gram-positive bacilli are a diverse group of bacteria. While C. diphtheriae is the most important pathogen, many corynebacteria and propionibacteria (anerobes) are members of the normal flora of skin and mucus membranes. These bacteria tend to be clubbed or irregularly shaped. C. durum (choice A) is a diphtheroid, a normal flora species that can be opportunistic in the right location, such as hair follicles and sebaceous glands. It may contribute to lesion development or be part of a mixed culture of skin bacteria present in the pustule. E. rhusiopathiae (choice B) causes disease in domestic swine. Erysipelas is caused by Group A streptococci. L. monocytogenes (choice C) enters the body through the GI tract after ingestion of contaminated cheese or vegetables. S. aureus (choice D) and S. epidermidis (choice E) are well-defined gram-positive cocci.

130. (D) Haemophilus species are a group of small gram-negative pleomorphic bacteria that require blood agar enriched with X and/or V factors for isolation. H. influenzae (choice D) is an important pathogen found on the mucus membranes of the upper respiratory tract in humans. It is an important cause of meningitis in children, and it would not be unusual to isolate the organism from spinal fluid in such a case. Children aged 6 months–5 years are the group most at risk. H. influenzae is also able to cause respiratory tract infections in children and adults. Such infections can be controlled by use of the H. influenzae type b conjugate vaccine as part of the pediatric vaccination series. Actinomyces (choice A) species are gram-positive rods, usually found in the oral cavity. B. fragilis (choice B) is a gram-negative rod usually found in the intestinal tract and may be opportunistic. These are anerobes, and appropriate conditions must be used for isolation. E. coli (choice C) is a larger enteric bacterium, also a very efficient opportunist, which will grow on less complex media. L. monocytogenes (choice E) is a gram-positive organism.

131. (C) C. perfringens (choice C) may well cause myonecrosis and gas gangrene in an invasive infection due to the many tissue-destroying toxins the bacteria can make. However, a powerful enterotoxin that induces intense diarrhea in 6–18 hours can be made by C. perfringens. It is similar to food poisoning caused by B. cereus (a soil organism) and tends to be self-limited. B cereus (choice C) produces an emetic type of food poisoning and a diarrheal form by toxins produced by the bacteria. It has a short incubation (hours) and recovery usually occurs in 24 hours. C. botulinum (choice A) produces a toxin that is ingested and affects the CNS in 2–4 days. Gastrointestinal anthrax (choice A) is quite rare. C. difficile (choice B) become predominant in the intestinal tract as a result of antibiotic treatment. It produces two toxins that cause pseudomembranous colitis. C. tetani (choice D) causes tetanus, not an enteric disease.

132. (C) The enterobacteriaceae are a large, heterogeneous group of gram-negative rods that normally inhabit the intestinal tract of humans and animals. The Escherichia genus (usual flora) can incidentally cause disease while Salmonella and Shigella genera are regularly pathogenic for humans. E. coli is the most common cause of urinary tract infection, but there are also several E. coli-associated diarrheal diseases that occur worldwide. Enterohemorrhagic E. coli (EHEC) produces verotoxin and is associated with hemorrhagic colitis and hemolytic uremic syndrome. E. coli serotype O157:H7 (choice C) is the most common strain for these disease presentations.
Many outbreaks could be prevented by thoroughly cooking ground beef. EPEC is a strain that causes diarrhea in infants while ETEC is a common cause of traveler’s diarrhea. C. jejuni (choice A) can be responsible for a shigella-like illness that is self-limited. Milk or undercooked fowl are frequent vectors of this organism. Non-01 serogroup of V. cholerae (choice B) only causes a cholera-like illness occasionally. Salmonella (choice D) enterocolitis can be caused by 1400 serotypes. Nausea, headache, vomiting, and profuse diarrhea with low-grade fever are common and resolve in 2–3 days. The natural habitat of shigellae (choice E) is limited to the intestinal tract of humans and other primates, where they produce bacillary dysentery.

133. (B) B. pertussis is a small gram-negative rod that produces a number of virulence factors that are involved in the pathogenesis of whooping cough (pertussis). The organism has a capsule that inhibits phagocytosis and is susceptible to several antibiotics. The pertussis vaccines (containing 1–5 antigens) provide excellent active immune protection. B. pertussis can be isolated and identified using Bordet-Gengou (choice B) medium. Blood agar (choice A) is a general enriched medium but is insufficient to isolate B. pertussis. MacConkey agar (choice C) is routinely used to isolate and identify lactose-positive and lactose-negative enteric bacteria. Thayer Martin agar (choice D) is used for the isolation of pathogenic neisseria species. Tryptic Soy agar (choice E) is a general medium that will support many species of normal flora bacteria.

134. (C) Mumps is an acute contagious disease characterized by nonsupportive enlargement of one or both salivary glands. While it is estimated that one-third of all infections are subclinical, mumps in children is mild. In adults, complications include meningitis and orchitis. Immunity is permanent after a single infection or vaccination with the single antigenic type live-attenuated vaccine (choice C). As stated, it does not recur in infected individuals (choice A) and is a human pathogen, not canine (choice B). Meningitis and orchitis are the main complications, but severe systemic manifestations (choice D) do not occur. Orchitis (choice E) occur in 20–50% of infected men.

135. (E) Leptospirosis is a zoonosis of worldwide distribution and is caused by spirochetes of the genus Leptospira. L. interrogans is the main pathogen. Leptospiroae grow best under aerobic conditions at 28–30°C in serum-containing semisolid media. After 1–2 weeks, the leptospiroae produce a diffuse zone of growth near the top of the tube and later in a ring corresponding to the level of optimal oxygen tension for the organisms. Human infection results usually from ingestion of water or food contaminated with the bacteria. The organisms establish themselves in the liver and kidneys. Kidney involvement in many animal species is chronic and results in the shedding of many leptospiroae in the urine (choice E). Other body fluid choices (A, B, C, and D) are not preferred specimens for leptospiroae isolation.

136. (B) Lyme disease is named after the town of Lyme, Connecticut, where clusters of cases were identified in children. Lyme disease is caused by the spirochete B. burgdorferi, which grows most readily in a complex liquid medium. It has been isolated most easily from the characteristic skin lesion called erythema migrans. B. burgdorferi is transmitted by a small, hard-bodied tick of the genus Ixodes. The vector in the Northeast and Midwest is I. scapulous and I. pacificus on the West coast of the United States. There is often flu-like illness when the erythema migrans lesion (flat, reddened area with central clearing) is present. Late manifestations of arthralgia and arthritis are seen if early diagnosis and treatment (doxycycline or amoxicillin) is missed. Only B. burgdorferi appears to be etiologic and only hard-bodies Ixoid ticks appear to be vectors.

137. (D) The pseudomonads are gram-negative, motile, aerobic rods that produce water-soluble pigments. They occur widely in soil, water, plants, and animals. P. aeruginosa is frequently present in small numbers in the normal intestinal tract and on the skin of humans. It is also commonly present in moist environments in hospitals. While a saprophyte
on normal immune-competent humans, it is a most efficient opportunist in people with deficient host defenses. Choice D is the correct answer. *S. pneumoniae* (choice E) are gram-positive, and *Mycoplasma* species (choice C) have no cell wall but are so small that they would not be observed in a Gram stain preparation. *H. influenzae* (choice A) are extremely small gram-negative rods, much smaller than pseudomonads. *Legionella* (choice B) stain poorly by the Gram stain procedure and are not seen in clinical specimens.


Questions

1. A 62-year-old woman has had atrial fibrillation since experiencing a myocardial infarction (MI) 7 months prior. Two weeks ago she was hospitalized following a car accident in which she suffered a compound fracture of her left femur and several severe contusions. She now returns to the emergency room with right flank pain, hematuria, and left-sided paralysis. These newly developing problems are most likely the result of which of the following?

   (A) air embolism from the compound fracture
   (B) bone marrow embolus from the fractured femur
   (C) fat embolism from the fractured femur
   (D) systemic thromboemboli from the left atrium
   (E) venous thromboemboli from the deep leg veins

2. A 67-year-old retiree was employed for many years in the plastics industry where he was exposed to vinyl chloride. This industrial exposure has increased his likelihood of developing which of the following?

   (A) focal nodular hyperplasia
   (B) hepatic adenoma
   (C) hepatic angiosarcoma
   (D) hepatic fibroma
   (E) hepatocellular carcinoma

3. A 67-year-old woman presents with a 4-week history of headaches, facial pain, blurred vision, and intense pain and stiffness in her shoulders and hips. She is diagnosed with a vasculitis, and a biopsy of an affected artery is taken. Histological examination is most likely to reveal which of the following characteristic findings?

   (A) concentric “onion skin” thickening and fibrosis
   (B) extensive intra- and extravascular granulomatous inflammation
   (C) fragmentation of the internal elastic lamina with giant cells
   (D) hyaline arteriolosclerosis and luminal narrowing
   (E) segmental fibrinoid necrosis and neutrophil infiltration

4. A 2-day-old male infant has not passed any meconium and is now developing signs of obstruction. Examination of the colon would reveal which of the following abnormalities?

   (A) absence of parasympathetic ganglion cells in the submucosal and myenteric plexus
   (B) absence of the nerve fibers that innervate the wall
   (C) atrophy of the mucosal lining of the wall
   (D) hypertrophy of the muscle coat of the wall
   (E) presence of multiple small polyps along the mucosal surface
5. A lung autopsy specimen with an abnormality of the vasculature is depicted in Figure 5-1. What is the most likely associated clinical finding?

(A) chronic idiopathic thrombocytopenic purpura
(B) disseminated intravascular coagulation
(C) hemoptysis due to aneurysmal rupture
(D) hemoptysis due to tumor eroding into blood vessel
(E) sudden death due to occlusive embolus

6. A 50-year-old woman complains of a lump in her thyroid gland. Fine-needle aspiration of this lump is reported as medullary carcinoma. A test of her serum would most likely reveal an increased level of which of the following?

(A) alpha-Fetoprotein
(B) cancer antigen (CA) 125
(C) CA 15–3
(D) calcitonin
(E) human chorionic gonadotropin

7. A 14-year-old boy is referred to you for nasal obstruction and frequent nosebleeds. Which of the following is the most likely diagnosis?

(A) inverted papilloma
(B) juvenile angiofibroma
(C) nasal polyps
(D) nasopharyngeal carcinoma
(E) Wegener granulomatosis

8. A 57-year-old woman had her last menstrual period at the age of 46. However, for the past 4 months she has experienced intermittent vaginal hemorrhage. A right ovarian mass is identified. Which of the following is the most likely diagnosis?

(A) arrhenoblastoma
(B) Brenner tumor
(C) dysgerminoma
(D) granulosa cell tumor
(E) Sertoli-Leydig cell tumor
(F) teratoma

9. A 28-year-old recently divorced man with no significant past medical history presents to the emergency room with progressive lower abdominal pain and cramping over the past 4 days, both of which are relieved by defecation. He has suffered from substantial bloody and mucoid diarrhea during this time. His temperature is 102.8°F. Laboratory studies reveal an elevated white blood cell (WBC) count and a high erythrocyte sedimentation rate. Sigmoidoscopy reveals extensive rectal and sigmoid hyperemia and edema, numerous superficial ulcerations, and small focal mucosal hemorrhages, many of which have supplicative centers. Significant intestinal narrowing is seen in the distal transverse colon. These findings most likely suggest a diagnosis of which of the following?

(A) amebic colitis
(B) collagenous colitis
(C) cytomegalovirus enterocolitis
(D) pseudomembranous colitis
(E) ulcerative colitis

10. A 15-month-old girl presents with a large abdominal mass, weight loss, and fever. At surgery, a large infiltrative tumor with areas of hemorrhage and necrosis is removed. A photomicrograph of a section from this tumor is shown in Figure 5-2. Which of the following is the most likely diagnosis?
11. A 52-year-old woman presents to her primary care physician complaining of increasing fatigue and mild shortness of breath. Blood work reveals a hypochromic anemia with a hemoglobin concentration of 10.4 g/dL, MCV of 76 μm³, MCHC of 29 g/dL, and a decrease in the absolute reticulocyte count. WBC and platelet counts are within normal limits. Serum iron and ferritin levels are low and total iron-binding capacity is elevated. Which of the following conditions best accounts for these findings?

(A) anemia of chronic disease  
(B) aplastic anemia  
(C) hypothyroidism  
(D) iron deficiency  
(E) pernicious anemia

12. A 52-year-old woman has had rheumatoid arthritis for many years. She now comes to you complaining of the development of the past few months of redness, burning, and itching of her eyes and a dry mouth, making swallowing difficult. This newly developing condition gives the patient a greatly increased risk for which of the following?

(A) esophageal carcinoma  
(B) leukemia  
(C) lymphoma  
(D) melanoma  
(E) pleomorphic adenoma

13. A 3-year-old girl develops gastroenteritis and a number of other children at the day care nursery that she attends are also affected. This was most likely caused by which of the following agents?

(A) Balantidium coli  
(B) Cryptosporidium parvum  
(C) Entamoeba histolytica  
(D) Giardia lamblia  
(E) rotavirus

14. A 9-year-old boy is stung on the arm by a wasp and very rapidly develops redness and swelling at the site of the sting. Which of the following substances is most responsible for these early changes?

(A) bradykinin  
(B) complement 3a  
(C) histamine  
(D) leukotriene B₄  
(E) thromboxane A₂
15. A 21-year-old woman presents with a 6-hour history of left-sided lower abdominal pain and is found to be hypotensive. A hemorrhagic mass is discovered in her left fallopian tube during laparoscopy. The tube is surgically excised. A photomicrograph of the tubal contents is displayed in Figure 5-3. Which of the following is the most likely diagnosis?

(A) chorioadenoma destruens  
(B) choriocarcinoma  
(C) ectopic tubal pregnancy  
(D) granular cell tumor  
(E) leiomyoma

16. A 45-year-old man is admitted to the hospital for elective gastrointestinal surgery. On the third post-operative day, the patient experiences a fever of 101.5°F, and reports having a slight cough, but is otherwise asymptomatic. Chest x-ray demonstrates a small, interstitial infiltrate in the left lower lobe. Three sets of blood cultures (two bottles each) are drawn and sent to the laboratory. Culture results report positive Staphylococcus epidermidis growth from one bottle of the first culture set, and negative growth from the second and third culture sets. Based on this information, what is the most likely diagnosis?

(A) intermittent bacteremia associated with postsurgical abscess formation  
(B) postoperative septicemia secondary to infective endocarditis  
(C) postoperative septicemia secondary to pneumonia  
(D) postoperative septicemia secondary to surgical manipulation of the gastrointestinal tract  
(E) skin flora contamination and not septicemia

17. A 32-year-old man is admitted for neuropsychiatric evaluation after exhibiting bizarre behavior. During his medical workup, he is found to have cirrhosis and a mild parkinsonian tremor. Which of the following diagnoses provides the best explanation for these findings?

(A) congenital hepatic fibrosis  
(B) peliosis hepatis  
(C) primary sclerosing cholangitis  
(D) Reye syndrome  
(E) Wilson disease

18. A 26-year-old man presents with a 3-week history of increasing pain just below his right knee. He does not recall sustaining any trauma to his leg and is not experiencing pain elsewhere; he states that he is otherwise healthy. Examination reveals only tenderness to palpation in the area. An x-ray of his right knee demonstrates a small lytic lesion in the tibial medial condyle surrounded by a focus of sclerosis. Based on this information, what is the most likely diagnosis?

(A) gout  
(B) osteochondroma  
(C) osteomyelitis  
(D) osteosarcoma  
(E) rheumatoid arthritis

19. A 63-year-old woman has a routine chest x-ray that reveals a suspicious subpleural lesion. The lesion is resected and sectioned, and reveals all (choices A through F) of the following microscopic findings. Which of these findings would most strongly indicate that the lesion is a malignant neoplasm?

(A) hyperchromatism  
(B) increased nuclear/cytoplasmic ratio
20. The bone marrow biopsy depicted in Figure 5-4 was obtained from an infant with hepatosplenomegaly and mental retardation. The pathologic basis of this disorder is best explained by which of the following?

(A) deficient cellular immunity that permits continued intracellular bacterial proliferation
(B) exposure to excessive radiation during embryogenesis
(C) hereditary defect of a catabolic enzyme leading to abnormal intracellular accumulation of lipids
(D) oncogenic viral integration into host’s DNA that initiates unregulated cellular proliferation
(E) traumatic injury during delivery

21. A 72-year-old man with a known history of chronic essential hypertension dies unattended at home. The medical examiner determines the cause of death to be hypertensive intracerebral hemorrhage. The most likely site of the hemorrhage is which of the following?

(A) basal ganglia or thalamus
(B) cerebellum
(C) frontal lobe
(D) occipital lobe
(E) pons

22. A 14-month-old baby boy is brought to your office by his mother because he seems to be in pain whenever he tries to move. During your physical examination you note bowing of his legs, depression of the sternum with outward projection of the ends of the ribs, reluctance to move his limbs, and numerous bruises on his legs as well as gingival hemorrhages. These findings lead you to suspect that this child suffers from a dietary deficiency of which of the following vitamins?

(A) A
(B) B₁ (thiamine)
(C) B₁₂ (cyanocobalamin)
(D) C (ascorbate)
(E) D (calciferol)
(F) K

23. A 10-year-old boy is brought to a pediatric clinic by his mother, who states that he has been voiding brown-colored urine for the past 2 days. The child’s history is negative except for a sore throat about 2 weeks ago. Physical examination reveals moderate periorbital edema and mild hypertension. Urinalysis demonstrates red cells, both red and white cell casts, and 2+ protein. If a renal biopsy were obtained, what would be the characteristic light and/or electron microscopic finding in the glomeruli?

(A) hypercellularity with duplication of the basement membrane
(B) hypercellularity with subepithelial “humps”
(C) hypercellularity with “wire loop” lesions
(D) normocellularity with effacement of epithelial cell foot processes
(E) normocellularity with segmental sclerosis
(F) normocellularity with thickened basement membranes
24. A 56-year-old man complains of increasing dyspnea on exertion over the past few days. He is noted to be overweight and cyanotic. He has smoked cigarettes for at least 35 years and has a long-standing history of persistent cough, producing a large amount of thick mucopurulent sputum. Auscultation reveals scattered rhonchi and wheezes. Histological examination of his lung tissue would most likely show which of the following?

(A) expanded alveolar septae infiltrated by mononuclear cells
(B) mucous gland hypertrophy and fibrosis of bronchiolar walls
(C) neutrophilic exudate occupying the alveoli of an entire lobe
(D) pink, proteinaceous layer lining the alveolar spaces
(E) thickened basement membranes and many eosinophils

25. A 6-year-old child presents with diarrhea, malabsorption, and steatorrhea. A photomicrograph from a small intestinal mucosal biopsy is displayed in Figure 5-5. An appropriate treatment would be which of the following?

(A) alpha-interferon therapy
(B) antineoplastic drugs
(C) initiation of a gluten-free diet
(D) referral to hospice for supportive care
(E) surgical resection of a segment of small bowel

26. A 57-year-old man seeks medical attention for the recent appearance of numerous, large, fluid-filled, cutaneous blisters. These involve the face, scalp, neck, and axillae. Manual pressure to the skin results in epidermal separation. These changes are most likely the result of which of the following?

(A) autoimmune disorder
(B) bacterial infection
(C) dietary deficiency
(D) exposure to a chemical toxin
(E) local ischemia

27. A 32-year-old male cyclist is struck at night by a hit-and-run motorist. He is unconscious and severely injured and is not discovered until a pedestrian walks by 2 or 3 hours later. When he arrives at the emergency room, he is in shock and his BP is 80/30 mm Hg. He is transfused and a large wound on his right leg is cleaned and sutured. However, by the next day his urine output has decreased to less than 20 mL/h. Which of the following microscopic descriptions best describes his kidneys at this time?

(A) acute PMN infiltration of tubules and interstitium
(B) fibrinoid necrosis of arterioles
(C) focal tubular necrosis with pigmented cellular casts
(D) interstitial mononuclear infiltrate with “thyroidization”
(E) wedge-shaped areas of coagulative necrosis

28. A 76-year-old woman suffers a massive myocardial infarct and dies in cardiogenic shock 20 hours after its onset. Microscopic examination of her infarcted myocardium would be expected to demonstrate which of the following?

(A) abundant neutrophils and monocytes
(B) coagulative necrosis with few neutrophils
(C) fibrosis and collagen deposition
(D) monocytes and neovascularization
(E) plasma cells and caseous necrosis
29. A 32-year-old man presents with diarrhea and symptoms of peptic ulcer disease. Endoscopy reveals two ulcers, one in the first portion of the duodenum and one in the midduodenum. However, they do not respond to the usual peptic ulcer treatment programs. The most likely explanation for the findings in this patient is which of the following?

(A) antibodies to intrinsic factor  
(B) ectopic hypersecretion of gastrin  
(C) gastric mucosal atrophy  
(D) pressure ulceration from bezoars  
(E) vascular abnormality

30. A 47-year-old man has been chronically ill for the past 18 months. He undergoes a lung biopsy and a section is shown in Figure 5-6. Which of the following is the most likely diagnosis?

(A) aspergillosis  
(B) leprosy  
(C) pneumocystosis  
(D) sarcoidosis  
(E) tuberculosis

31. A 5-week-old girl, who appeared to be healthy at birth, develops diarrhea and vomiting a few days after birth. Your current examination reveals that she has hepatomegaly, jaundice, and early cataract formation and is not meeting developmental milestones. You suspect that she has which of the following conditions?

(A) galactosemia  
(B) Hurler syndrome  
(C) pyloric stenosis  
(D) Tay-Sachs disease  
(E) type I glycogenosis

32. A 39-year-old woman reports headaches, weakness, and fatigue, and frequent urination over the past several weeks. Physical examination reveals diastolic hypertension. Laboratory findings include hypokalemia and reduced renin levels. Which of the following is the most likely cause of these various findings?

(A) Conn syndrome  
(B) diabetes insipidus  
(C) diabetes mellitus  
(D) pheochromocytoma  
(E) polycystic renal disease
33. A 43-year-old woman with a long history of chronic allergies visits her primary care physician with a 2-week history of progressive left perinasal pain and nasal pressure, increasing episodes of yellowish-green nasal discharge, and a fever 1 day prior of 100.8°F. Significant findings on physical examination include a temperature of 101.0°F, tenderness to palpation over the left maxillary sinus, and nasal speculum observation of obstruction of the left middle meatus by a large, pale, polypoid mass with a small focus of ulceration and a similar but smaller mass seen in the right middle meatus. A clinical diagnosis of left maxillary sinusitis is made and the patient is started on antibiotics. She is subsequently referred to an otolaryngologist who excises the bilateral masses to relieve the sinus obstruction. Which of the following findings would you expect the pathologist to see on microscopic examination of these masses?

(A) hyperkeratotic squamous epithelium with a submucosal core of myxoid connective tissue, frequent blood vessels, mild fibrosis, and a mononuclear infiltrate

(B) myofibroblastic proliferation in a dense fibrovascular stroma with numerous endothelial-lined channels

(C) papillomatous proliferation of squamous epithelium extending downward through the submucosal connective tissue

(D) respiratory epithelium containing an edematous, loose stroma and a mixed inflammatory infiltrate, with a prominence of neutrophils and eosinophils

(E) undifferentiated large epithelial cells with round vesicular nuclei and prominent nucleoli in a syncytial arrangement with a marked lymphocytic infiltration

34. A 71-year-old woman suffers severe head injuries in a mugging and is hospitalized in a comatose state. While in the hospital, she develops severe pneumonia and on day 11 goes into cardiac arrest and cannot be resuscitated. At autopsy she is found to have advanced coronary atherosclerosis and a pulmonary embolism judged to have occurred within the past 2–3 days. The coroner should list which of the following on the death certificate as the underlying (or proximate) cause of death?

(A) atherosclerosis

(B) blunt trauma to the head

(C) cardiopulmonary arrest

(D) pneumonia

(E) pulmonary embolism

35. A 66-year-old woman with a 3-year history of right hip pain undergoes a prosthetic hip replacement. A photograph of her diseased femoral head is displayed in Figure 5-7. What is the likely cause of this abnormality?

(A) benign neoplastic process

(B) coagulopathy

(C) degenerative process

(D) infection

(E) malignant neoplastic process

36. A 51-year-old alcoholic man is admitted to the emergency room with a 6-hour history of severe epigastric pain that radiates to his back and is more intense in a supine position. Physical examination reveals tachycardia, hypotension, and low-grade fever consistent with the early stage of shock. Which of the following serum measurements would be most useful in providing a diagnosis of his condition?

(A) amylase

(B) aspartate aminotransferase
37. A 26-year-old woman complains of the acute onset of anuria, purpura, and mental confusion. Her peripheral blood film displays marked thrombocytopenia and abundant schistocytes. Laboratory studies reveal elevations of bilirubin, creatinine, and lactose dehydrogenase. A skin biopsy shows numerous intravascular thrombi within the dermal microvasculature. What is the most likely diagnosis?

(A) acute idiopathic thrombocytopenia purpura
(B) Bernard–Soulier syndrome
(C) Glanzmann thrombasthenia
(D) May–Hegglin anomaly
(E) thrombotic thrombocytopenic purpura

38. A 58-year-old man has a 5-year history of progressively worsening heart failure. An autopsy limited to the heart reveals extensive replacement of the myocardium by an acellular eosinophilic material. This material is most likely to be which of the following?

(A) amyloid
(B) calcium salt deposition
(C) cholesterol
(D) myocyte fibrinoid necrosis
(E) postinfarctive cicatrix

39. A 29-year-old male AIDS patient presents with discrete and confluent white plaques adherent to the oral and pharyngeal mucosa. Microscopic examination of these plaques would most likely reveal which of the following?

(A) broad nonseptate mold with right angle branching
(B) encapsulated yeast with narrow-based budding
(C) narrow septate mold with acute angle branching
(D) pseudohyphae with yeast-like forms
(E) unencapsulated yeast with broad-based budding

40. A 67-year-old woman notices a lump in her left supraclavicular area. The lesion is excised and a section of it is shown in Figure 5-8. The microscopic appearance is most consistent with which of the following diagnoses?

(A) adenocarcinoma
(B) carcinoid
(C) fibroadenoma
(D) fibrosarcoma
(E) malignant fibrous histiocytoma

41. A 56-year-old woman returns to clinic for a follow-up after undergoing a lung biopsy of a 1.4 × 2.1 cm, left upper lobe lesion originally discovered on chest x-ray. Her physician checks her record for the pathology report and reads that histology of the biopsy demonstrated “scattered spindle cells with a minimal mononuclear inflammatory infiltrate and few blood vessels in a background of abundant pale connective tissue. Small areas of calcification are observed and there is no evidence of normal lung parenchyma.” Which of the following is most likely responsible for these findings?

(A) deposition of amyloid protein
(B) hamartoma formation
(C) healing of an abscess
(D) malignant transformation of type 1 pneumocytes
(E) unresolved infection with *Mycobacterium tuberculosis*
42. A liver biopsy of a 61-year-old man reveals the presence of clusters of cells with large, intracellular vacuoles and nuclei eccentrically displaced to the cell periphery. From which of the following conditions does this patient most likely suffer?

(A) alcoholism  
(B) chronic liver congestion  
(C) hepatitis A  
(D) metastatic colon carcinoma  
(E) portal vein thrombosis

43. A 22-year-old man recovers from a bout of hepatitis A after 3 weeks. One year after this infection, which of the following would a liver biopsy most likely demonstrate?

(A) bridging fibrosis  
(B) lymphocytes spilling out of the portal tracts with piecemeal necrosis  
(C) lymphocytic infiltrates limited to portal triads  
(D) massive hepatic necrosis  
(E) normal histology

44. A 27-year-old woman who recently delivered her first child develops an infiltrative mass in the anterior abdominal wall. A biopsy reveals sweeping fascicles of well-differentiated, plump monomorphic fibroblasts that infiltrate surrounding tissues. Based on this information, what is the most likely diagnosis?

(A) desmoid tumor  
(B) fibrosarcoma  
(C) malignant fibrous histiocytoma  
(D) myositis ossificans  
(E) nodular fasciitis

45. A 72-year-old woman was hospitalized after becoming acutely ill. Despite intervention, she died 9 days later. One of the findings at her autopsy is shown in Figure 5-9 which is a section of her left kidney. Which of the following conditions could have led to the changes seen in this patient’s kidney and was most likely the reason for her hospitalization?

(A) MI  
(B) pyelonephritis  
(C) renal carcinoma  
(D) sepsis  
(E) shock

46. A 31-year-old previously healthy woman develops pelvic inflammatory disease and subsequently undergoes a complete hysterectomy; her ovaries are left intact. Incidental findings in the myometrium are three discrete, sharply circumscribed masses that range from 4 to 8 cm in diameter and have a whitish, whorled cut surface. What would have been the most likely outcome over the next 5 years if these masses had not been removed?

(A) complete regression  
(B) continued expansile growth  
(C) infiltration into surrounding tissues  
(D) metastasis via blood vessels  
(E) necrosis and hemorrhage

47. A 47-year-old man has undergone a gradual personality change over the past 6–7 months with increasing moodiness and irritability.
During your examination you note some choreiform involuntary movements and also recognize some cognitive impairment. Afterward you talk to the man’s brother who accompanied the patient to your office and he tells you that their father had similar problems for about a year prior to his death. If you could examine this patient’s brain, which of the following would you expect to find?

(A) areas of demyelination of the white matter
(B) atrophy and loss of neurons of the caudate nucleus
(C) loss of pigmented neurons of the substantia nigra
(D) neurons ballooned with cytoplasmic vacuoles
(E) selective atrophy of anterior frontal and temporal lobes

48. A 54-year-old construction worker collapses at his work site and is brought to the emergency room in a comatose state. His skin is dry and hot and his rectal temperature is 105°F. Which of the following is the most likely diagnosis?

(A) heat cramps
(B) heat exhaustion
(C) heat stroke
(D) malignant hyperthermia
(E) pyrexia

49. A 38-year-old woman with a history of 3–5 urinary tract infections over the past 2 years presents with another similar episode, including symptoms of dysuria and flank pain. Additional history includes one episode of a renal stone. Renal ultrasound is unremarkable. Urinalysis reveals pyuria, no RBCs, and no casts. Urine culture is positive for *E. coli*. Which of the following is the most likely underlying cause of this patient’s urinary tract infections?

(A) autosomal dominant polycystic kidney disease
(B) focal segmental glomerulosclerosis
(C) medullary sponge kidney (MSK)
(D) minimal change disease
(E) renal cell carcinoma

50. A 45-year-old woman complains of gradually increasing fatigue. On physical examination she is noted to have obesity, hypertension, buffalo hump deformity of her back, moon facies, abdominal striae, and muscle weakness. Radiographic imaging studies identify an abnormality of her right adrenal gland which is then surgically resected. The intact specimen weighed 24 g. A hemisection of the gland is displayed in Figure 5-10. What is the most likely diagnosis?

(A) adrenal cortical adenoma
(B) Krukenberg tumor
(C) multifocal infarction
(D) neuroblastoma
(E) pheochromocytoma

51. A 74-year-old man dies after a 4-day hospital course with a clinical diagnosis of adult respiratory distress syndrome. At autopsy a pathologic diagnosis of diffuse alveolar damage is rendered. Which of the following microscopic findings of the lung tissue is most expected at autopsy?

(A) alveolar hyaline membrane formation
(B) eosinophilic inflammatory infiltrates
(C) hemorrhagic infarction
(D) pleural effusion and fibrous pleuritis
(E) pulmonary vasculature occluded by microthrombi
52. A 35-year-old lifeguard requests a consultation for a lesion on his upper back that his girlfriend first noticed about a year ago. He states that he is more concerned since it has increased in size. Your examination reveals a 15 × 16 mm raised nodule with irregular borders and variable areas of dark and light pigmentation. This most likely represents which of the following?

(A) actinic keratosis
(B) compound nevus
(C) Lentigo simplex
(D) malignant melanoma
(E) seborrheic keratosis

53. A 45-year-old man is bitten by a poisonous snake the venom of which triggers the release of thromboplastin in his circulation. Which of the following would you most expect to see as a consequence of this event?

(A) abnormal neutrophilic degranulation resulting in small vessel vasculitis and subsequent hemorrhage or thrombosis
(B) deposition of antigen-antibody complexes in various tissue beds, causing vasculitis with thrombosis, glomerulonephritis, and arthritis
(C) formation of multiple, migratory peripheral venous thromboses without evidence of tissue ischemia or hemorrhage
(D) immediate mast cell degranulation of vasoactive amines followed by progressive vascular leakage and subsequent tissue ischemia
(E) widespread development of thrombi in the microvasculature followed by hemorrhage

55. A 34-year-old woman has a history of menorrhagia. Within the wall of her uterus are several solid nodules of various sizes. The histological appearance of one of the nodules is depicted in Figure 5-11. These nodules represent which of the following?

(A) adenomyosis
(B) Krukenberg tumors
(C) leiomyomas
(D) metastatic malignancy
(E) Ovarian ectopias

56. A 73-year-old man with a history of an MI 2 years ago has been experiencing gradually increasing shortness of breath over the past 4 weeks. Physical examination reveals bilateral crackles on pulmonary auscultation and 2+ pitting edema of the lower legs bilaterally. Which of the following most likely occurred in this patient to produce these changes?

(A) interventricular septal wall thickening
(B) lobar pneumonia
57. A 28-year-old woman has an ultrasound examination during the second trimester of her third pregnancy. She is found to have greatly decreased amniotic fluid but the fetus appears to be the appropriate size for the gestational age. Her two previous pregnancies produced normal-term infants. The family history is otherwise unremarkable. Which of the following conditions most likely explains these findings?

(A) bilateral cystic renal dysplasia
(B) bronchopulmonary dysplasia
(C) hypoplasia of the lungs
(D) Klinefelter syndrome
(E) placenta previa

58. A 2-month-old girl with a history of persistent physiologic jaundice following birth is now reported by her parents to sleep excessively and display little activity. Physical examination reveals abnormal deep tendon reflexes, hypothermia, and muscular hypotonia. Based on this information, which of the following would be the best therapy for her condition?

(A) antibiotics
(B) growth hormone
(C) thiamine
(D) thyroxine
(E) vitamin D

59. On otoscopic examination, a patient is found to have a 2-cm mass protruding from a retraction pocket in his right tympanic membrane. The lesion is removed and determined to be a cystic mass lined by squamous epithelium containing desquamated cellular debris and a mononuclear infiltrate. Which of the following is the most likely cause of this lesion?

(A) barotrauma
(B) chronic otitis media
(C) exostosis formation in the external auditory canal

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60. A 66-year-old man presents with a 3-month history of intermittent dysphagia that has now become constant and is accompanied by pain and some weight loss. X-rays of the esophagus with barium swallow show structural and filling defects, and reduced peristalsis. A biopsy is taken and is shown in Figure 5-12. The best diagnosis is which of the following?

(A) adenocarcinoma of the esophagus
(B) Barrett esophagus
(C) Candida esophagitis
(D) fibrous stricture of the esophagus
(E) squamous cell carcinoma of the esophagus

61. During a routine physical examination, a 16-year-old boy is found to have only minimal secondary sexual development, gynecomastia, and a tall, eunuchoid habitus. A chromosomal determination on this individual would most likely reveal which of the following?

(A) 45, XO
(B) 45, YO
(C) 46, XX
(D) 46, XY
(E) 47, XXY
(F) 47, XYY
62. A 75-year-old woman, a life-long smoker with Type II diabetes, dies secondary to complications of alcoholic cirrhosis. At autopsy, a hard, infiltrative mass is observed in the head of the pancreas. Microscopic examination of the body and tail of the pancreas demonstrates acinar loss with marked fibrosis, duct dilation, some lymphocytic infiltration, and sparing of islets. Based upon the information given, which of the following would most likely represent the microscopic appearance of the pancreatic mass?

(A) deposition of an acellular, eosinophilic material between parenchymal cells
(B) diffuse interstitial fibrosis with intra- and extracellular golden-brown pigment
(C) moderately differentiated, mucus-secreting cells in a dense, fibrotic stroma
(D) necrosis of pancreatic parenchyma and adjacent fat with a neutrophil infiltrate
(E) plugging of ducts, atrophy of exocrine glands, and fibrosis

63. A 6-year-old child has a long history of a hereditary bleeding disorder characterized by spontaneous nontraumatic hemorrhages into joint spaces, skeletal muscle, and mucous membranes. Laboratory studies reveal a normal prothrombin time, elevated partial thromboplastin time, very low factor VIII, normal factor X, normal factor XI, and normal platelet aggregation studies with ristocetin. Which of the following is the most likely diagnosis?

(A) Christmas disease
(B) hemophilia A
(C) hemophilia B
(D) Rosenthal syndrome
(E) von Willebrand disease

64. A 15-month-old baby girl is brought to the emergency room by her parents for a 1-week history of malaise, poor feeding, mild fever, and diarrhea. Physical examination is unremarkable. This is the sixth such occasion for which the parents have brought their daughter to a physician. Past visits have revealed repeated infections, including *Candida*, cytomegalovirus, and *M. avium-intracellulare*. A complete blood count (CBC) is remarkable only for a low total lymphocyte count. Immunoglobulin levels are normal. A lymph node biopsy is remarkable for paracortical cell depletion, but is otherwise normal. Which of the following is the most likely diagnosis?

(A) Bruton congenital agammaglobulinemia
(B) chronic granulomatous disease of childhood
(C) severe combined immunodeficiency disease
(D) thymic hypoplasia
(E) Wiskott-Aldrich syndrome

65. A 28-year-old man has a long history of intermittent bloody diarrhea. The colon is surgically removed and displayed in Figure 5-13. The most likely diagnosis is which of the following?

(A) amebic colitis
(B) collagenous colitis
(C) gangrenous colitis
(D) pseudomembranous colitis
(E) ulcerative colitis
but he was otherwise asymptomatic. Based upon this information, the most likely causative agent is which of the following?

(A) *Borrelia burgdorferi*
(B) *Francisella tularensis*
(C) *Rickettsia rickettsii*
(D) *Toxoplasma gondii*
(E) *Yersinia pestis*

67. A laboratory test for a newly discovered infectious disease is found to have a sensitivity of 90% and a specificity of 90%. The disease has a prevalence of 1%. The test is run on one of your patients and yields a negative result. What is the probability (to the nearest whole number) of this result being a true negative rather than a false-negative result (what is the predictive value negative)?

(A) 1%
(B) 10%
(C) 50%
(D) 90%
(E) 100%

68. A 34-year-old woman who has been taking oral contraceptives for many years presents with acute abdominal pain and fullness. Paracentesis harvests 200 mL of bloody fluid. Imaging studies show a 6-cm mass in the liver that is subsequently resected. Histological examination of this specimen would most likely reveal this to be which of the following?

(A) angiosarcoma
(B) cholangiosarcoma
(C) focal nodular hyperplasia
(D) hepatocellular carcinoma
(E) liver cell adenoma

69. A 71-year-old man presents to his primary care physician for a check-up accompanied by his wife, who reports that she had to “push him out of the door” to go to see a doctor as his last physical examination was almost 8 years ago. He states that he has been feeling well other than having some lower back pain. Physical examination reveals a firm, nodular prostate. On further questioning, the patient states that he has not noticed any change in urination. Laboratory studies reveal a mildly elevated serum prostate-specific antigen level and a serum alkaline phosphatase level almost three times normal. These findings are most consistent with which of the following?

(A) acute prostatitis
(B) benign prostatic hyperplasia
(C) chronic prostatitis
(D) local invasion of the prostate by bladder carcinoma
(E) metastatic prostate carcinoma

70. A 3-day-old girl develops numerous skin lesions followed soon thereafter by severe encephalitis. Despite extensive treatment, she dies a few days later. An autopsy examination reveals that the infant has a systemic infection involving all major organs. The photomicrograph in Figure 5-14 is taken from a section of adrenal gland. Which of the following is the most likely infectious agent?

(A) cytomegalovirus
(B) herpes
(C) rubella
(D) syphilis
(E) *Toxoplasma*
71. On a routine, employment-related chest x-ray, a 26-year-old woman is found to have a solitary rib lesion appearing as a well-demarcated, radiolucent area with a ground glass appearance and cortical thinning. When questioned, the patient states that she has never experienced any pain and does not recall ever sustaining trauma to the area. Which of the following is the most likely diagnosis?

(A) chondrosarcoma  
(B) Ewing sarcoma  
(C) fibrous dysplasia  
(D) osteogenesis imperfecta  
(E) osteomalacia

72. Molecular studies on a certain carcinoma demonstrate DNA containing multiple sites of adjacent pyrimidine cross-linking to form pyrimidine dimers. This malignancy most likely arose in which of the following sites?

(A) bladder  
(B) colon  
(C) lung  
(D) pancreas  
(E) skin

73. A 66-year-old woman initially develops some subtle changes in memory, judgment, and behavior. However, this is followed by a very severe and rapidly progressive dementia that is accompanied by startle myoclonus. She dies 8 months after the original onset of her symptoms. Her disease is most likely the result of which of the following?

(A) acquired or inherited prion  
(B) hereditary lysosomal storage disease  
(C) increased neurofibrillary tangles (NFTs)  
(D) protozoan infection  
(E) repeated exposure to a chemical toxin

74. A 59-year-old man complains of periorbital edema and ankle swelling which has been gradually increasing over the past few months. Blood pressure is 120/80 mm Hg. Urinalysis shows a 4+ proteinuria but no cells or casts. Serum albumin is moderately decreased but blood urea nitrogen (BUN) and creatinine are normal. Which of the following is the most likely diagnosis?

(A) acute proliferative glomerulonephritis  
(B) diabetic nephropathy  
(C) IgA nephropathy  
(D) lupus nephritis  
(E) membranous glomerulopathy

75. A 16-year-old boy fractured his leg while running track at school. X-ray studies revealed an abnormality at the lesion site indicating that this was a pathological fracture. A biopsy of the area was taken and a photomicrograph of the tissue is shown in Figure 5-15. The most likely diagnosis is which of the following?

![FIG. 5-15 (Also see color insert.)](image)

(A) chondroblastoma  
(B) chondrosarcoma  
(C) osteoid osteoma  
(D) osteoblastoma  
(E) osteochondroma  
(F) osteosarcoma

76. A 78-year-old woman is found to have a first morning urine specific gravity of 1.010. Assuming that she has not had anything to drink since yesterday evening, this is most indicative of which of the following?

(A) acute pyelonephritis  
(B) advanced renal failure
77. A 26-year-old man is found dead in his apartment. A neighbor, who had seen him the previous day, said that he appeared to be perfectly healthy at that time. The coroner performs an autopsy and the only significant finding is hyperinflation of the lungs with areas of atelectasis and thick mucus in the bronchioles. Microscopically, there is thickening of the bronchial epithelial basement membranes, hyperplasia of submucosal mucous glands and bronchial smooth muscle, and infiltration by eosinophils. All of these findings are consistent with which of the following diagnoses?

(A) adult respiratory distress syndrome  
(B) bronchiolitis obliterans—organizing pneumonia  
(C) chronic bronchitis  
(D) emphysema  
(E) status asthmaticus

78. A 74-year-old woman with left heart failure develops pulmonary edema. This accumulation of fluid is best explained by which of the following mechanisms?

(A) decreased hydrostatic pressure  
(B) decreased lymphatic drainage  
(C) decreased oncotic pressure  
(D) increased hydrostatic pressure  
(E) increased lymphatic drainage  
(F) increased oncotic pressure

79. A 19-year-old freshman football player collapses during preseason workouts on a very hot afternoon. He has no significant prior medical history other than a recent upper respiratory infection. He is taken to the emergency room but cannot be revived. An autopsy reveals an enlarged heart that, on microscopic examination, shows myocyte disarray. Which of the following was the most likely cause of death?

(A) alcoholism  
(B) cardiac amyloidosis  
(C) heat stroke  
(D) hypertrophic cardiomyopathy  
(E) viral myocarditis

80. The changes seen in the kidney shown in Figure 5-16 were an incidental finding in the autopsy of a 39-year-old woman. The most likely cause is which of the following?

(A) abuse of analgesics  
(B) hypertension  
(C) postrenal obstruction  
(D) renal cell carcinoma  
(E) renal infarct
81. A 64-year-old man with long-standing hypertension experiences severe abdominal pain and loses consciousness. He dies en route to the hospital. Significant autopsy findings include dilation of the aorta just above the iliac bifurcation and massive abdominal hemorrhage. Which of the following was most likely the initiating event that resulted in his fatal lesion?

(A) antibody-mediated endothelial damage  
(B) autosomal dominant inheritance of an abnormal gene on chromosome 15  
(C) intimal proliferation with fibrous cap formation  
(D) luminal narrowing of the vasa vasorum leading to medial degeneration and fibrosis  
(E) ossification of calcific deposits in the tunica media

82. A 5-year-old boy is brought to a pediatrician by his mother for progressive abdominal girth and poor appetite. His mother is concerned over a “growing lump” she has felt in his abdomen, and physical examination confirms the presence of a large palpable mass in the left upper quadrant. Abdominal ultrasound demonstrates an 18-cm solid mass in the upper pole of the left kidney. A renal biopsy is taken. Which of the following is the pathologist most likely to see on microscopic examination of the biopsy?

(A) a mixture of proliferating smooth muscle cells, mature fat cells, and abnormal blood vessels  
(B) numerous fusiform cysts lined by uniform cuboidal cells and no normal parenchyma  
(C) primitive mesenchymal tissue with minimal tubular and glomerular differentiation  
(D) sheets of large cells with abundant clear cytoplasm and small uniform nuclei  
(E) well-formed papillary frond structures lined by cytologically normal, thickened epithelium

83. Over the past few months, a 5-year-old boy has developed changes suggestive of puberty. Physical examination reveals the presence of secondary sex characteristics including pubic hair and penile enlargement. Laboratory studies reveal increased levels of ACTH. If you were able to examine his adrenals, which of the following would you most likely find?

(A) bilateral atrophy of the cortex  
(B) bilateral atrophy of the medulla  
(C) bilateral cortical hyperplasia  
(D) bilateral medullary hyperplasia  
(E) nodule in the cortex  
(F) nodule in the medulla

84. A 7-year-old girl presents with a neck mass located at the anterolateral aspect of the neck, anterior to the sternocleidomastoid muscle. A biopsy of the lesion revealed a largely cystic mass lined by stratified squamous epithelium surrounded by an underlying dense layer of lymphoid tissue with germinal centers. Based on these findings, what is the most likely diagnosis?

(A) branchial cleft cyst  
(B) granulomatous lymphadenitis  
(C) Hodgkin lymphoma  
(D) metastatic laryngeal carcinoma  
(E) thyroglossal duct cyst

85. A 45-year-old man developed severe abdominal pain and was transported to the emergency room where he was found to be hypotensive and in shock. He was unresponsive to therapy and died 2 days later. Based upon this history and the accompanying image in Figure 5-17, which of the following most likely initiated this sequence of events?
Questions: 81–89

86. Approximately 6 months ago, a 59-year-old man developed a dull, continuous abdominal pain that radiated to the right upper quadrant and was relieved by bending forward. He has also had recurrent thrombophlebitis. He now develops jaundice. Of the following, which is the condition that would most likely explain all of these findings?

(A) acute pancreatitis
(B) esophageal varices
(C) gastric ulcer
(D) liver cirrhosis
(E) splenic infarct

87. A 67-year-old man complains of low back pain and generalized weakness, gradually worsening over the past 6 months. Physical examination reveals an individual in moderate discomfort due to the back pain. Laboratory examination reveals an anemia with rouleaux formation of the erythrocytes on the peripheral smear. Urinalysis demonstrates proteinuria and hypercalciuria. X-rays reveal diffuse osteoporosis of the spine and small lytic lesions in the ribs. Which of the following diagnoses most likely explains these findings?

(A) fibrous dysplasia
(B) iron-deficiency anemia
(C) metastatic prostatic carcinoma
(D) multiple myeloma
(E) osteosarcoma

88. A 67-year-old woman complains of gradually increasing fatigue. On physical examination, she is found to be anemic and has a peripheral neuropathy characterized by loss of position and vibratory sense. Laboratory studies document a macrocytic anemia and decreased WBC and platelets counts. What pathological mechanism accounts for these findings?

(A) a diet deficient in folate
(B) autoantibodies against parietal cells or intrinsic factor
(C) chronic blood loss
(D) diabetes mellitus
(E) myelodysplastic sideroblastic anemia

89. A 27-year-old woman complains of double vision and drooping of her eyelids. She also states that she has recently noticed weakening of her jaws when chewing tough foods. Physical examination reveals mild weakness of her facial and neck muscles but no atrophy is noted. Which of the following diagnoses is most likely?

(A) conjunctivitis
(B) myasthenia gravis
(C) orbital inflammatory pseudotumor
(D) Parkinson’s disease
(E) polymyositis
90. During a routine dental examination of a 55-year-old man, a small, reddish, and raised lesion is noted on the posterior of the median sulcus of his tongue. The patient is referred to a surgeon who performs an excisional biopsy of the lesion. A section of the biopsy is shown in Figure 5-18. Which of the following is the most appropriate diagnosis?

(A) amyloidosis
(B) candidiasis
(C) inverted papilloma
(D) leukoplakia
(E) squamous cell carcinoma

91. A 47-year-old gardener receives an insect sting while pruning some rose bushes. Within a few minutes the area around the sting is swollen and red. The swelling is mostly the result of which of the following?

(A) decreased plasma oncotic pressure
(B) increased hydrostatic pressure
(C) increased vascular permeability
(D) lymphatic obstruction
(E) venous obstruction

92. The prevalence for disease X is 1%. A new laboratory test is positive in 99% of the patients with disease X, but half of the total of positive test results obtained correspond to patients without disease X. Based on this information, the test would be classified as which of the following?

(A) sensitive and nonspecific
(B) sensitive and specific

93. A 47-year-old woman has a 3-month history of fatigue and pruritus. A percutaneous liver biopsy reveals a nonsuppurative, granulomatous distention of medium-sized intrahepatic bile ducts. What is the most common etiology of this disorder?

(A) acquired vascular abnormality
(B) alcohol abuse
(C) autoimmune disease
(D) parasitic infection
(E) viral infection

94. A 5-year-old girl has had numerous childhood fractures. She is also found to have blue sclera, hearing abnormalities, and misshapen teeth. Which of the following is the most likely cause of these findings?

(A) abnormal intestinal receptors for calcium
(B) an inability to metabolize vitamin D
(C) inadequate mineralization of bone matrix
(D) renal inability to conserve phosphorous
(E) synthesis of abnormal type I collagen

95. A 53-year-old woman recently noticed a firm, 2-cm nodule in her right breast during monthly self-examination. The histology of her breast biopsy tissue is displayed in Figure 5-19. Which of the following is an adverse prognostic indicator that may be seen with this disorder?

(A) microcalcifications
(B) high nuclear grade
(C) lymphatic invasion
(D) mitotic activity
(E) cytoplasmic clearing

FIG. 5-18 (Also see color insert.)

FIG. 5-19 (Also see color insert.)
96. A 17-year-old boy presented to his orthopedist complaining of progressive knee pain for 3 months. Physical examination revealed a swollen, warm, and tender right knee. Serum alkaline phosphatase levels were increased. Right knee x-ray revealed a lytic lesion in the metaphyseal area of the knee extending into the proximal diaphysis, and elevation of the periosteum with new bone production. Microscopically, biopsy demonstrated haphazard osteoid formation, pleomorphic cells with hyperchromatic nuclei, and tumor giant cells. Based on this information, what is the most likely diagnosis?

(A) chondrosarcoma
(B) Ewing sarcoma
(C) giant cell tumor
(D) malignant fibrous histiocytoma
(E) osteosarcoma

97. A 71-year-old man was diagnosed with prostate cancer approximately 1 year ago. At that time he weighed 182 lbs (with a height of 75 in). He has progressively lost weight since then and is now found to weigh 148 lbs. Although he reports a moderate loss of appetite, it does not correlate with his total weight loss. Which of the following mediators is most likely contributing to this patient's decrease in weight?

(A) C-reactive protein
(B) vomplement 3a protein
(C) interleukin-2
(D) parathyroid hormone-related protein
(E) tumor necrosis factor

98. A 21-year-old previously healthy man had a headache, malaise, and low-grade fever for the past 4 days. He was brought to the emergency room this morning after he started behaving in an unusual manner and experienced difficulty in speaking. While he was being transported, he suffered a generalized seizure. Physical examination showed a fever of 103°F and total disorientation. Deep tendon reflexes were exaggerated and the plantar response was bilaterally extensor. He had mild neck stiffness and the optic fundi showed early papilledema. A lumbar puncture produced clear CSF under an opening pressure of 300 mm H2O. Protein was 160 mg/dL, glucose 66 mg/dL (blood glucose 90 mg/dL), and there were 32 mononuclear cells/μL. No PMNs were present. Which of the following is the most likely cause of this man's condition?

(A) glioblastoma multiforme
(B) herpetic meningoencephalitis
(C) meningioma
(D) meningococcal meningitis
(E) spontaneous cerebral hemorrhage
(F) subarachnoid hemorrhage

99. A 46-year-old obese woman has had symptoms of vulvovaginitis for the past 9 months that is found to be caused by Candida. Laboratory tests reveal proteinuria and glucosuria, and increased serum glucose, BUN and creatinine. If a renal biopsy were performed, which of the following would be the most likely light and electron microscopic findings, respectively, in the glomeruli?

(A) hypercellularity with thickened basement membranes (GBM); duplication of GBM
(B) hypercellularity with PMNs; subepithelial deposits
(C) normocellularity with thickened GBM; subepithelial deposits
(D) normal morphology; loss of epithelial foot processes
(E) thickened GBM; no deposits
100. An overweight, 46-year-old man has complained of heartburn for the past 2 years. A biopsy of his lower esophagus is displayed in Figure 5-20. Which of the following is the most likely diagnosis?

(A) Barrett esophagitis
(B) Candida esophagitis
(C) granulomatous esophagitis
(D) Plummer–Vinson syndrome
(E) viral esophagitis

101. A 47-year-old man has had a cough that produces yellowish sputum for the past week. He is found to have a total WBC count of 16,300 per μL with a differential count of 75% segmented neutrophils, 11% band neutrophils, 9% lymphocytes, 4% monocytes, and 1% eosinophils. His temperature is 100°F and chest x-ray reveals a lesion in the right lower lobe that has a central cavity and an air-fluid level. Which of the following is the most likely diagnosis?

(A) bronchogenic carcinoma
(B) interstitial pneumonia
(C) lobar pneumonia
(D) pulmonary abscess
(E) pulmonary tuberculosis

102. A 23-year-old woman develops a sore throat, chills, headache, coryza, and a nonproductive cough. A chest x-ray reveals an indistinct, patchy interstitial infiltrate. She has an uneventful recovery within a few days without receiving therapy. Which of the following outcomes is most likely to occur in the region of the affected lung?

(A) healing by first intention
(B) metaplasia
(C) repair by scar formation
(D) resolution
(E) subacute inflammation

103. An 89-year-old man develops a persistent cough with increasing dyspnea. He worked in the shipyards during his 20s, is a lifelong smoker, and has a positive purified protein derivative (PPD) skin test. During the physical examination, a pleural effusion is detected and subsequently drained. Laboratory analysis reveals a specific gravity of 1.013, protein of 1.4 g/dL, and a small number of macrophages. Based upon these laboratory values, which of the following is the most likely diagnosis for this patient?

(A) heart failure, left-sided
(B) heart failure, right-sided
(C) lung infection, bacterial
(D) lung infection, tuberculous
(E) primary malignancy, squamous cell
(F) primary malignancy, mesothelioma

104. An 81-year-old man who contracted syphilis while serving in World War II is now found to have a saccular aneurysm of the thoracic aorta. The pathogenesis of this lesion is best explained by which of the following?

(A) endarteritis obliterans of the vasa vasorum with subsequent mural ischemia
(B) hypersensitivity reaction with multinucleated giant cells and mural fibrinoid necrosis
(C) immune complex formation and complement activation
(D) intimal fibroplasia and lipid deposition
(E) medial cystic necrosis

105. A 12-year-old boy develops a large facial tumor. The histology of the lesion obtained from a fine-needle biopsy is displayed in Figure 5-21. The most likely diagnosis is which of the following?
(A) adenocarcinoma
(B) Burkitt lymphoma
(C) chronic lymphocytic leukemia-lymphoma
(D) parasitic lymphadenitis
(E) salivary gland lymphoepithelioma

106. A 76-year-old man with a long history of coronary artery disease presents to the emergency room with progressive substernal chest pain over the past 4 hours. He is short of breath and reports pain in his left jaw and shoulder area. His vital signs include blood pressure of 146/90 mm Hg, respiration rate of 20 per minute, pulse of 98 per minute, and normal temperature. An initial ECG demonstrates ST elevation changes and a baseline troponin I level of 2.8 ng/mL. He is admitted to the coronary care unit for treatment. Four hours post-admission, the patient reports having no chest pain or dyspnea and is resting comfortably. His vital signs are stable. Which of the following complications are you most concerned about occurring in this patient within the next 24 hours?

(A) cardiac tamponade
(B) cardiogenic shock
(C) holosystolic murmur
(D) systemic thromboembolism
(E) ventricular arrhythmia

107. A 43-year-old man complains of a 25-lbs weight gain over the past 2 years distributed mostly in the trunk and face. He also states that he has developed abdominal stretch marks and facial acne during the same time period. Physical examination reveals BP 160/100 mm Hg and pulse 90 per minute. Significant laboratory tests were fasting glucose 145 mg/dL and 24-hour urinary free cortisol greatly increased at 390 μg/d. The dexamethasone suppression test showed suppression of the urinary free cortisol at high but not low doses. Based upon this information, you would expect to find a hormonally-active tumor in which of the following sites?

(A) adrenal cortex
(B) adrenal medulla
(C) anterior pituitary
(D) posterior pituitary

108. A 38-year-old woman has experienced the gradual onset of a goiter. Serum T4 and T3 are within the reference range and thyroid-stimulating hormone (TSH) is slightly increased. Serum antithyroid peroxidase (antimicrosomal) antibodies are detected but there are no TSH receptor antibodies. Which of the following is the most likely diagnosis?

(A) chronic autoimmune thyroiditis
(B) Graves disease
(C) primary atrophy of the thyroid
(D) riedel struma
(E) subacute thyroiditis

109. A 25-year-old woman discovers a breast lump during self-examination. On physical examination you identify a firm, round, movable, non-tender mass in the upper outer quadrant of the left breast. Your provisional diagnosis would be which of the following?

(A) carcinoma
(B) fibroadenoma
(C) fibrocystic change
(D) glandular hyperplasia
(E) liposarcoma
110. A 46-year-old woman with a 30-year history of juvenile diabetes undergoes a left renal allograft for advanced diabetic nephropathy. The transplant is initially successful; however, 3 months later she develops an unproductive cough with associated arthralgia, malaise, diarrhea, and fever of 101.6°F. Upon hospital admission, she is found to be leukopenic. The patient continues to decompensate and dies 3 days following admission. A section of her right kidney taken at autopsy is shown in Figure 5-22. This figure indicates an infection with which of the following agents?

(A) cytomegalovirus  
(B) Epstein-Barr virus  
(C) Human immunodeficiency virus  
(D) Pneumocystis carinii  
(E) S. epidermidis  
(F) Streptococcus pyogenes

111. A 3-day-old male infant is diagnosed with meconium ileus. You should be concerned that he has which of the following conditions?

(A) alkaptonuria  
(B) cystic fibrosis  
(C) hemophilia A  
(D) phenylketonuria  
(E) Wilson disease

112. A 29-year-old woman presents with weakness, fatigue, easy bruising, and nosebleeds. Analysis of her blood reveals a reciprocal translocation between chromosomes 22 and 9, and low leukocyte alkaline phosphatase levels. These findings confirm a diagnosis of which of the following?

(A) acute lymphoblastic leukemia  
(B) Burkitt lymphoma  
(C) chronic myelogenous leukemia  
(D) follicular lymphoma  
(E) Hodgkin lymphoma

113. A 35-year-old apparently healthy man undergoes a medical examination while applying for life insurance. He is not anemic. His hemoglobin electrophoresis is reported as: HbA, 62%; HbS, 35%; HbE, 1%; HbA2, 1%; no variant C, D, G, or H bands detected. The most likely diagnosis is which of the following?

(A) sickle-cell disease  
(B) sickle thalassemia minor  
(C) sickle trait  
(D) thalassemia major  
(E) thalassemia minor

114. A 37-year-old man visiting a third world country drinks from a fecally contaminated source of water. During the next week he has gradually increasing fever, anorexia, myalgia, and headache. He subsequently develops a maculopapular rash on his abdomen and his fever increases to 104°F with abdominal pain and splenomegaly. During the third week, his condition rapidly deteriorates with intestinal bleeding, shock, and death. An autopsy reveals ulcerations overlying the Peyer patches of the small intestine, one of which is perforated. Which of the following is the most likely diagnosis?

(A) amebiasis  
(B) cholera  
(C) cryptosporidiosis  
(D) giardiasis  
(E) typhoid fever

115. A retroperitoneal mass was discovered during exploratory surgery on a 49-year-old woman. A photomicrograph of a section taken from the mass is shown in Figure 5-23. Which of the following terms would be most appropriate to describe its appearance?
Parents of an 18-month-old boy bring their child to their pediatrician as they are concerned about their son’s recurring skin and lung infections. Biopsy of one of the boy’s current skin lesions reveals the presence of neutrophils, lymphocytes, and scattered epithelioid cell granulomas. Culture of the lesion is positive for Staphylococcus aureus. Which of the following would best account for this patient’s condition?

- (A) absence of T-helper cell activity
- (B) adenosine deaminase enzyme deficiency
- (C) complement C3b opsonization abnormality
- (D) decreased hydrogen peroxide production
- (E) defective macrophage phagocytosis

A 57-year-old man has just returned from an overseas trip and reports having had severe substernal chest pain 3 days ago. Which of the following is the most appropriate laboratory test to order for this patient?

- (A) aspartate aminotransferase
- (B) creatine kinase, MB fraction
- (C) creatine kinase, total
- (D) lactate dehydrogenase, LD1 fraction
- (E) lactate dehydrogenase, total
- (F) troponin I

A 48-year-old man with a long history of chronic viral hepatitis secondary to chronic hepatitis B virus (HBV) infection presented with a 2-month history of weight loss. Physical exam showed a cachectic man in mild distress. Scleral icterus and abdominal distension were present. Workup showed the presence of two mass lesions within the liver on ultrasound, which were confirmed on CT scan. Laboratory values revealed the following: AST 161 U/L; ALT U/L 188; total bilirubin 6.8 mg/dL; direct bilirubin 4.9 mg/dL; alkaline phosphatase 245 U/L; total protein 5.9 g/dL; albumin 2.8 g/dL; HBsAg positive; anti-HBs negative; anti-HCV negative; alpha-fetoprotein 7200 ng/mL. A needle biopsy of one of the mass lesions was performed under CT guidance. Which of the following is the most likely diagnosis?

- (A) fholangiocarcinoma
- (B) focal nodular hyperplasia
- (C) hepatocellular carcinoma
- (D) liver cell adenoma
- (E) metastatic carcinoma

A 14-year-old, severely physically disabled individual is now on a respirator. His first 4 years of life were medically uneventful. Over the last 10 years, he has suffered from increasing symmetric muscle weakness that first affected the pelvic girdle and now involves almost all muscle groups. Several years ago, the calf portion of his legs appeared enlarged and on biopsy demonstrated fatty pseudohypertrophy with random alternating muscle fiber atrophy and hypertrophy. Which of the following is the most likely diagnosis?

- (A) cerebral palsy
- (B) muscular dystrophy
- (C) myositis ossificans
- (D) poliomyelitis
- (E) trichinosis
120. A 64-year-old man presents to his family physician with hematuria and flank pain. A radiology study identifies a renal mass. A photograph of this renal lesion’s histology is displayed in Figure 5-24. The kidney mass is most likely which of the following?

(A) angiomyolipoma  
(B) oncocytoma  
(C) renal cell carcinoma  
(D) transitional cell carcinoma  
(E) xanthogranulomatous pyelonephritis

121. A 79-year-old woman presents with a complaint of chronic and progressive mid-back pain for several months but no other symptoms. Spinal x-rays reveal two compression fractures of the T10 vertebral body. Calcium, phosphate, and alkaline phosphatase levels are all within normal range. Histological examination of the affected vertebral bone would most likely reveal which of the following?

(A) bony necrosis with acute and chronic inflammation and granulomas  
(B) disorganized interconnecting trabeculae of woven bone rimmed by osteoblasts  
(C) thickened, irregular trabeculae with prominent cement lines  
(D) thinning of the cortical and trabecular bone  
(E) widened osteoid seams of peripheral trabeculae

122. A 52-year-old woman has experienced personality change and headaches over the past 3 months and is now developing a right hemiparesis. CT scan shows a mass in the left temporal lobe. Her condition deteriorates rapidly and she dies 7 months later. At autopsy, a large, hemorrhagic, necrotic tumor is identified in the left temporal lobe with extension to the right hemisphere. Microscopically there are highly pleomorphic cells with frequent mitoses. Serpentine areas of necrosis can be seen surrounded by masses of tumor cells. Which of the following is the most likely diagnosis?

(A) ependymoma  
(B) glioblastoma multiforme  
(C) medulloblastoma  
(D) meningioma  
(E) oligodendroglioma

123. A 73-year-old man is brought to his primary care physician by his wife who is concerned about his husband’s progressive memory problems over the past year. She notes that he originally began forgetting to do his normal household chores, and then started routinely misplacing things around the house; he has also forgotten to close or lock doors or turn off the oven and has left the car running in the garage. He is having trouble remembering the driving routes to familiar places and names of longtime friends and acquaintances. The patient’s neurological examination reveals disorientation to place and time, inability to recall three objects, and difficulty following a three-stage command. Based on this information, which of the following best explains the pathogenesis of his condition?

(A) cortical atrophy with neuronal cytoskeletal abnormalities and abnormal filamentous protein aggregation  
(B) gray matter damage to mammillary bodies and hemorrhage associated with nutritional deficiency  
(C) infiltrative mass of pleomorphic cells with areas of pseudopalisading, necrosis, and endothelial cell proliferation
124. A 33-year-old man comes to see you because of several episodes of hemoptysis and dyspnea during the last 2 weeks. Physical examination reveals hypertension and edema. You order some laboratory tests and the results indicate an iron-deficiency anemia, hematuria, and proteinuria with RBC casts. At this point you strongly suspect that he has which of the following diseases?

(A) fibrosing alveolitis
(B) Goodpasture syndrome
(C) Kartagener syndrome
(D) systemic lupus erythematosus
(E) Wegener granulomatosis

125. During a routine pediatric visit, you discover a large abdominal mass in a 2-year-old boy. The mass is surgically removed and is illustrated in Figure 5-25. What is the most likely diagnosis?

(A) abscess
(B) neuroblastoma
(C) renal cell carcinoma
(D) tuberculosis
(E) Wilms’ tumor

![FIG. 5-25 (Also see color insert.)](image)

126. A 28-year-old woman with no significant past medical history presents to her primary care physician complaining of a chronic productive cough with blood-tinged sputum, night sweats, low-grade fever, and a 15-lbs weight loss over the past 6 weeks. Chest x-ray reveals a cavitary lesion in the left upper lobe and a calcified left hilar lymph node. Biopsy of the left upper lobe mass would most likely demonstrate which of the following?

(A) amorphous eosinophilic material surrounded by epithelioid cells and T-lymphocytes
(B) disorganized pleomorphic and hyperchromatic cells with rare mitotic figures
(C) numerous neutrophils and necrotic debris surrounded by a fibrotic capsule
(D) scattered macrophages interspersed with regenerating alveolar cells and sparse collagen deposition
(E) sheets of small, uniform basophilic cells with large nuclei and scant cytoplasm

127. A 22-year-old man is evaluated for repeated episodes of pulmonary infections, including a recent one that is productive of foul, purulent sputum, accompanied by shortness of breath. Past medical history is also significant for chronic sinus infections with mucopurulent discharge. Physical examination is remarkable for scattered rhonchi and rales throughout all lung fields. Imaging studies show abnormally dilated and thickened airways extending close to the pleural surface and a cardiac silhouette in the right thorax. Bronchoscopy demonstrates numerous mucopurulent plugs. Which of the following is most likely responsible for these changes?

(A) abnormal neutrophilic function resulting in impaired degranulation
(B) alpha-1 antiprotease deficiency (PiZZ phenotype)
(C) cell membrane defect resulting in abnormally viscous glandular secretions
(D) defect in ciliary motility due to the absence of dynein arms
(E) hypersensitivity reaction associated with c-ANCA and granuloma formation
1. (D) Atrial fibrillation produces turbulence that is conducive to the formation of thrombi which can then embolize throughout the systemic circulation. In this patient the right flank pain and hematuria and left-sided paralysis suggest that thromboemboli traveled to the right kidney and the brain, respectively. Embolism of air (choice A) has variable effects, although small amounts are typically inconsequential. Larger volumes (~ >100 mL) can obstruct arteries and lead to ischemia and necrosis; an air embolism that lodges in the right heart may lead to sudden death. However, air embolism is rare and is not the most likely event in this patient. Bone marrow embolism (choice B) can occur following a broken bone or cardiac resuscitation, but typically will have no clinical consequences. However, fat embolism (choice C) from a broken long bone or traumatized areas of adipose tissue can, when severe, produce clinical manifestations. These follow the trauma by about 1–3 days and usually include dyspnea, skin rash, and acute neurologic changes. In a few cases this has been fatal. Venous thromboemboli from deep leg veins (choice E) could not get past the lungs (with the unusual exception of paradoxical embolism in a person with a septal defect) so could not reach the kidneys or brain to cause the effects reported for this patient.

2. (C) Environmental exposure to vinyl chloride is associated with the later development of hepatic angiosarcoma. Focal nodular hyperplasia (choice A) and hepatic fibroma (choice D) do not at present have well-defined antecedent environmental exposure histories. Hepatic adenomas (choice B) occur sporadically in the setting of exogenous steroid hormone usage. Hepatocellular carcinoma (choice E) is associated with cirrhosis, chronic viral hepatitis, and aflatoxin exposure.

3. (C) The most likely diagnosis in this case is giant cell (temporal) arteritis; it is both the most common systemic vasculitis in this woman’s age group (>60) and is suggested by the clinical history. Giant cell arteritis may affect any medium- and large-sized arteries, but principally involves vessels in the head, that is, extracranial branches of the carotid arteries. Vascular insufficiency leads to symptoms of jaw or facial pain, headaches, and visual changes, as reported by this patient. In particular, ischemic optic neuropathy may occur abruptly, resulting in permanent blindness; for this reason, patients with ocular disturbances in suspected cases demand immediate medical intervention. Temporal arteritis has a strong, well-known association with polymyalgia rheumatica, a systemic inflammatory disorder causing symmetrical, often severe muscle pain and stiffness in the shoulders and pelvic girdle (also reported by this patient); both conditions are associated with the HLA-D4 haplotype. Microscopically, a section of a vessel affected by giant cell arteritis will demonstrate fragmentation of the internal elastic lamina and the presence of multinucleated giant cells. Concentric “onion skin” thickening and fibrosis (choice A) may be seen most commonly in malignant hypertension but also in other conditions such as primary sclerosing cholangitis. Extensive intra- and extravascular granulomatous inflammation (choice B) refers to Wegener granulomatosis which often includes: (i) acute necrotizing granulomas of the upper and/or lower respiratory tract; (ii) granulomatous vasculitis; and (iii) renal disease. Hyaline arteriolosclerosis and luminal narrowing (choice C) is found in association with benign hypertension and in diabetes mellitus but is also seen in some normotensive, nondiabetic elderly individuals. Segmental fibrinoid necrosis and neutrophil infiltration (choice E) is a description of the acute phase of polyarteritis nodosa.
4. (A) Hirschsprung disease is caused by the congenital absence of parasympathetic ganglion cells in the submucosal and myenteric plexus. This presents clinically soon after birth as an inability to pass stool and abdominal distention. The diagnosis is usually confirmed by a full-thickness colon biopsy showing disorganized, nonmyelinated nerve fibers replacing the missing ganglion cells. In Hirschsprung disease, the ganglion cells, not the nerve fibers (choice B), are missing. Muscular hypertrophy (choice D) and atrophy (choice C) are not specific diagnostic findings with Hirschsprung disease. Mucosal polyp development (choice E) is not associated with Hirschsprung disease.

5. (E) Figure 5-1 depicts a large occlusive embolus in the pulmonary artery. Clinically, this finding is most frequently associated with the formation of deep venous thrombi; sudden death may occur with thromboemboli large enough to lodge in the pulmonary artery bifurcation (saddle embolus). Chronic idiopathic thrombocytopenic purpura (choice A) is an unlikely milieu to form thromboemboli due to the paucity of platelets. Both hemorrhage and thrombosis may occur in disseminated intravascular coagulation (choice B); however, this condition affects the microvasculature, not large vessels. The figure does not display an aneurysm (choice C) or a neoplasm (choice D).

6. (D) Calcitonin is a hormone secreted by the parafollicular C cells of the thyroid gland. Medullary carcinoma arises from malignant transformation of these cells. Alpha-fetoprotein (choice A) may be elevated in the serum in association with hepatocellular carcinomas and gonadal tumors. CA 125 (choice B) is a tumor-associated glycoprotein frequently expressed by ovarian carcinomas. CA 15–3 (choice C) is a tumor-associated glycoprotein frequently expressed by breast carcinomas. Elevations of human chorionic gonadotropin (choice E) in the serum may be seen in normal pregnancies, gonadal tumors, and choriocarcinomas.

7. (B) Juvenile angiofibroma is a very vascular tumor originating in the nasopharynx that is typically found in teenage boys and young adult males. It may lead to obstruction and, because of its vascularity, it is a frequent cause of epistaxis. It should be suspected in any teenage boy with frequent epistaxis. Inverted papilloma (choice A) is a benign tumor but is aggressive locally and can erode into surrounding structures. Rather than having an exophytic growth pattern, it grows down (thus inverted) into other structures and may be difficult to excise completely. It can cause unilateral obstruction and occasionally epistaxis but is generally seen in an older age group (50s). Nasal polyps (choice C) are not tumors but edematous growths commonly found in patients with allergic rhinitis. They produce chronic nasal obstruction and a gradual loss of olfaction. Nasopharyngeal carcinoma (choice D) is associated with Epstein-Barr virus and is another potential cause of obstruction and hemorrhage but again is seen in older patients. Wegener granulomatosis (choice E) is a necrotizing granulomatous vasculitis involving the nose sinuses, lungs, and kidneys. It occurs most frequently in the fifth and sixth decades.

8. (D) An ovarian mass raises the possibility of a tumor and vaginal hemorrhage in a postmenopausal woman and suggests an estrogen-producing tumor. One of the first estrogen-producing tumors to consider is granulosa cell tumor. Arrhenoblastoma (Sertoli-Leydig cell tumor) (choice A) secretes androgens, not estrogens. Brenner tumor (choice B) is an uncommon ovarian neoplasm without hormonal activity. Dysgerminoma (choice C) is the female counterpart of the male seminoma and does not produce hormones. Sertoli-Leydig cell tumor (choice E) is a synonym for arrhenoblastoma (choice A). Teratoma (choice F) is also hormonally inactive.

9. (E) Clinical history and sigmoidoscopy findings are consistent with a diagnosis of ulcerative colitis, an idiopathic inflammatory bowel disease that involves the rectum in virtually all cases and extends proximally in a continuous manner without skip lesions to include variable lengths of the colon. Psychological stress (recent divorce) may serve to precipitate acute attacks of the disease. The significant narrowing seen
in the transverse colon in this patient suggests the possible progression to toxic megacolon, a rare complication in severe acute disease that carries a high mortality rate and requires emergency colectomy. Amoebic colitis (choice A) is characterized by acute inflammation with multiple areas of enzymatic tissue necrosis leading to submucosal, flask-shaped abscesses throughout the colon. Clinical features include bloody and mucoid diarrhea with low-grade fever. Collagenous colitis (choice B) is a more recently recognized form of colitis characterized clinically by episodic or chronic watery diarrhea that is not severe enough to cause dehydration, and pathologically by the presence of a distinct collagenous band beneath the colonic surface epithelium. Patients very often have a variety of autoimmune and other diseases. Cytomegalovirus enterocolitis (choice C) is a common GI infection in acquired immunodeficiency syndrome (AIDS) patients that infects the entire GI tract and produces severe, chronic diarrhea. Both mucosal epithelial and vascular endothelial cells are infected. Vasculitis may result in focal ischemic necrosis of the intestinal wall. Pseudomembranous colitis (choice D) is caused by a necrolytic enzyme produced by Clostridium difficile bacteria that most often proliferate secondary to a variety of antibiotic therapies; clindamycin is a frequent culprit. Diarrhea is most often watery and profuse. Gross findings include patchy areas of mucosal inflammation with multiple, discrete yellowish plaques constituting the pseudomembrane, which is composed of fibrin, mucin, and necrotic debris.

10. (C) This is a neuroblastoma and is one of a group of childhood tumors described as “small, round, blue-cell tumors,” consisting as they do of monotonous small cells with dense, blue nuclei. The characteristic microscopic feature of a neuroblastoma is the pseudorosette, a ring of primitive neuroblasts surrounding a central space filled with fibrillar extensions from the cells. Many of these can be seen in Figure 5-2. These are called pseudorosettes because they do not have a central lumen as is found, for example, in the rosettes in retinoblastoma. Embryonal rhabdomyosarcoma (choice A) is a type of rhabdomyosarcoma typically found in children under the age of 10. It can arise in a number of locations and sarcoma botryoides is one form. It does not form rosettes. Malignant lymphomas (choice B) and leukemias are together the most common malignancies of childhood in the United States, but rosette formation is not a distinctive microscopic feature. Teratomas (choice D) in infants and young children are usually benign tumors found in the midline (e.g., sacrococcygeal, mediastinal). They are composed of tissues with a normal histologic appearance derived from all three germ layers. Wilms’ tumor (choice E) or nephroblastoma is derived from primitive blastema cells and sometimes displays aborted attempts to form glomeruli or renal tubules, but not rosettes.

11. (D) Laboratory findings of a hypochromic anemia with a decrease in MCV and MCHC indices and a decreased reticulocyte count suggest a hypoproliferative anemia. The various microcytic, hypochromic anemias belong to this category and a partial differential diagnosis for these includes iron-deficiency anemia, anemia of chronic disease (ACD) (choice A), thalassemias, and sideroblastic anemias. ACD (choice A) may be distinguished from iron-deficiency anemia by additional iron studies, as were performed in this case. While serum iron and ferritin levels are low and total iron-binding capacity (TIBC) is elevated in iron-deficiency anemia, in ACD ferritin is typically normal or elevated, iron is low, and TIBC is low. ACD is associated with a functional, not an absolute, deficiency in iron as a result of sequestration by reticuloendothelial cells. Aplastic anemia (choice B) causes a pancytopenia, which was not the case in this patient as WBC and platelet levels were normal. Hypothyroidism (choice C) and pernicious anemia (choice E) are megaloblastic anemias, which demonstrate increased, not decreased, MCV values (~ >110 fL).

12. (C) Sjögren syndrome is an autoimmune disease in which there is immune-mediated destruction of lacrimal and salivary gland epithelium leading to diminished secretion by
these organs. This disease may occur as a primary disorder or more commonly secondary to another autoimmune disorder, such as rheumatoid arthritis, as seen in this patient. One of the long-term risks for Sjögren syndrome is a 40-fold increase in malignant lymphoma. The development of esophageal carcinoma (choice A) is associated with alcohol use, smoking, Barrett metaplasia, and Epstein-Barr virus infections. Chronic Sjögren syndrome is not known to cause an increased incidence of leukemia (choice B). Melanoma (choice D) is a malignancy of melanocytes unrelated to Sjögren syndrome. Pleomorphic adenoma (choice E) is a benign salivary gland tumor composed of both neoplastic epithelium and stroma. Its occurrence is not associated with Sjögren syndrome.

13. (E) Rotavirus is the most common cause of severe diarrhea worldwide and is most widespread in very young children. It is passed readily to others and can result in outbreaks such as described here. B. coli (choice A) is a ciliated intestinal protozoal parasite that is found mostly in the tropics. It is a rare cause of diarrhea in the United States. C. parvum (choice B) is a spore-forming protozoan that can cause severe diarrhea in immunocompromised individuals. E. histolytica (choice C) is another protozoan parasite. It infests the colon forming flask-shaped ulcers (i.e., having narrow neck and a wide base that undermines the adjacent mucosa). These organisms can also be carried in the portal circulation to the liver where they form characteristic “anchovy paste” abscesses. G. lamblia (choice D) is an intestinal flagellate that infests the upper small intestine. It is very common worldwide and is the most common intestinal protozoan parasite in the Western world. The majority of infected individuals remain asymptomatic but it can cause diarrhea that is usually mild but can be severe.

14. (C) Histamine is a preformed inflammatory mediator found principally in mast cells and basophils that has a major role in the early vascular changes of inflammation; that is, dilation of precapillary arterioles which produces the local redness (rubor) and warmth (calor), and the increased permeability of postcapillary venules which produces the swelling (tumor). Bradykinin (choice A) has similar effects to histamine, but it is produced by the activation of the kinin system so it is not immediately available as is histamine. Complement 3a (choice B) and complement 5a are called anaphylatoxins because they can stimulate the release of histamine from mast cells. Leukotriene B₄ (choice D) is a major activator and chemotactic agent for leukocytes and potentiates their adhesion to vessel walls. Thromboxane A₂ (choice E) promotes platelet aggregation and vasoconstriction; it functions in opposition to prostaglandin, which inhibits platelet aggregation and causes vasodilation.

15. (C) Figure 5-3 displays viable benign chorionic villi that are diagnostic of an ectopic tubal pregnancy. The clinical history of acute lower abdominal pain and hypotension are expected findings with an ectopic pregnancy. Chorioadenoma destruens (choice A) is also referred to as invasive mole, and would display invasion of chorionic elements into the uterine, not tubal, muscular layers. Choriocarcinoma (choice B) is a malignant neoplasm composed of gestational trophoblastic tissue. Figure 5-11 displays benign chorionic elements. Granular cell tumor (choice D) is a neoplasm of neural-type tissue. The photomicrograph is incompatible with this diagnostic consideration. Leiomyomas (choice E) rarely occur in the fallopian tube. They are most commonly seen in the wall of the uterus. Bundles of benign smooth muscle cells are seen microscopically.

16. (E) True positive blood cultures are defined by positivity in multiple cultures in a series, whereas contaminates generally are not found in repeat cultures. For example, finding S. epidermidis (found in normal skin flora) in only one bottle of six in three blood culture sets (as in this patient) most probably represents skin contamination. If, however, S. epidermidis were isolated from all six bottles drawn from a patient suspected of having infectious endocarditis, this would be interpreted as a true positive. Thus, the results do not support a diagnosis of either bacteremia or septicemia (choices A through D).
17. (E) Wilson disease is an autosomal recessive disorder of copper metabolism due to defective biliary excretion of the copper-protein complex ceruloplasmin. Cells of the liver and brain, notably the basal ganglia, are particularly vulnerable to the toxic effects of excessive copper accumulation. Treatment with copper chelating agents, such as penicillamine or triethylene tetramine, has a dramatically beneficial effect.

Congenital hepatic fibrosis (choice A) is a rare disorder of unknown etiology. It is most prevalent in India. Peliosis hepatitis (choice B) is a rare hepatic circulatory disorder caused by dilation of sinusoids, resulting in small, blood-filled spaces within the liver; the condition is typically asymptomatic. Steroid hormone usage is associated with its development in some instances. Primary sclerosing cholangitis (choice C) is due to chronic inflammation and fibrosis of intra- and extrahepatic bile ductules. The etiology is obscure. Most of those affected also have ulcerative colitis. Reye syndrome (choice D) refers to acute hepatic failure in children following ingestion of aspirin for certain upper respiratory illnesses, particular influenza, or chickenpox.

19. (C) One might see all of these microscopic findings in a malignant neoplasm, but invasion is the strongest indicator. Hyperchromatism (choice A) is a typical finding in malignant cells indicating their increased DNA content. However, it is not a reliable marker for malignancy. Increased nuclear/cytoplasmic ratio (choice B) can also be seen as part of the normal proliferative response. Mitoses (choice D) indicate an increased proliferative rate, but again the proliferation is not necessarily neoplastic. Necrosis (choice E) is often a feature of rapidly dividing tumors but is also found with infarction, infection, and other conditions. Pleomorphism (choice F) is another feature that is common in malignant tumors, but it can be seen in non-neoplastic conditions and there are some malignancies that are fairly monomorphic.

21. (A) About 65% of hypertensive intracerebral hemorrhages occur within the basal ganglia or thalamus. Chronic hypertension predisposes to weakening of arteriole walls with subsequent production of Charcot–Bouchard aneurysms. A rupture of these aneurysms frequently results in fatal intracerebral hemorrhage. The cerebellum (choice B) is the site of hypertensive hemorrhage about 8% of the time. Hypertensive hemorrhages are very rare in the frontal lobe (choice C) and in the occipital lobe.
The pons (choice E) is the site of hypertensive hemorrhage about 15% of the time.

22. (D) Deficiencies of vitamin C and vitamin D can produce similar skeletal abnormalities in young children such as those listed. However, a major difference is that vitamin C deficiency is accompanied by hemorrhages, as seen in this child. This also leads to hemarthrosis (bleeding into joints) that makes movement very painful. Vitamin A deficiency (choice A) is associated with night blindness, with or without keratomalacia and papular dermatitis. Vitamin B₁ deficiency (choice B) produces beriberi marked by polyneuropathy, heart failure, and edema (or Wernicke syndrome in chronic alcoholics). Vitamin B₁₂ deficiency (choice C) produces megaloblastic anemia and subacute combined degeneration of the spinal cord. Vitamin D deficiency (choice E) produces osteomalacia in adults and rickets in children due to defective mineralization of bone. Vitamin K deficiency (choice F) can result in a bleeding diathesis because it is required for the activity of clotting factors II, VII, IX, and X.

23. (B) Acute postinfectious (poststreptococcal) glomerulonephritis occurs more commonly in young children following a sore throat or, less frequently, a skin infection. They usually present with mild periorbital edema, mild to moderate hypertension, and urinary changes. Urinalysis will show hematuria, mild proteinuria, and red and white cells casts. Light microscopy of a renal biopsy will reveal hypercellularity due to proliferation of endothelial and mesangial cells and the infiltration of neutrophils and monocytes. Immune complexes are deposited in the subepithelium of the glomerular basement membrane and may be seen as subepithelial “humps” by electron microscopy. Choices A, C, D, E, and F refer to the microscopic findings in membranoproliferative glomerulonephritis type 1, lupus nephritis, nil disease, focal segmental glomerulosclerosis, and membranous glomerulopathy, respectively.

24. (B) This presentation is fairly typical for a patient with chronic bronchitis. Microscopically one would expect to see hypertrophy of bronchial mucous glands accompanied by chronic inflammation and fibrosis of bronchiolar walls. Expanded or thickened alveolar septae infiltrated by mononuclear cells (choice A) would be seen when there is an interstitial response in the lung as, for example, in viral or mycoplasmal pneumonia. Neutrophilic exudate occupying the alveoli of an entire lobe (choice C) is a description of a classic lobar pneumonia. Pink, proteinaceous layer lining the alveolar spaces (choice D) is a hyaline membrane that one might see in shock lung or respiratory distress syndrome. Thickened basement membranes and many eosinophils (choice E) would be seen in asthma.

25. (C) The child has celiac disease, a disorder resulting from a hypersensitivity reaction to gluten in the diet. Withdrawal of gluten from the diet is usually curative. Clinically, there is diarrhea, malabsorption, and steatorrhea. Histologically, there is villous atrophy of the small intestinal mucosa. A referral to hospice for supportive care (choice D) is unlikely to be necessary; more than 95% of patients respond to the removal of gluten from their diet. Recalcitrant cases are rarely life threatening and may be successfully treated with various forms of hyperalimentation that bypass the small intestine. Because the disease is usually cured by dietary measures, the use of alpha-interferon therapy (choice A), antineoplastic drugs (choice B), and surgical resection of the small intestine (choice E) are not appropriate treatment options.

26. (A) Pemphigus vulgaris is an autoimmune disorder. The autoantibodies are directed against keratinocyte antigens with subsequent dysheision and fluid-filled blister formation. Bacterial infections (choice B), dietary deficiencies (choice C), chemical toxins (choice D), and local ischemia (choice E) are not thought to be the causative agent of pemphigus vulgaris.

27. (C) One of the consequences of shock is hypoperfusion of the kidneys producing ischemia and acute tubular necrosis, which in turn produces acute renal failure. In this patient this was expressed in the greatly reduced urine
production. The pigmented casts are formed from Tamm-Horsfall protein and the sloughed tubule cells. Acute PMN infiltration of tubules and interstitium (choice A) may be observed in acute pyelonephritis. Fibrinoid necrosis of arterioles (choice B) is seen in both malignant hypertension and in some vasculitides such as polyarteritis nodosa. Interstitial mononuclear infiltrate with "thyroidization" (choice D) would be an expected finding for chronic pyelonephritis. Wedge-shaped areas of coagulative necrosis (choice E) describe typical renal infarcts.

28. (B) A 20-hour-old ischemic infarct of the myocardium should demonstrate coagulative necrosis without much of an inflammatory response. Abundant neutrophils and monocytes (choice A) typically are seen about 2–4 days after an infarction. Fibrosis and collagen deposition (choice C) are late healing phenomena that do not begin until at least 1 week after the infarct has occurred. Monocytic infiltration and neovascularization (choice D) usually occur about 3–6 days after an infarction. Plasma cells and caseous necrosis (choice E) are not seen with ischemic myocardial damage. Plasma cells are typically seen in areas of chronic inflammation and caseous necrosis is found in granulomas produced in response to tuberculosis and certain fungal infections.

29. (B) Peptic ulcerations seen in Zollinger–Ellison syndrome are due to ectopic hypersecretion of gastrin. An islet cell tumor of the pancreas is the most frequent ectopic site. Antibodies to intrinsic factor (choice A) are seen with pernicious anemia and usually cause gastric mucosal atrophy and metaplasia. Gastric mucosal hypertrophy, not atrophy (choice C), is the expected result with an increased secretion of gastrin as is seen with Zollinger–Ellison syndrome. Pressure ulceration from bezoars (choice D) and vascular abnormalities (choice E) are not the etiology of the peptic ulcerations seen with Zollinger–Ellison syndrome.

30. (E) Figure 5-6 shows a microscopic section of lung in which there are a number of necrotizing granulomas-containing giant cells. Aspergillosis (choice A) and pneumocystosis (choice C) are not associated with granuloma formation. Leprosy (choice B) does (in tuberculoid leprosy) form granulomas and may be found in the upper airways, but does not involve viscera such as the lung. Sarcoidosis (choice D) is a granulomatous disease of unknown etiology that can involve the lung and many other organs but the granulomas are non-necrotizing.

31. (A) Galactosemia is an autosomal recessive disorder due (in this more common and more severe form of the disease) to a lack of galactose-1-phosphate uridyl transferase. This results in the formation and accumulation of galactose metabolites. If the infant’s diet is not modified to exclude milk products, this will result in damage to the liver (fatty change, cholestasis, cirrhosis, liver failure), eyes (cataract formation), and brain (mental retardation). Hurler syndrome (choice B) is a severe form of mucopolysaccharidosis that typically becomes apparent between 6 months and 2 years of age. Prominent features include coarse facies, dwarfism, organomegaly, cataracts, and mental retardation, not diarrhea, vomiting, and jaundice. Pyloric stenosis (choice C) can occur as a congenital condition, more frequently in baby boys (M:F = 4:1). It is marked by projectile vomiting in the first month of life, but not the other findings in this case. Tay-Sachs disease (choice D) is a lipid storage disease due to a deficiency of hexosaminidase A. There is an inexorable deterioration of mental and motor functions within a few months of birth culminating in a vegetative state and death within 3 or 4 years. Type I glycogen storage disease or von Gierke disease (choice E) is due to a deficiency of glucose-6-phosphatase and usually becomes apparent in the first year of life as hypoglycemia and/or hepatomegaly.

32. (A) Primary aldosteronism caused by an aldosterone-secreting adrenal neoplasm is known as Conn syndrome. Excess aldosterone production leads to increased sodium retention and reciprocal potassium depletion in the renal distal tubule; polyuria results from impairment in urinary concentrating ability. Increased sodium reabsorption and associated
extracellular fluid expansion lead to diastolic hypertension and suppression of the renin-angiotensin pathway. Muscle weakness and fatigue are a consequence of hypokalemia, which may be severe in some cases. Diabetes insipidus (choice B) is marked by the fairly sudden onset of extreme polyuria and (for the central type) is due to decreased activity of antidiuretic hormone typically associated with an intracranial lesion or trauma. In diabetes mellitus (choice C), glucose levels exceed renal reabsorption capacity, leading to glycosuria and a consequent osmotic diuresis, hypovolemia, and pseudohyponatremia. Diabetes mellitus (choice C), glucose levels exceed renal reabsorption capacity, leading to glycosuria and a consequent osmotic diuresis, hypovolemia, and pseudohyponatremia. Pheochromocytomas (choice D) are unilateral, solitary neoplasms most commonly arising from chromaffin cells in the adrenal medulla. Although biologically benign, excessive secretion of catecholamines causes paroxysmal systolic and diastolic hypertension that may reach life-threatening pressures. The adult form of polycystic renal disease (choice E) is an autosomal-dominant condition characterized by grossly enlarged bilateral kidneys containing numerous, and variably-sized expansile cysts. Hematuria, pyelonephritis, hypertension, and polyuria are common symptoms.

33. (D) Given the history of allergies and the finding of bilateral polypoid masses, it is most likely that this patient has nasal polyps, the typical histology of which is as described. Hyperkeratotic squamous epithelium with a submucosal core of myxoid connective tissue, frequent blood vessels, mild fibrosis, and a mononuclear infiltrate (choice A) is the histological description of a vocal cord polyp. Myofibroblastic proliferation in a dense fibrovascular stroma with numerous endothelial-lined channels (choice B) describes the histology of a benign neoplasm (choice A), coagulopathy (choice B), infection (choice D), or malignant neoplastic process (choice E).

34. (B) The proximate or underlying cause of death is the initiating event that led to the person’s death and is what should be listed on the death certificate as the cause of death. In this case, if the woman had not been struck on the head she would not have been hospitalized, not contracted a nosocomial pneumonia (choice D), not had a pulmonary embolism due to the prolonged immobilization (choice E), and not had a cardiopulmonary arrest (choice C). Atherosclerosis (choice A) must have been present for many years prior to the mugging and had no role in her death.

35. (C) The femoral head shows marked degenerative osteoarthritis. The gradual destruction of articular cartilage can eventually lead to joint compromise through eburnation, osteophyte formation, subchondral cysts, and osteochondral loose body formation. Clinically, these anatomic changes are reflected as joint pain and a restricted range of motion. Figure 5-7 does not display evidence of a benign neoplasm (choice A), coagulopathy (choice B), infection (choice D), or malignant neoplastic process (choice E).

36. (A) The hallmark of acute pancreatitis is abdominal pain that is initially localized to the epigastrium and later becomes diffuse. It typically radiates to the back and is frequently more intense in the supine position. Other common symptoms and signs include nausea, vomiting, and tachycardia. If the pancreatitis is severe, hypotension can occur due to extravasation of blood and fluids into peritoneal (third) spaces and shock may ensue. Measurement of both amylase and lipase enzyme levels are useful in the diagnosis of acute pancreatitis. Amylase levels rise early in the course of the disease, while elevation of lipase levels may not occur until 24 hours after onset of illness. Although false positives and false negatives do occur, an elevated amylase level in conjunction with a consistent pattern of acute epigastric/abdominal pain is considered evidence of acute pancreatitis if other acute surgical conditions have been ruled out. Aspartate aminotransferase (choice B) is produced by a number of tissues and is increased in a variety
of diseases; however, its greatest value is in liver function testing. Bilirubin (choice C) may be increased in an alcoholic but has no value in the diagnosis of acute pancreatitis. Calcium soap formation in the areas of fat necrosis may lead to a decrease in serum calcium (choice D) levels, but this is considered to be a nonspecific test. Troponin I (choice E) is now the preferred serum marker for the diagnosis of MI and has no role in the diagnosis of acute pancreatitis.

37. (E) Thrombotic thrombocytopenic purpura is an acute microangiopathic hemolytic anemia. The clinical picture usually includes mental alterations, anuria, mucosal bleeding, and purpura. An abnormal platelet-aggregating substance is the likely initiating event. Acute idiopathic thrombocytopenia (choice A) does not have a hemolytic component, lacks renal failure, and does not display thrombi in the skin biopsy. Bernard–Soulier syndrome (choice B) and Glanzmann thrombasthenia (choice C) are hereditary disorders of platelet aggregation. Clinical symptoms of a coagulopathy usually occur in infancy. May–Hegglin anomaly (choice D) is an inherited condition with thrombocytopenia and morphologically abnormal WBCs. Hemolysis, acute onset, and mental aberrations do not typify this disorder.

38. (A) Amyloid is an acellular material that is eosinophilic. After Congo-red staining, there is apple-green dichroism when examined under polarized light microscopy. Calcium salts (choice B) tend to be deeply basophilic, not eosinophilic, with routine stains. Cholesterol deposits (choice C) tend to dissolve out of tissues with routine processing agents and only empty outlines of where the crystals once were are present remain. Myocyte fibrinoid necrosis (choice D) would be moderately cellular and eosinophilic. Congo-red dichroism is not evident. A postinfarctive cicatrix (choice E) also displays a relatively acellular eosinophilic morphology. Congo-red staining would not be dichroic, however.

39. (D) Candida is the most common fungal infection in AIDS patients and most frequently involves the oral cavity and esophagus; the clinical appearance is typically as described. Microscopically, Candida is composed of pseudohyphae with some yeast-like forms. Choices A, B, C, and E are, respectively, the microscopic appearances of Mucor, Cryptococcus, Aspergillus, and Blastomyces.

40. (A) The finding of an enlarged left supraclavicular lymph node (Virchow or signal node) should raise the question of an underlying GI malignancy. This is confirmed in the above case by the microscopic findings in Figure 5-8. The pleomorphism of these cells and the fact that they are located in a lymph node indicate that these are malignant cells. Additionally, the glandular appearance identifies this as an adenocarcinoma metastatic to a lymph node. Carcinoid tumors (choice B) arise from neuroendocrine cells present in the mucosa throughout the GI tract. About 40% are found in the appendix, where they are benign in 99% of cases. Another 25% are found in the ileum. Of these, about 60% are malignant. If they metastasize to the liver, they can give rise to the carcinoid syndrome. Fibroadenoma (choice C) is the most common benign tumor of the female breast. Fibrosarcoma (choice D) and malignant fibrous histiocytoma (choice E) are both fibroblastic sarcomas; the photomicrograph clearly indicates a malignancy of epithelial (glandular) origin.

41. (C) The first sentence of the pathology report describes the histological morphology of granulation tissue, representing evidence of healing within the biopsied lesion. The absence of normal lung parenchyma indicates that injury to the lung was extensive enough to prohibit regeneration, and this would be expected due to the liquefactive necrosis occurring with abscess formation. Areas of calcification can develop in any necrotic tissue and represent a nonspecific finding. Deposition of amyloid protein (choice A), or amyloidosis, is associated with particular chronic diseases (AA protein) or certain immunoglobulin-secreting neoplasms (AL protein). It appears histologically as extra-cellular, diffusely distributed, acellular material and is best demonstrated using Congo-red stain. The pathology report was not consistent
with the morphology of a hamartoma (choice B), which refers to a disorganized mass of mature tissue indigenous to the organ in which it arises. There was also no cytological description suggestive of malignancy (choice D, malignant transformation of type 1 pneumocytes), such as pleomorphism or hyperchromatism. Granulation tissue could potentially be seen in an unresolved infection with *M. tuberculosis* (choice E); however, evidence of granuloma formation is necessary to establish the diagnosis.

42. (A) The biopsy findings are descriptive of macrovesicular fatty change, a characteristic morphological change in the liver of patients with alcohol abuse. Morphological changes in chronic liver congestion (choice B) would demonstrate areas of centrilobular necrosis and hemorrhage, with hemosiderin-laden macrophages and varying degrees of acute inflammation. Fatty change is unusual in hepatitis A (choice C), and in most forms of hepatitis C, where typical morphological changes would include cellular edema, a cytoplasmic ground glass appearance, lymphocytic infiltrate, and focal or centrilobular necrosis. Histological findings for metastatic colon carcinoma (choice D) would demonstrate pleomorphic cells with hyperchromatic nuclei, and possible mitotic figures. Liver biopsy of an area with portal vein thrombosis (choice E) would reveal sinusoidal distention with areas of hemorrhage and hepatocellular atrophy.

43. (E) Hepatitis A does not progress to a chronic phase so one year after infection the liver histology will appear as normal. The other choices are found in active hepatitis. Bridging fibrosis (choice A) and lymphocytes spilling out of the portal tracts with piecemeal necrosis (choice B) are major features of chronic hepatitis although both can be found in severe acute hepatitis. Lymphocytic infiltrates limited to portal triads (choice C) may be seen in mild acute or chronic hepatitis. Massive hepatic necrosis (choice D) is associated with fulminant hepatitis but can also be caused by various chemical and drug toxicities.

44. (A) Desmoid tumors are mesenchymal tumors that are locally aggressive but do not metastasize and have a benign microscopic appearance characterized by well-differentiated fibroblasts. Those tumors arising in the anterior abdominal wall are usually seen in women who are pregnant or recently postpartum. Fibrosarcomas (choice B) are rare malignant mesenchymal tumors that can metastasize and would typically be expected to have a more pleomorphic microscopic appearance (often with a “herringbone pattern”) than that seen in desmoid tumors. Malignant fibrous histiocytomas (choice C) are also malignant mesenchymal tumors that would have a pleomorphic microscopic appearance. Myositis ossificans (choice D) is a non-neoplastic lesion that often forms following blunt trauma to muscle in a lower limb. The initial hematoma undergoes organization with calcification and can have a pleomorphic appearance with numerous mitoses, leading to the possibility of a misdiagnosis as a malignancy. Of special note, however, is that the bone in myositis ossificans matures from the periphery to the center, whereas the opposite pattern is seen in a malignant tumor. Nodular fasciitis (choice E) presents as a rapidly growing, potentially painful mass that may occur in association with prior trauma. Its histological appearance can be worrisome and, similar to myositis ossificans, may lead to misdiagnosis as a malignancy (sarcoma) as it is somewhat pleomorphic with immature fibroblasts and many mitoses. However, these lesions are self-limited and excision is curative.

45. (A) The photomicrograph in Figure 5-9 shows recognizable glomeruli and tubules but no nuclear staining, enabling one to recognize this as a renal infarct. Most renal infarcts result from thromboemboli originating in the left ventricle of a patient who has had an MI. This woman’s age and her history of an acute illness leading to her death 9 days later are compatible with this sequence of events. The histology of pyelonephritis (choice B) would show viable kidney involved in an inflammatory response. Additional findings would depend upon whether it is an acute or chronic pyelonephritis. Renal carcinoma (choice C) would show
viable malignant cells and not necrotic normal renal tissue. Sepsis (choice D) may show indications of the infection within the renal parenchyma with an associated inflammatory response, but this is not seen in the image. Shock (choice E) is associated with acute tubular necrosis, which is a patchy necrosis affecting the proximal more than the distal tubules, but the glomeruli remain unaffected. The image shows complete necrosis of all renal elements.

46. **(B)** This description of the myometrial masses is consistent with leiomyomas, benign tumors of smooth muscle origin. Uterine leiomyomas are the most frequent tumor in women and are estimated to occur in up to 75% of women of reproductive age. As benign tumors, the expected outcome for such masses in a premenopausal woman would be continued expansile growth. Growth of leiomyomas is stimulated (but not initiated by) estrogen, therefore, regression (choice A) would be more probable in a woman of postmenopausal age or a younger woman who may have had her ovaries removed but is unlikely to be complete. Infiltration into surrounding tissues (choice C) and metastasis via blood vessels (choice D) are characteristics of malignant tumors only. While necrosis and hemorrhage (choice E) may rarely occur in benign neoplasms, they are quite characteristic of malignant neoplasms, as blood vessels are more numerous and are often poorly formed. Uterine leiomyomas and colonic adenomas are two of the exceptions to the general rule that benign neoplasms develop as single lesions.

47. **(B)** In Huntington’s disease there is a symmetric atrophy of the caudate nuclei with a great reduction in the number of neurons. The putamen is also affected but usually less so. Areas of demyelination of white matter (choice A) are the classic finding in multiple sclerosis. Loss of pigmented neurons of the substantia nigra (choice C) is a consistent change seen in Parkinson’s disease. Neurons ballooned with cytoplasmic vacuoles (choice D) may be seen in a number of lysosomal storage diseases of which Tay-Sachs disease is the classic example. Selective atrophy of anterior, frontal, and temporal lobes (choice E) is seen in Pick disease. There is a severe atrophy of the frontal and temporal lobes which can be sufficient to produce the “knife-edge” appearance characteristic of this disease.

48. **(C)** Heat stroke is a life-threatening condition resulting from a failure of heat regulation. It is marked by high body core temperature and the failure of sweating. Heat cramps (choice A) are the result of the loss of fluid and electrolytes through sweating. Painful cramping of muscles can occur, but core temperature remains normal. Heat exhaustion (choice B) results from excessive sweating and failure to replace the lost fluid. This results in hypovolemia, venous pooling, and reduced cardiac output. The skin is wet and the temperature is usually normal. Heat exhaustion is not life threatening, and there is usually spontaneous recovery when the person is moved to a cool place. Malignant hyperthermia (choice D) is an inherited condition in which there is an increased temperature when the person is exposed to certain anesthetics. It has no relationship to environmental temperature. Pyrexia (choice E) is fever and is usually defined as a cytokine-mediated increase in body temperature as part of a response to disease. This results in the hypothalamus having a higher “set point” for the body’s temperature.

49. **(C)** MSK is a relatively common disorder, appearing on approximately 1% of all intravenous pyelograms. It is a congenital, typically bilateral condition and almost all cases are sporadic. The pathological lesion consists of multiple cystic dilations of the medullary collecting ducts. Patients are generally asymptomatic until their third or fourth decade when secondary complications of urinary tract infections (UTIs), calculi, or hematuria may develop. The condition is usually benign and renal function is generally normal; in atypical cases, renal damage may result from secondary pyelonephritis or severe stone disease. Although UTIs and calculi may be complications of autosomal dominant polycystic kidney disease (choice A), this genetic condition is much more severe than MSK and chronic renal
failure is the typical outcome. Patients usually present with many other common features, including hematuria, proteinuria, and hypertension; renal ultrasound is capable of detecting cystic disease in virtually all patients over the age of 30. Focal segmental glomerulosclerosis (choice B) typically presents as nephrotic syndrome or subnephrotic proteinuria, accompanied by hypertension and mild renal insufficiency in some cases. This disease may occur idiopathically or as a secondary manifestation of other conditions (e.g., HIV). There is no association with UTIs and diagnosis is made by biopsy. Minimal change disease (choice D) (also nil disease, lipid nephrosis) is the leading cause of nephrotic syndrome in children. While adults may be affected, peak incidence of disease is 2–8 years. The distinguishing pathology is diffuse effacement of foot processes of glomerular visceral epithelial cells. Diagnosis is made by biopsy and electron microscopy analysis as glomeruli appear essentially normal on light microscopy, which is a disease-defining characteristic. Etiology is unknown although an immune dysfunction has been proposed. Increased incidence of disease in adults with lymphoproliferative malignancies has been reported. Disease is often limited to massive proteinuria and prognosis is excellent; response to corticosteroid therapy is dramatic. Renal cell carcinoma (also clear cell carcinoma) (choice E) is most common in older individuals (>60), and patients often present with symptoms of hematuria and flank pain; constitutional symptoms of cancer (e.g., fever, fatigue, weight loss) may also be reported. Additional findings may develop from any of a number of paraneoplastic syndromes connected with this malignancy; there is no association with recurrent UTIs however. CT scan is used for standard evaluation, although ultrasound is capable of detecting most lesions.

50. (A) The adrenal gland shown in Figure 5-10 contains a cortical adenoma. Grossly, these neoplasms appear as well-demarcated, round to oval, yellowish, solitary nodules arising within the adrenal cortex. The surrounding non-neoplastic cortex is thinned and atrophic. The underlying medulla is normal. The associated clinical findings suggest Cushing syndrome due to excessive secretion of cortisol by the adenoma. Krukenberg tumor (choice B) is an enlarged ovary due to metastatic carcinoma. Adrenal infarcts (choice C) may be associated with certain bacterial infections and shock. The gland appears diffusely hemorrhagic and necrotic, without the formation of a discrete tumor nodule. Neuroblastoma (choice D) is an adrenal tumor of infancy. The typical gross appearance is a large, tan hemorrhagic mass. Hypercortisolemia is not seen. A pheochromocytoma (choice E) appears as a hemorrhagic, red-tan medullary tumor. Clinically, there may be signs of excessive norepinephrine secretion.

51. (A) Hyaline membranes are usually seen microscopically in lungs showing diffuse alveolar damage. Grossly, the lungs are heavy, wet, and meaty. The clinical course is termed adult respiratory distress syndrome and is characterized by relative unresponsiveness to oxygen therapy. Eosinophilic inflammatory infiltrates (choice B), hemorrhagic infarction (choice C), pleural effusions (choice D), and vascular microthrombi (choice E) are not typically seen with diffuse alveolar damage.

52. (D) A skin lesion that is >10 mm, increasing in size, has variable pigmentation, and irregular borders elicits extreme concern and is most probably a malignant melanoma. Actinic keratoses (choice A) are potentially premalignant skin lesions that, as the name suggests, are the result of chronic sun exposure; they are typically <1 cm in diameter. The accumulation of keratin on the surface imparts a rough or scaly texture to the skin. Compound nevi (choice B) (moles) develop when nests of nevi cells (modified melanocytes) extend from the dermoepidermal junction (junction nevus) into the underlying dermis; they are typically brown or flesh-colored, raised, dome-shaped lesions that are symmetrical and uniform. Lentigo simplex (choice C) refers to a benign focal hyperplasia of melanocytes; lesions typically appear as small (<1 cm) brown, sharply defined, oval macules. They have no predisposition to neoplastic change. Seborrheic keratoses (choice E) are benign pigmented skin tumors that are
usually found on older individuals; lesions are flat, round waxy plaques that may seem to be glued on to the skin. Close inspection reveals pore-like structures with keratin plugs which helps to differentiate them from melanomas. These lesions have no malignant potential, but the sudden appearance of multiple lesions could be a paraneoplastic syndrome indicating a visceral malignancy (sign of Leser-Trélat).

53. (E) Thromboplastin-like substances (or tissue factor) released into the circulation can initiate disseminated intravascular coagulation (DIC). In this situation, thromboplastin activates the coagulation cascade, leading to the formation of multiple thrombi distributed throughout the microvasculature. As this process progresses, platelets and coagulation factors are consumed and hemorrhage can occur; bleeding is exacerbated by activation of the fibrinolytic system. Abnormal neutrophilic degranulation resulting in small vessel vasculitis and subsequent hemorrhage or thrombosis (choice A) is an example of a type II hypersensitivity reaction associated with circulating antineutrophil cytoplasmic antibodies (ANCA); examples of ANCA-associated vasculitides include Wegener granulomatosis and Churg-Strauss syndrome. Deposition of antigen-antibody complexes in various tissue beds, causing vasculitis with thrombosis, glomerulonephritis, and arthritis (choice B) describes a nonspecific systemic type III hypersensitivity response (which takes several days to develop). Formation of multiple, migratory peripheral venous thromboses without evidence of tissue ischemia or hemorrhage (choice C) refers to migratory thrombophlebitis, a condition associated with certain types of cancers, particularly adenocarcinomas in which hypercoagulability occurs as a paraneoplastic syndrome; this is referred to as Trousseau syndrome. These and other tumors are also independently capable of initiating DIC. Immediate mast cell degranulation of vasoactive amines followed by progressive vascular leakage and subsequent tissue ischemia (choice D) describes anaphylaxis, a type I hypersensitivity reaction.

55. (C) Figure 5-11 displays interweaving bundles of smooth muscle cells, which, as a discrete myometrial nodule, define a leiomyoma. These are common tumors that may be asymptomatic or produce menorrhagia. Gross appearance is that of a solid white nodule. Adenomyosis (choice A) may clinically and grossly mimic leiomyomas. Adenomyosis, however, has a triphasic microscopic appearance consisting of benign endometrial glands, benign endometrial stroma, and smooth muscle hypertrophy. A Krukenberg tumor (choice B) is replacement of the ovary by metastatic GI adenocarcinoma. The diagnosis of metastatic malignancy (choice D) is not supported by the photomicrograph of a benign process. Ovarian ectopia (choice E) is exceedingly rare and is incompatible with the histology of the photomicrograph.

56. (C) Bilateral crackles on lung auscultation and 2+ pitting edema of the bilateral lower extremities are signs of left-sided and right-sided congestive heart failure, respectively. The only logical choice that could lead to both in this patient is an MI, where left ventricular failure subsequently leads to right ventricular failure. Interventricular septal wall thickening (choice A) is a particular characteristic of idiopathic hypertrophic cardiomyopathy, and frequently causes outflow tract obstruction during systole. It is an autosomal-dominant genetic disease leading to serious progressive cardiac abnormalities typically beginning in young adulthood, and is a common cause of sudden, necrosis and acute inflammation are seen microscopically in the acute phase. Muco- cutaneous lymph node syndrome (Kawasaki disease) (choice A) is a childhood disorder with coronary vasculitis, cervical lymphadenopathy, and acute onset. Takayasu disease (choice C) is characterized by fibrosis of the upper aorta. The classic patient is a Japanese woman with HLA-DR4. Temporal or giant cell arteritis (choice D) is a granulomatous arterial inflammation seen in the elderly. The superficial temporal and intracranial arteries are preferentially involved. Thromboangiitis obliterans (choice E) is an occlusive disease of small arteries strongly related to cigarette smoking.
otherwise unexplainable, death in young athletes. While lobar pneumonia (choice B) is common in older patients, and could lead to shortness of breath, it would not be associated with right heart failure and bilateral lower extremity edema. Similarly, a spontaneous idiopathic pneumothorax (choice D) may also result in shortness of breath, but does not cause right heart failure; this phenomenon is most commonly encountered in young individuals, not an older population. Ventricular aneurysms (choice E) occur as a possible complication of extensive transmural anteroseptal MIs in which a large area of thin scar tissue produces external bulging; they are not associated with rupture.

57. (A) Most of the amniotic fluid is derived from the urine of the fetus. In a fetus with bilateral cystic renal dysplasia, little or no urine is being produced, which leads to the oligohydramnios seen in this case. Bronchopulmonary dysplasia (choice B) may be seen in babies who have respiratory distress syndrome and are given oxygen therapy. Hypoplasia of the lungs (choice C) is a consequence of oligohydramnios because inhalation of amniotic fluid by the fetus is necessary for normal lung development. Klinefelter syndrome (choice D) occurs in males with XXY karyotype and does not explain the findings in this case. Placenta previa (choice E) occurs when there is abnormally low implantation of the fertilized ovum in the uterus such that it overlies the internal os.

58. (D) This infant has cretinism, a condition caused by a neonatal lack of thyroxine. Thyroid agenesis, iodine deficiency, ingestion of goitrogens, and hereditary enzymatic deficiencies may all result in a relative lack of biologically active thyroxine. Affected children may display lethargy, jaundice, hypothermia, muscular hypotonia, and mental retardation. Medicinal replacement of thyroxine is therapeutic. The mental retardation may not be reversible, however, unless treated early. Antibiotics (choice A) have no effect in treating cretinism. Growth hormone (choice B) is an effective treatment for pituitary dwarfism but it has no benefit in cretinism. Treatment with thiamine (choice C) is the appropriate therapy for beriberi, not cretinism. A lack of vitamin D (choice E) causes rickets, not cretinism.

59. (B) A cholesteatoma is a cystic lesion lined by squamous epithelium and containing keratinaceous material. It is most probably formed by the protrusion of squamous epithelium from the middle ear canal through a perforation in the eardrum that was itself the result of chronic otitis media. Barotrauma (choice A) to the ear can be produced by sudden changes in atmospheric pressure compared to the relatively low middle ear pressure. This results in inflammation of the mucous membrane of the middle ear (serous otitis media). Exostosis formation in the external auditory canal (choice C) refers to the growth of a bony swelling that may occur with chronic exposure to cold water. Squamous cell carcinomas of the external auditory canal (choice D) are unusual and have a histological appearance similar to other squamous cell carcinomas (polygonal cells with prickle and pearls), which is quite different from the description given. Tympanosclerosis (choice E) of the tympanic membrane results from resolved acute otitis media producing acellular hyaline and calcific deposits in the tympanic membrane.

60. (E) The cells in Figure 5-12 are pleomorphic and invasive indicating their malignant character. Additionally, there are many intercellular bridges (“prickles”) joining the cells indicating their squamous origin. Therefore, this is a squamous cell carcinoma. The presentation described is fairly typical for squamous cell carcinoma of the esophagus. Its development is closely associated with the risk factors of smoking and alcoholism. Adenocarcinoma of the esophagus (choice A) arises in the lower esophagus in a background of Barrett esophagus and is, of course, composed of malignant glandular cells, not the squamous cells seen here. Barrett esophagus (choice B) demonstrates metaplastic glandular epithelium. Candida esophagitis (choice C) is recognized by the presence of yeast and pseudohyphae. Fibrous stricture (choice D) can be caused, for example, by severe chronic
reflux from ingestion of corrosives and produces fibrosis. Lye ingestion is associated with a 1000-fold increase in risk for squamous cell carcinoma.

61. (E) The physical description of this boy is that of Kleinfelter syndrome. This condition is not usually diagnosed until after puberty when the secondary sexual characteristics do not develop normally. Most of these individuals are 47, XXY but some may have additional X or Y chromosomes. 45, XO (choice A) is characteristic of a female with Turner syndrome which is usually diagnosed early in life. 45, YO (choice B) is not compatible with life and is not seen. 46, XX (choice C) is the chromosome number of a normal female and 46, XY (choice D) is that of a normal male. Males with 47, XYY (choice F) are above average in height and have an increased incidence of developing severe acne. IQ is normal but there may be mild learning disabilities.

62. (C) Little is known about the etiology of pancreatic adenocarcinoma although smoking, chronic pancreatitis, and diabetes mellitus (especially in women) have been associated with an increased risk for the disease. The microscopic description for the body and tail of the pancreas is consistent with chronic pancreatitis, thus, this woman had all three of these risk factors. The microscopic appearance of ductal pancreatic adenocarcinoma most usually (~70%) demonstrates moderately to well-differentiated cells producing mucus and surrounded by a dense fibrotic stroma. Deposition of an acellular, eosinophilic material (choice A) is a description of amyloidosis. Diffuse interstitial fibrosis with intra- and extracellular golden-brown pigment (choice B) describes hemochromatosis. Necrosis of pancreatic parenchyma and adjacent fat with inflammation (choice D) would be seen in acute pancreatitis. Plugging of ducts, atrophy of exocrine glands and fibrosis (choice E) may be seen in cystic fibrosis. In addition, choices A, B, D, and E would not be expected to be associated with a focal mass.

63. (B) Hemophilia A is a genetic disorder characterized by very low levels of factor VIII, elevated partial thromboplastin time, normal prothrombin time, normal platelet aggregation with ristocetin, and spontaneous hemorrhages into joints, soft tissues, and mucosal surfaces. Christmas disease (choice A) is an alternative term for hemophilia B. Hemophilia B (choice C) is a hereditary coagulopathy due to a very low level of factor IX. Rosenthal syndrome (choice D) defines a deficiency of factor XI. von Willebrand disease (choice E) is characterized by a mild hereditary bleeding diathesis and abnormal platelet aggregation with ristocetin.

64. (D) In thymic hypoplasia, the congenital developmental failure of the thymus leads to a lack of T-lymphocytes in the blood as well as in appropriate areas of lymph nodes (paracortical area). Deficient T-cell immunity will thus lead to severe, recurrent viral, mycobacterial, fungal, or protozoal infections during infancy. Thymic hypoplasia is best described in association with DiGeorge syndrome, in which defective embryological development of the third and fourth pharyngeal pouches results in developmental failure of thymus and parathyroid formation, congenital heart defects, and severe hypocalcemia, secondary to hyperparathyroidism. An associated, but less well-defined, entity is Nezelof syndrome, in which there is hypoplasia of the thymus, retention of normal parathyroid function, and possible varying degrees of humoral immunodeficiency. Bruton congenital agammaglobulinemia (choice A) is an X-linked recessive disorder characterized by the failure of B-cell precursors to differentiate into mature B-lymphocytes, which are absent in the peripheral blood, lymph nodes, tonsils, and spleen. Serum immunoglobulin levels are decreased; however, the thymus and T-lymphocyte development are normal and cell-mediated immunity is intact. Chronic granulomatous disease of childhood (choice B) refers to a group of X-linked or autosomal recessive disorders characterized by different enzyme deficiencies of neutrophils and macrophages that lead to inhibition of hydrogen peroxide formation. Although still capable of bacterial phagocytosis, neutrophils and macrophages cannot kill bacteria, particularly the catalase-positive species such as *Staphylococcus*,
Serratia, and Salmonella, which destroy their own endogenous hydrogen peroxide by virtue of catalase production. The disease occurs chiefly in males who present with recurrent bacterial infections of the skin, lymph nodes, lungs, and bones; widespread abscesses and granulomas are present. Severe combined immunodeficiency disease (choice C) is one of the most dramatic forms of congenital immunodeficiency in which a defect of lymphoid stem cells leads to failure of development of both B- and T-lymphocytes. Although probably an embodiment of several different inherited diseases, most patients with severe combined immunodeficiency have the autosomal recessive form, and greater than half of these lack the enzyme adenosine deaminase, resulting in the accumulation of lymphotoxic metabolites. Failure of both cellular and humoral immunity causes a variety of severe viral, bacterial, fungal, and protozoal infections early in life, with death usually occurring within the first year. Wiskott-Aldrich syndrome (choice E) is an X-linked recessive disease characterized by thrombocytopenia, eczema, and immunodeficiency; both cellular and humoral immunity is impaired. Progressive T-cell deficiency occurs despite a morphologically normal thymus, and serum IgM levels are low, although IgG levels are usually normal. Recurrent bacterial, viral, and fungal infections occur, particularly with S. pneumoniae and Haemophilus influenzae as these organisms have polysaccharide antigens that mainly elicit IgM antibody response. Thrombocytopenia may be severe and approximately one-third of patients die from hemorrhage. Patients are prone to developing lymphoma.

65. (E) The colon segment in Figure 5-13 demonstrates ulcerative colitis. The disease is limited to the colon and preferentially involves in continuity the rectum, sigmoid, and descending colon. The affected colon demonstrates a red, granular mucosa with occasional pseudopolyp formation. Deep fissures, skip lesions with alternating areas of diseased and normal colon, and strictures do not typically occur. Amebic colitis (choice A) is usually limited to the right colon and displays multiple, scattered, separate ulcerations. In collagenous colitis (choice B), the colon appears grossly normal. Gangrenous colitis (choice C) has an acute clinical course. Grossly, the colon demonstrates a transmural area of blackened, thinned tissue. Pseudomembranous colitis (choice D) is usually an acute colitis occurring after antibiotic therapy. White, custard-like debris that partially coats the mucosal surface is the characteristic gross observation of pseudomembranous colitis.

66. (A) Lyme disease (caused by the spirochete B. burgdorferi) occurs worldwide but in the United States is found principally in northeastern and some mid-western states. It is transmitted by the Ixodes tick and the site of its bite is usually indicated by an expanding erythematous lesion with central clearing (erythema chronicum migrans (stage 1), which corresponds to the lesion the patient found just prior to his return home. Days or weeks following this stage, the organisms spread hematogenously and may cause secondary skin lesions, fever, chills, fatigue, severe headaches, arthralgias, and cardiac arrhythmias as well as many other findings (stage 2). It was at this point that the patient presented to his physician. Without treatment, many months later patients may enter stage 3 and develop more severe complications, including frank arthritis and encephalopathy. Tularemia is a zoonosis caused by F. tularensis (choice B); transmission occurs from contact with wild animals or biting insects. It is common in the southern mid-western region. Infection typically results in an ulcerative lesion at the inoculation site and regional lymphadenopathy. R. rickettsii (choice C) causes Rocky Mountain spotted fever, the most severe of the rickettsial diseases. Intracellular infection of systemic and pulmonary endothelial cells via tick or insect vector causes a macular rash, appearing first on the wrists and ankles with subsequent spread to the full extremity and the trunk. Typically by 1 week lesions become hemorrhagic and form petechiae. Extensive microcirculatory infection may cause significant multisystemic effects, causing mortality in 3–5% of cases. Infection with the parasite T. gondii (choice D) is most often associated with immunocompromised
patients; transmission typically occurs from ingestion of soil contaminated with cysts shed in cat feces or from undercooked meat. Common manifestations include cervical lymphadenopathy in immunocompetent individuals and CNS involvement in the immunocompromised. *Y. pestis* (choice E) is the bacterium responsible for causing plague, a zoonotic disease carried by rats and wild rodents; it is transmitted to humans by bites from infected fleas. There are three forms of plague—bubonic, septicemic, and pneumonic. Bubonic is the most common, and is associated with a characteristic lymphadenopathy of rapid onset in which enlarging lymph nodes (buboes) become progressively painful and tender, often surrounded by considerable edema.

67. (E) In a population of 100,000, 1000 people will have the disease and 99,000 will be disease free (the prevalence of the disease equals 1%). The sensitivity equals 90%, which indicates that in a population of people with the disease, 90% will have a positive test result (true positives) and 10% will have a negative test result (false negatives). The specificity also equals 90%, which indicates that in a population of people without the disease, 90% will have a negative test result (true negatives) and 10% will have a positive test result (false positives). Thus, looking at the negative test results, there were 100 false negatives (10% of the 1000 people with the disease) and 89,100 true negatives (90% of the 99,000 people without the disease). Therefore the chances of the test result being a true negative = (true negatives)/(true negatives + false negatives) = (89,100)/(89,100 + 100) = 99.9% (= 100% to the nearest whole number). Mathematically, 1% (choice A), 10% (choice B), 50% (choice C), and 90% (choice D) can be eliminated.

68. (E) Liver cell adenomas may occur after several years of taking oral contraceptives but the actual mechanism of tumor formation is unknown. The clinical presentation is often acute abdominal pain due to necrosis of the tumor and hemorrhage. Given the patient’s history, liver cell adenoma is by far the most likely choice. Angiosarcomas of the liver (choice A) are very rare tumors associated with exposure to vinyl chloride (used in the manufacture of the plastic polyvinyl chloride). Cholangiosarcomas (choice B) are rare tumors that arise in the intrahepatic bile ducts. However, they are more common in the Far East, where there is an association with the liver fluke, *Clonorchis sinensis*. Focal nodular hyperplasia (choice C) is a tumor-like lesion that occurs more frequently in women. It has a weak association with oral contraceptive use. On cut section, it typically has a central stellate scar. It is usually asymptomatic and is only resected in the symptomatic patient. Hepatocellular carcinoma (choice D) in the United States usually arises in a background of cirrhosis due either to alcoholism or HBV infection. However, worldwide, hepatitis B is the major etiologic factor and up to 50% of patients with hepatocellular carcinoma may be noncirrhotic.

69. (E) Serum prostate-specific antigen can be elevated in both benign prostatic hyperplasia and prostatic carcinoma (it is worth noting that both can also be within the reference range). However, this patient has a firm, nodular prostate with no urinary changes making carcinoma the more likely of the two. The additional finding of high levels of alkaline phosphatase is compatible with osteoblastic metastases. These findings taken together make metastatic prostate carcinoma the most likely of the choices given. Prostate-specific antigen can be elevated in acute prostatitis (choice A), benign prostatic hyperplasia (choice B), and chronic prostatitis (choice C), but none of these conditions, or local invasion of bladder carcinoma (choice D) would be expected to produce the increase in alkaline phosphatase that is seen in this case.

70. (B) Figure 5-14 shows areas of necrosis and cell nuclei containing Cowdry A inclusions, indicating that this is a disseminated herpes infection acquired during passage through the birth canal. Cytomegalovirus (choice A), rubella (choice C), syphilis (choice D), and *Toxoplasma* (choice E) are the other members of the TORCHS complex, but are typically acquired transplacentally. Cytomegalovirus (choice A) has Cowdry A nuclear inclusions but, in
addition, has multiple cytoplasmic inclusions and greatly increased cell size. The other agents do not generate Cowdry A inclusions.

71. (C) This woman’s findings are consistent with a diagnosis of monostotic fibrous dysplasia (FD), variably considered to be either a benign tumor or a developmental disorder in which an abnormal proliferation of mesenchymal cells replaces normal cancellous bone with immature woven bone and fibrous tissue. In 70% of cases, a single bone is affected (monostotic FD), most frequently involving the ribs, long bones, or jawbones. Patients tend to be asymptomatic and are typically diagnosed between 20–30 years of age by incidental radiograph findings (as described). Multiple bone involvement occurs in 30% of cases (polyostotic FD), often affecting shoulder and pelvic girdles and craniofacial bones. These patients tend to be younger (<10) and have a more severe course, often with pain, recurrent pathological fractures, and permanent skeletal deformity. Chondrosarcoma (choice A) has a peak incidence in the fourth to sixth decades and typically involves the flat bones of the pelvic and shoulder girdles. The histological classification of these tumors is complex. The majority of the tumors (~75%) fall into the “conventional” hyaline/myxoid category; however, some of the minority classifications such as “mesenchymal” and “clear cell” may occur in much younger individuals. Most patients with Ewing sarcoma (choice B) are 10–20 years of age. Although the femur and pelvic flat bones are common sites, similar to fibrous dysplasia, these tumors present as painful enlarging masses, which frequently are warm, swollen, and tender on examination. The x-ray appearance is also quite different, demonstrating an irregular destructive lesion extending into the surrounding soft tissues and a periosteal reaction layered in an “onion-peel” fashion. Osteogenesis imperfecta (choice D) results from a deficiency in the synthesis of type I collagen. The result is a patient with very brittle bones who manifests numerous fractures during childhood. Osteomalacia (choice E) arises from a deficiency of vitamin D (comparable to rickets in children), causing inadequate mineralization and excessive production of bone matrix (osteoid) that results in deformities of weight-bearing bones. There are no focal lesions as seen in this patient.

72. (E) DNA pyrimidine dimer formation is a possible carcinogenic consequence induced by the ultraviolet (UV) component of solar radiation. UV radiation comprises three wavelength ranges that are designated UVA, UVB, and UVC. UVB is the principal fraction responsible for the induction of squamous cell carcinoma, basal cell carcinoma, and possibly malignant melanoma of the skin (UVC is also carcinogenic, but is more effectively absorbed by the ozone layer). Aberrant pyrimidine linkages are normally corrected by DNA repair genes (nucleotide excision pathway); however, some errors remain uncorrected if these mechanisms are overwhelmed by excessive sun exposure, potentially leading to transcription errors and oncogenesis. Bladder, colon, lung, and pancreatic cancers (choices A–D) frequently arise from mutations in various RAS oncogene proteins, resulting in defective guanine triphosphate (GTP) enzyme activity and increased growth factor signal transduction.

73. (A) Creutzfeldt-Jakob disease is caused by a prion that may either be inherited or acquired during life. Prions are composed of protein only and behave like a slow viral infection. Human prion disease has recently become more prominent with the outbreak of mad cow disease in England due to human consumption of beef tainted with prions. Creutzfeldt-Jakob disease is not known to be inherited as a lysosomal storage disease (choice B) or to be caused by protozoan infections (choice D). Increased NFTs (choice C) are seen with Alzheimer’s disease (AD), not Creutzfeldt-Jakob disease. Repeated exposure to chemical toxins (choice E) can cause dementia. Alcohol is a common example. However, the histology of chemical dementia usually differs in character and distribution from the cortical spongiform changes seen in Creutzfeldt-Jakob disease.

74. (E) This patient has nephrotic syndrome as indicated by the edema, 4+ proteinuria, and
hypoproteinemia and the most common cause of this syndrome in adults is membranous nephropathy. Acute proliferative glomerulonephritis (choice A) produces a nephritic syndrome marked by a mild proteinuria, hematuria, azotemia, and hypertension. Diabetic nephropathy (choice B) does produce proteinuria that is sometimes sufficient to cause nephrotic syndrome, but hypertension is often present along with some indication of chronic renal failure neither of which are seen in this case. IgA nephropathy or Berger disease (choice C) is a cause of nephrotic syndrome but with hematuria often associated with an upper respiratory infection unlike the presentation in this case. Patients with lupus nephritis (choice D) may present with either nephrotic or nephritic syndrome, but certainly this is a much less common cause of nephrotic syndrome than membranous glomerulonephritis.

### 75. (F) This section in Figure 5-15 shows many large, hyperchromatic, pleomorphic cells that are producing osteoid, typical of an osteosarcoma. A chondroblastoma (choice A) would display sheets of primitive chondroblasts within a cartilage matrix that is irregularly calcified. Chondrosarcoma (choice B) most typically occur in the age range of 40–60 with the most common locations being the pelvic girdle, ribs, shoulder girdle, and to a lesser extent the long bones, vertebrae, and sternum. Microscopically, the lower grade tumors will show chondroid differentiation whereas a grade 3 tumor may appear as a spindle cell tumor with little chondroid differentiation. Osteoid osteoma (choice C) and osteoblastoma (choice D) have a very similar microscopic appearance consisting of a random pattern of woven bone with many osteoblasts in evidence within a stroma of granulation-like tissue. Osteoid osteomas are small, very painful tumors that are found in teenagers and young adults and respond very well to aspirin. It usually occurs in the long bones of the leg. Osteoblastomas are larger tumors that more usually affect the vertebrae. Osteochondromas (choice E) (or exostoses) are mushroom-like growths that usually bud from the metaphysis of long bones but may occur, less frequently, at many other sites. Microscopically, one sees irregular trabecular bone covered by a cartilaginous cap.

### 76. (B) A urine specific gravity of 1.010 is the same as the specific gravity of glomerular filtrate (i.e., isosthenuric). Thus, this woman was not concentrating her urine overnight (usual SG > 1.020) which is an indication of severe renal damage as seen in advanced renal failure. Patients with acute pyelonephritis (choice A), diabetic glomerulosclerosis (choice C), and hyperlipidemia (choice D) who are not in advanced renal failure would still be expected to show some overnight concentrating ability as, of course, would normal kidney function (choice E).

### 77. (E) Characteristic microscopic findings in asthma are thickened basement membranes, hyperplasia of bronchial smooth muscle, hyperplasia of submucosal mucous glands, and the presence of eosinophils, all of which were seen in this case. The hyperinflation of the lungs and mucous plugging are common gross findings in someone dying in status asthmaticus. The principal microscopic finding in adult respiratory distress syndrome (choice A) is the formation of hyaline membranes rather than the changes described above. Idiopathic bronchiolitis obliterans with organizing pneumonia (BOOP) (choice B) is often a difficult clinical diagnosis to make and may require a lung biopsy which will show connective tissue forming in alveoli and distal bronchioles. Chronic bronchitis (choice C) shows hyperplasia of the bronchial mucous glands and fibrosis of bronchial walls. Emphysema (choice D) is marked by the loss of alveolar walls, leaving large irregular air spaces.

### 78. (D) In left-sided heart failure, poor chamber contractility results in impaired systolic outflow, creating an increase in end diastolic volume and a corresponding increase in ventricular hydrostatic pressure. Impaired ventricular emptying causes stasis in the pulmonary circulation, resulting in a similar increase in volume and pressure in the microvasculature. Capillary congestion leads
to widening of endothelial intercellular junctions, leakage of fluid into the interstitium/alveoli, and the formation of pulmonary edema. Decreased hydrostatic (choice A) and oncotic (choice C) pressures and increased lymphatic drainage (choice E) theoretically would reduce total blood volume, thus acting to retard, not induce, pulmonary edema. Decreased lymphatic drainage (choice B) and increased oncotic pressure (choice F) could potentially lead to pulmonary edema; however, they would be secondary factors in cases of left heart failure, as increased hydrostatic pressure is directly responsible for the accumulation of fluid in the lungs.

79. (D) Hypertrophic cardiomyopathy often presents with dyspnea and chest pain. Arrhythmias are a common problem in these individuals and sudden death, particularly after very strenuous exercise, can occur. There is good evidence that at least half of these cases are familial—probably autosomal dominant. A distinctive microscopic finding is myocyte disarray. Alcoholism (choice A) can produce dilated cardiomyopathy which does not show myocyte disarray. Cardiac amyloidosis (choice B) would not be expected in a young adult with no history of chronic disease and would show interstitial hyaline deposits of amyloid microscopically. Heat stroke (choice C) is marked by a life-threatening increase in core temperature and would not produce the changes described above. Viral myocarditis (choice E) can produce an enlarged flabby heart but does not have myocyte disarray.

80. (C) The kidney in Figure 5-16 demonstrates severe hydronephrosis characterized by dilatation of the renal pelvis at the expense of the subadjacent renal medulla and cortex. Postrenal obstruction, such as a ureteral stone, is the most likely etiology. Abuse of analgesics (choice A) may be associated with necrosis of the renal papillae. The papillae in the photo are not necrotic. Hypertension (choice B) mainly affects the blood vessels of the renal cortex, sparing the pelvic region of the kidney. Renal cell carcinoma (choice D) displays a yellowish cortical-based tumor, not hydronephrosis. An acute renal infarct (choice E) demonstrates a pale, wedge-shaped area with its base along the renal capsule. A chronic infarct shows either fibrous scarring or cyst formation. The renal pelvis is usually unaffected by renal infarcts.

81. (C) This man had a ruptured abdominal aortic aneurysm. Most commonly, this is the result of severe atherosclerotic changes that lead to weakening, dilation, and possible rupture of the affected aorta. (In this case, the hypertension would have accelerated the atherosclerotic changes and increased the likelihood of rupture of the aneurysm.) Initial vascular changes found in atherosclerosis include intimal thickening and fibrous cap formation. Antibody-mediated endothelial damage (choice A) is a common cause of vasculitis but is not involved in atherosclerosis. Of the diseases that result from autosomal dominant inheritance of an abnormal gene on chromosome 15 (choice B), the most common is probably adult polycystic disease but this has no bearing on the development of atherosclerosis. Luminal narrowing of the vasa vasorum leading to medial degeneration and fibrosis (choice D) is seen in the development of a syphilitic aortic aneurysm but has no role in this patient’s disease process. Ossification of calcific deposits in the tunica media (choice E) and other areas of dystrophic calcification may occur as a complication of atherosclerotic plaques, but even if present in this patient, this process would not represent the initiating event.

82. (C) A large tumor appearing in the pole of a kidney in a child of this age is almost certainly a Wilms’ tumor. The microscopic appearance of this neoplasm can be highly variable with some areas resembling renal blastema, as well as epithelial and stromal areas. One usually sees attempts to form glomeruli and tubules. A mixture of proliferating smooth muscle cells, mature fat cells, and abnormal blood vessels (choice A) describes an angiomyolipoma. Numerous fusiform cysts lined by uniform cuboidal cells and no normal parenchyma (choice B) is the microscopic appearance of infantile polycystic disease. Sheets of large
cells with abundant clear cytoplasm and small uniform nuclei (choice D) describe a renal oncocytoma. Well-formed papillary frond structures lined by cytologically normal, thickened epithelium (choice E) is a description that is compatible with a renal papillary adenoma.

83. (C) This child has one of a group of unusual diseases (congenital adrenal hyperplasia) in which there is an inherited deficiency of an enzyme in the biosynthetic pathway for the corticosteroids; most of these cases are due to a partial deficiency of 21-hydroxylase. The decreased feedback inhibition to the pituitary results in increased production of ACTH, resulting in bilateral adrenal cortical hyperplasia. Impairment of corticosteroid synthesis shunts more substrate into the sex steroid pathway, leading to increased production of androgens (resulting in precocious puberty or virilism in a female child). Bilateral atrophy of the cortex (choice A) has a number of causes. Primary causes are unusual and tend to affect both glucocorticoid and mineralocorticoid production; however, secondary causes (e.g., exogenous steroids) are more common and tend to affect only glucocorticoid production. Precocious puberty is not seen. Bilateral atrophy of the medulla (choice B) with a normal cortex would be extremely unusual and would not be expected to produce precocious puberty. Bilateral medullary hyperplasia (choice D) has been reported but is very unusual and would also not produce precocious puberty. A nodule in the cortex (choice E) could be either a hyperplastic nodule or an adenoma. The former is asymptomatic and the latter is most unlikely to produce precocious puberty but, if it did, would probably also demonstrate hypercortisolism, which is not seen in this patient. A nodule in the medulla (choice F) could be a small, early pheochromocytoma but this would not produce precocious puberty.

84. (A) A cystic structure in the lateral neck lined by squamous or, less usually, columnar epithelium and surrounded by lymphoid issue with germinal centers is invariably a branchial cleft cyst. Granulomatous lymphadenitis (choice B) should demonstrate granulomatous inflammation in a lymph node which is not described here. Hodgkin lymphoma (choice C) occurs in five subtypes, none of which is associated with epithelial tissue. Metastatic laryngeal carcinoma (choice D) is usually squamous cell in origin and would demonstrate pleomorphic polygonal cells with “prickles” and “pearls.” A thyroglossal duct cyst (choice E) can have a histological appearance very similar to that of a branchial cleft cyst but the most important difference is the midline location of the thyroglossal duct cyst.

85. (A) In the lower left corner of Figure 5-17 is pancreas while the rest is composed of necrotic fat cells, some viable fat cells, and inflammatory exudate. Thus, the initiating event in this case is acute pancreatitis. The image does not show any of the other organs listed, thereby ruling out choices B through E.

86. (D) Carcinomas in the head of the pancreas often obstruct the ampulla of Vater and the common bile duct, producing jaundice; carcinoma in the body and tail do not obstruct and remain clinically silent much longer. A dull, continuous abdominal pain is also a typical symptom and many patients report that the pain decreases when they lean forward. About 10% of patients with pancreatic carcinoma develop a migratory thrombophlebitis known as Trousseau syndrome. Alcoholic cirrhosis (choice A), cholecystitis (choice B), cholelithiasis (choice C), and viral hepatitis (choice E) may all be associated with abdominal pain and jaundice, but not the other findings in this case.

87. (D) This is a patient with multiple myeloma and one of the earliest symptoms of the disease is back pain. These patients have increased levels of Ig in the blood (which produces an increased erythrocyte sedimentation rate and will be seen as rouleaux formation on the blood smear) and light chains (Bence–Jones protein) in the urine. Multiple myeloma causes multifocal osteolytic lesions throughout the skeletal system and these are apparent on x-rays and are also responsible for the hypercalcemia as the ongoing bone destruction releases calcium.
Fibrous dysplasia (choice A) is a disorder of bone in children with progressive replacement of a localized area of bone by an abnormal proliferation of benign fibrous tissue and bony trabeculae composed of haphazardly arranged woven bone. It occurs as a monostotic and polyostotic form, but neither could account for the findings in this case. Iron-deficiency anemia (choice B) does not produce any of the findings in this case. Metastatic prostatic carcinoma (choice C) can spread quite easily to the lumbar-sacral spine and this causes back pain. However, these bone lesions are osteoblastic rather than osteolytic. Osteosarcoma (choice E) is typically found in teenagers or young adults. When seen in older individuals, it usually occurs in association with Paget disease of the bone.

88. (B) The clinical and laboratory findings suggest a diagnosis of pernicious anemia. Almost all cases are due to autoantibodies against parietal cells or intrinsic factor. These autoantibodies disrupt the normal absorption of vitamin B₁₂. The inability to absorb vitamin B₁₂ leads to a macrocytic pancytopenia and peripheral neuropathy. A diet deficient in folate (choice A) can cause a macrocytic anemia, but there are no concomitant neurological findings. Chronic blood loss (choice C) usually results in microcytic hypochromic anemia due to iron deficiency. Anemia and peripheral neuropathy commonly occur with diabetes mellitus (choice D). However, the anemia is normocytic and the neuropathy is sensory. Myelodysplastic sideroblastic anemia (choice E) may present hematologically with a macrocytic pancytopenia. A peripheral neuropathy is not seen.

89. (B) Myasthenia gravis is an autoimmune disease characterized by autoantibodies to acetylcholine receptors, and weakness of both facial and ocular muscles. Conjunctivitis (choice A) defines an inflammatory or infectious condition of the conjunctiva, and is not consistent with this clinical scenario. Orbital inflammatory pseudotumor (choice C) is a benign mass lesion of the eye region and is not associated with muscle weakness and autoantibodies. Parkinson’s disease (choice D) is a neurologic movement disorder that does not demonstrate either weakness or acetylcholine autoantibodies. Polymyositis (choice E) is a subacute inflammatory disease of skeletal muscle, typically affecting proximal muscle groups, and specifically does not include facial muscles.

90. (E) In Figure 5-18, the pleomorphism of the nuclei and the clearly invasive nature of these cells indicate the malignant nature of this lesion. Furthermore, three keratin “pearls” at the bottom of the image and the sheets of cells, many with discernable intercellular bridges (prickles), allow one to recognize this as a squamous cell carcinoma. Amyloidosis (choice A) can affect many organs including the tongue. However, amyloid would appear as acellular, eosinophilic deposits around vessels and in the parenchyma of tissues which is not seen here. Candidiasis (choice B) is commonly seen on the tongue, but is not invasive in a person with an intact immune system. Its appearance is that of pseudohyphae with yeast forms. Inverted papilloma (choice C) is a benign but locally aggressive tumor found in the nose and paranasal sinuses but not seen in the tongue. Leukoplakia (choice D) of the oral cavity appears as a white patch that cannot be scraped off and cannot be otherwise identified. This is not the gross description given for this patient.

91. (C) Following tissue injury (in this case caused by the insect sting), vasoactive inflammatory mediators originating from both cellular and humoral sources are released at the site of injury. These produce vasodilation of arterioles and increased blood flow producing the redness, and increased vascular permeability of venules allowing the formation of an exudate that produces swelling. All of the other choices can produce edema, but do not feature an increase in vascular permeability (they produce noninflammatory edema). Decreased plasma oncotic pressure (choice A) can result from either excessive loss (e.g., nephrotic syndrome) or decreased synthesis (e.g., cirrhosis, protein malnutrition) of plasma proteins, principally albumin. Increased hydrostatic pressure (choice B) occurs, for example, in heart failure.
where the pressure builds up behind the failing pump. Lymphatic obstruction (choice D) occurs where there is blockage to the normal lymphatic drainage. This could be due to the growth of an obstructing cancer or to inflammation and fibrosis (e.g., postsurgery, filariasis). Venous obstruction (choice E) leads to increased hydrostatic pressure as the blood backs up behind the obstruction.

92. (B) Let us take a population of 100,000 individuals. Since the prevalence of disease X is 1%, 1000 individuals have disease X and 99,000 are disease-free. The test is positive in 99% of individuals with the disease (i.e., of the 1000 with disease, there are 990 true positives and 10 false negatives), thus the test is clearly sensitive. However, half of all positive test results are occurring in disease-free individuals. If 990 individuals with disease had a positive test result (true positives), then there must also be 990 disease-free individuals who had a positive test result. It was stated above that 99,000 are disease-free, so of these 990 have a positive test result (false positives) and the remainder (99,000 – 990 = 98,010) must have a negative test result (true negatives). Specificity may be defined as the percentage of individuals in a disease-free population who have a negative test result. This is mathematically equivalent to (true negatives)/(true negatives + false positives) = (98,010)/(98,010 + 990) = 98,010/99,000 = 99%. Thus the test is both sensitive and specific, and the other answers (choices A, C, D, and E) are incorrect.

93. (C) Primary biliary cirrhosis is an autoimmune disorder. Autoantibodies against mitochondria are usually present. Hyperbilirubinemia, steatorrhea, portal hypertension, and osteomalacia may be seen in the later stages of the disease. Vascular abnormalities (choice A), alcohol abuse (choice B), parasitic infections (choice D), and viral infections (choice E) all may mimic the clinical picture of primary biliary cirrhosis. They are not, however, the usual etiologic agents.

94. (E) Osteogenesis imperfecta type I, is a genetic disorder characterized by synthesis of an abnormal type I collagen. Frequent childhood fractures, blue sclera, poor hearing, and misshapen teeth may all occur clinically because of the abnormal collagen synthesis. Abnormal intestinal receptors for calcium (choice A), inability to metabolize vitamin D (choice B), inadequate mineralization of bone matrix (choice C), and renal inability to conserve phosphorous (choice D) are not the primary pathologic alterations responsible for this disorder.

95. (C) Overexpression of NEU oncogene in invasive breast carcinoma (shown in Figure 5-19) is an adverse prognostic indicator. Breast cancers that are estrogen-receptor positive (choice A), have a low S phase (choice B), are progesterone-receptor positive (choice D), and are well differentiated (choice E), considered to have more favorable prognostic implications. Size of the primary breast carcinoma and the status of the axillary lymph nodes are also major factors that influence the prognosis of invasive ductal breast adenocarcinoma.

96. (E) In a 17-year-old boy, the anatomical location and the x-ray findings are very typical of osteosarcoma. In this case, the tumor has broken through the cortex, elevated the periosteum with reactive periosteal bone formation (the characteristic triangular shadow seen on x-ray is known radiographically as Codman triangle). The microscopic findings of pleomorphic cells with hyperchromatic nuclei, tumor giant cells, and bone formation confirm the diagnosis. Chondrosarcomas (choice A) most typically occur in the age range of 40–60 with the most common locations being the pelvic girdle, ribs, shoulder girdle, and to a lesser extent the long bones, vertebrae, and sternum. Microscopically, the lower grade tumors will show chondroid differentiation, whereas a grade 3 tumor may appear as a spindle cell tumor with little chondroid differentiation. Ewing sarcomas (choice B) occur in children and young adults and usually originate in long bones, ribs, pelvis, and vertebrae. Microscopically one sees small, uniform, oval to round cells with hyperchromatic nuclei and little cytoplasm, which may appear clear due to glycogen abundance. Giant cell tumors (choice C) usually occur in the age range of 20–40 most
commonly originating in distal femur, proximal tibia, distal radius, and proximal humerus, but virtually any bone may be affected. These are usually benign tumors that can, however, be locally aggressive; roughly 4–10% do metastasize and these must be considered as malignant. Not surprisingly, the microscopic appearance is marked by the presence of many giant cells that have an osteoclast-like, syncytial appearance. Malignant fibrous histiocytomas (choice D) are fibroblastic, collagen-producing bone tumors that may also arise from soft tissues; indeed, they are the most common type of soft tissue sarcoma. They occur more frequently in the middle-aged and elderly but have been reported at all ages. Microscopically, lesions reveal spindle cells arranged in a whorled pattern with variable amounts of collagen deposition; also present may be large, plump cells (resembling histiocytes), tumor giant cells, many mitoses, and a chronic inflammatory infiltrate.

97. (E) Progressive weight loss, anorexia, and weakness comprise the wasting syndrome known as cachexia that is often associated with cancer. Although patients report anorexia and abnormalities in taste, the reduction in caloric intake does not sufficiently explain the often profound degree of wasting. While the mechanism is poorly understood, cancer frequently causes an increased metabolic rate that is postulated to occur as a result of cytokine production by both the tumor and the host response to the tumor. A variety of cytokines may function synergistically to cause cachexia; however, experimental animal studies suggest that tumor necrosis factor is the major contributor. C-reactive protein and complement 3a protein (choices A and B) both act as opsonins in acute inflammation, while interleukin-2 (choice D) is an important growth factor for the proliferation of T-lymphocytes. Parathyroid hormone-related protein (choice E) production is responsible for causing the hypercalcemia paraneoplastic syndrome associated with certain malignancies, most notably carcinomas of the lung and kidney.

98. (B) The presence of neck stiffness, the increase in the amount of protein, and the number of cells in the CSF confirm the presence of meningitis. However, the unusual behavior, disorientation, seizure, speech disorder, and abnormal reflexes represent involvement of various parts of the cerebral cortex. Thus this is an acute inflammation of the meninges and brain or a meningoencephalitis. This also accounts for the very high CSF pressure since there is brain edema in addition to the meningitis. The somewhat more prolonged course and the presence of mononuclear cells in the CSF are evidence for viral etiology making herpes the best choice of those listed and eliminating meningococcal meningitis (choice D) which elicits PMNs in the CSF and does not produce encephalitis. Tumors (choices A and C) and hemorrhage (choices E and F) would not give this clinical presentation or CSF results.

99. (E) An obese woman presenting with chronic candidal vulvovaginitis should certainly be suspected of having diabetes, and the laboratory results confirm this diagnosis. A renal biopsy of this patient would be expected to show glomerular basement membrane thickening and focal and diffuse glomerulosclerosis by light microscopy, but electron microscopy would not show any electron-dense deposits since antigen-antibody complexes are not formed in diabetes. Hypercellular glomeruli with thickened and duplicated basement membranes (tram tracks; train tracks) (choice A) is found in membranoproliferative glomerulonephritis type 1. Hypercellular glomeruli with PMNs and subepithelial deposits (humps) (choice B) are an indication for postinfectious (poststreptococcal) glomerulonephritis. Noremocellular glomeruli with thickened basement membranes and subepithelial deposits (spikes) (choice C) are found in membranous glomerulopathy. Normal morphology by light microscopy with loss of epithelial foot processes by electron microscopy is a classic finding of nil disease.

100. (A) Barrett esophagitis is a metaplastic alteration of the lower esophagus in response to chronic acid reflux. Figure 5-20 displays the specialized type of Barrett esophagitis, complete with numerous goblet mucous cells.
Candida esophagitis (choice B) does not contain glandular epithelium. Squamous epithelium, yeast, and pseudohyphae are expected instead. Granulomatous esophagitis (choice C) and viral esophagitis (choice E) are not characterized by metaplastic glandular epithelium. Giant cells or inclusion bodies may be seen, depending on the etiology. Plummer-Vinson syndrome (choice D) describes the formation of a luminal web in the upper third of the esophagus. Microanatomy displays squamous epithelium, not metaplastic glandular epithelium.

101. (D) The productive cough and leukocytosis with a high percentage of neutrophils and bands indicates that this is a bacterial infection and, of the choices given, is most likely an abscess. Bronchogenic carcinoma (choice A) can obstruct an airway and produce infection, but there is no evidence presented to support this. Interstitial pneumonia (choice B) is typically caused by *Mycoplasma* or viruses and produces a mononuclear response rather than a neutrophilic response; the cough is usually nonproductive. Lobar pneumonia (choice C) fills the affected lobe with exudate, but does not typically result in necrosis or abscess formation. Pulmonary tuberculosis (choice E) can produce a cavitary lesion, typically at the apices, but also is marked by a mononuclear response.

102. (D) Resolution, or restoration of tissue to its preinjury state, occurs in tissue injury where minimal cell necrosis has occurred, such as this case of interstitial pneumonia. Removal of debris associated with the accompanying acute inflammatory response is sufficient to restore parenchymal tissue to its normal state. Regeneration of new parenchymal cells will occur to replace necrotic cells provided the involved cells have: (i) regenerative capacity; (ii) exist in remaining sufficient viable number, and (iii) possess an adequate connective tissue-supporting framework. Healing by first intention (choice A), also known as primary union, describes healing of skin wounds in which the edges are in close apposition, such as a surgical incision. Metaplasia (choice B), the replacement of one mature cell type by another mature cell type abnormal to that location, occurs most commonly in epithelial tissues where chronic physical or chemical irritation is present, such as squamous metaplasia of the endocervix or bronchial mucosa, and intestinal metaplasia of the esophagus. Repair by scar formation (choice C) occurs either in injured tissue comprised of permanent cells (e.g., myocardium), when resolution fails to occur in acute inflammation, or if chronic inflammation persists with ongoing necrosis. Subacute inflammation (choice E) describes repeated attacks of acute inflammation in which incomplete resolution of individual attacks leads to increasing chronic inflammation with superimposed acute inflammation.

103. (A) Pleural effusion that has a specific gravity less than 1.012 and a protein concentration of less than 1.5 g/dL is classified as a transudate and is associated with circulatory problems (increased hydrostatic pressure, decreased oncotic pressure, lymphatic obstruction). Exudates usually have a specific gravity >1.020 and protein concentration higher than 3 g/dL and are associated with inflammatory or neoplastic processes. Based upon the laboratory results, the patient has a transudate which rules out infection (choices C and D) and neoplasms (choices E and F). The persistent cough and dyspnea indicate that the fluid is accumulating in his lungs, which occurs in left-sided heart failure. A pure right-side heart failure would be expected to produce a systemic rather than pulmonary edema.

104. (A) Syphilitic saccular aneurysms of the thoracic aorta result from endarteritis obliterans of the vasa vasorum with subsequent mural ischemic necrosis. Hypersensitivity reactions, multinucleate giant cells, and fibrinoid necrosis (choice B) play no significant role in the development of syphilitic aortic aneurysms. Immune complex formation and complement activation (choice C) may be seen with tertiary syphilis, but involve only the small vessels, without aneurysm formation. Intimal fibroplasia and lipid deposition (choice D) are the early lesions of atherosclerosis. Cystic medial
necrosis (choice E) is a noninfectious disorder characterized by abnormally weak connective tissue in the aortic media and deposits of myxoid substances.

105. **(B)** The fine-needle biopsy shown in Figure 5-21 demonstrates a fairly monomorphic population of small, mitotically active neoplastic lymphocytes with associated starry sky histiocytes. The morphology of the tumor and the clinical history are typical for endemic Burkitt lymphoma. The diagnosis of adenocarcinoma (choice A) is incompatible with the photograph because malignant epithelial elements are not seen. Chronic lymphocytic leukemia-lymphoma (choice C) is distinctly uncommon in children and features mature lymphocytes without a starry sky background. There are no parasitic elements (choice D) evident in the photograph. Salivary gland lymphoepithelioma (choice E) is usually seen in an older age group, contains some remaining epithelial elements, and has larger immunoblastic-type lymphocytes.

106. **(E)** The findings in this patient confirm the diagnosis of an acute MI. While all of the given choices are potential post-MI complications, they differ in incidence and temporality. Ventricular arrhythmias are the most common complication, occurring in >75% of cases; they typically arise in the first 3 days following an MI, but are especially frequent in the first 24 hours. Cardiac tamponade (choice A) can develop with rupture of the left ventricular free wall and is frequently fatal; although this is most likely to occur within the first 48 hours, incidence is far lower compared to arrhythmias (~<10%). Cardiogenic shock (choice B) may occur at any time, either as an early post-MI event (24 hours) with large infarctions or secondary to later complications (3–7 days); however, incidence is estimated at roughly 10%, and patients suffering from early cardiogenic shock would have signs of hypotension and pulmonary edema. Post-MI holosystolic murmurs (choice C) may develop secondary to mitral valve regurgitation (infrequently, tricuspid valve regurgitation) stemming from rupture of a papillary muscle, or from potential rupture of the interventricular septum; these are both rare events (1–2%). Systemic thromboembolism (choice D) is a potential consequence of mural thrombus formation, which develops as a result of endocardial injury and stasis caused by poor myocardial contractility; incidence of both events is fairly common (20–40%). Mural thrombi typically form within the first 1–2 weeks post-MI; systemic thromboemboli may occur at any point after formation of a mural thrombus, and do not adhere to any particular time course.

107. **(C)** This patient has the physical stigmata of excess cortisol or Cushing syndrome which is confirmed by the urinary free cortisol levels. Cortisol also has some mineralocorticoid activity producing sodium and water retention and hypertension. Cortisol promotes gluconeogenesis leading to glucose intolerance, hyperinsulinism and, in some patients, frank diabetes. The fact that urinary cortisol levels were suppressed by high but not low doses of dexamethasone strongly suggests a pituitary-based Cushing syndrome due to excess ACTH production or Cushing disease. ACTH-producing cells or corticotropes are found in the anterior pituitary. The dexamethasone suppression test rules out the adrenal (choices A and B) as a site for the tumor and posterior pituitary (choice D) is not the location of the ACTH-producing cells.

108. **(A)** Patients with chronic autoimmune thyroiditis or Hashimoto disease may demonstrate several different serum thyroid autoantibodies, but these vary from patient to patient. Thyroid peroxidase antibodies are found in roughly 85% of patients with Hashimoto disease, about 40% of patients with Graves disease, and in <15% of patients with other thyroid disorders. The absence of TSH receptor antibodies rules out Graves disease (choice B), making Hashimoto disease the most likely diagnosis. Primary atrophy of the thyroid (choice C) and Riedel struma (choice D) are not usually associated with the formation of thyroid autoantibodies. Thyroid autoantibodies are only found transiently in a few patients with subacute thyroiditis (choice E) making this choice unlikely.
109. (B) A single, firm, non-tender, freely movable breast mass in a woman of this age is most likely a fibroadenoma but, of course, this would need to be confirmed. These same factors make carcinoma (choice A) much less likely. Fibrocystic change (choice B) and glandular hyperplasia (choice D) would be expected to be bilateral rather than a single, isolated mass. Liposarcoma of the breast is very rare.

110. (A) Opportunistic infections can occur in post-transplant patients on immunosuppressive therapy. Figure 5-22 shows greatly enlarged renal tubular cells containing both nuclear and multiple cytoplasmic inclusion bodies. These findings in combination are diagnostic of cytomegalovirus infection. Epstein-Barr virus (choice B) has been associated with a number of diseases, including infectious mononucleosis, Burkitt lymphoma, and nasopharyngeal carcinoma. However, even though this is also a herpes virus, it does not give the morphologic appearance described. Human immunodeficiency virus (choice C) does not produce inclusion bodies in infected cells. *P. carinii* (choice D) is an opportunistic fungus that can cause pneumonia in immunocompromised individuals, particularly AIDS patients. It may be visualized with silver staining methods. *S. epidermidis* (choice E) and *S. Pyogenes* (choice F) are bacteria that one would not associate with this histologic appearance.

111. (B) Meconium ileus is a very common early clinical expression of cystic fibrosis. Increased sweat sodium chloride level confirms the diagnosis. About 70% of children with cystic fibrosis have a deletional abnormality of chromosome 7. Pancreatic insufficiency, recurrent pulmonary infections, and biliary obstruction may complicate the disorder. Alkaptonuria (choice A) is an autosomal recessive disease that causes abnormal pigmentation and degeneration of cartilage. Hemophilia A (choice C) is an X-linked hereditary disease caused by a relative lack of coagulation factors VIII or IX. Phenylketonuria (choice D) is due to a hereditary lack of the enzyme phenylalanine hydroxylase. Mental retardation is the major clinical finding. Wilson disease (choice E) is an autosomal recessive disorder of copper accumulation that principally affects the liver and brain.

112. (C) Ninety percent of individuals with chronic myelogenous leukemia have an acquired Philadelphia chromosome abnormality consisting of a translocation between chromosomes 22 and 9. The translocation places the proto-oncogene c-abl from chromosome 9 next to the breakpoint cluster region (bcr) on chromosome 22. The unique gene sequence bcr-abl confers a growth advantage with subsequent clonal expansion. Acute lymphoblastic leukemia (choice A) does not have a known reproducible gross chromosomal derangement. Burkitt lymphoma (choice B) is associated with a translocation of the c-myc oncogene from chromosome 8 to chromosome 14. Follicular lymphoma (choice D) is associated with a translocation between chromosomes 14 and 18. Hodgkin lymphoma (choice E) is characterized by the presence of Reed–Sternberg cells and has a number of subtypes.

113. (C) Individuals with sickle trait are healthy and not anemic. Hemoglobin electrophoresis demonstrates a minor proportion of hemoglobin S and a major proportion of hemoglobin A. Fetal hemoglobin and A2 hemoglobin are usually normal. Sickle trait confers the benefit of protecting erythrocytes from some forms of malarial infection. About 9% of blacks in the United States have sickle trait. In sickle cell disease (choice A), almost all hemoglobin is hemoglobin S. No hemoglobin A is detected and patients have a clinical history of severe anemia. Sickle thalassemia minor (choice B) presents as a chronic microcytic anemia with a major hemoglobin S component and elevated hemoglobin A2. Thalassemia major (choice D) and thalassemia minor (choice E) do not demonstrate hemoglobin S on electrophoresis.

114. (E) This is a case of typhoid fever. During the prodromal stage there is a gradual, step-like increase in fever with malaise, anorexia, myalgia, and headache. By the second week, the fever usually plateaus and the patient is very sick. There may be constipation or diarrhea with
abdominal pain and distention, weakness, and a maculopapular rash (rose spots), particularly on the abdomen. If there are no complications, the patient may gradually improve over the next 2 weeks. One of the classic pathologic findings in typhoid is intestinal ulcerations over hyperplastic and necrotic Peyer patches. These may perforate and hemorrhage, as in this patient. Amebiasis (choice A) can produce a range of symptoms from being subclinical to producing fulminant dysentery. However, it involves the large bowel rather than the small intestine and produces flask-shaped ulcers separated by areas of normal bowel. Cholera (choice B) does not actually invade the intestinal epithelium and therefore causes insignificant microscopic changes and no ulceration. Cryptosporidiosis (choice C) causes a severe, chronic diarrhea in AIDS patients. The protozoa attach to the brush border of the intestinal epithelial cells but do not cause ulceration. Giardia (choice D) attaches to duodenal epithelial cells, but does not invade those cells and does not cause ulceration.

115. (A) The cells in Figure 5-23 show dramatic differences in the size, shape, and staining intensity of nuclei as well as differences in the cells overall, which allows one to say that they are pleomorphic. An additional factor is the lack of differentiation of these cells such that the cell type cannot be recognized, which is the definition of anaplasia. Aplasia (choice B) is a lack of growth of the anlage or primordium of an organ. Dysplasia (choice C) at the cellular level refers to disorderly maturation, usually of an epithelium. Hyperplasia (choice D) is an increase in the number of cells and this process may be either physiological or pathological. Metaplasia (choice E) is the replacement of one mature cell type by another (e.g., columnar epithelium being replaced by squamous epithelium in a smoker’s lung).

116. (D) Decreased hydrogen peroxide production is associated with chronic granulomatous disease of childhood, a group of X-linked or autosomal recessive disorders associated with defects in genes that encode for different components of NADPH oxidase, the enzyme required for hydrogen peroxide production by neutrophils and macrophages. Impaired killing of intracellular organisms by neutrophils and macrophage leads to persistent cell-mediated immunity and granuloma formation as a second line of defense against organisms that are normally eradicated by an acute inflammatory response. As previously mentioned (see answer to question 624), patients are more susceptible to infections with catalase-positive species such as Staphylococcus, Serratia, and Salmonella, which destroy their own endogenous hydrogen peroxide by virtue of catalase production. Absence of T-helper cell activity (choice A), as occurs with human immunodeficiency virus infection, would not allow for the presence of epithelioid cell granulomas, as was shown on this biopsy, as this process is dependent on activated T-cell lymphokine production. Adenosine deaminase enzyme deficiency (choice B) is associated with severe combined immunodeficiency in which failure of both B and T lymphocytes occurs. Complement C3b opsonization abnormality (choice C) and defective macrophage phagocytosis (choice E) would result in abnormalities of immune phagocytosis, and here again would not be consistent with the histological finding of epithelioid cell granulomas, in which macrophages have phagocytosed the infectious bacteria.

117. (F) Troponin I is now the method of choice for the laboratory diagnosis of MI. There is a detectable increase within 4–8 hours of the infarction and the peak level is reached within 14–36 hours. Levels do not return to baseline for 3–10 days making it an appropriate test for this patient who was 3 days post-infarction. Aspartate aminotransferase (choice A) was the first serum enzyme marker used for the diagnosis of MI, but it has poor specificity and sensitivity compared to newer markers and is no longer used for this purpose. Creatine kinase, total (choice C) is not used for the diagnosis of MI since the cardiac fraction (MB) can be overwhelmed by the presence of the skeletal muscle fraction. Creatine kinase-MB (choice B) is still being used in some institutions but it returns to baseline in 2–3 days and would not be useful.
for this patient. Lactate dehydrogenase, either LD1 fraction (choice D) or lactate dehydrogenase, total (choice E) return to baseline later than creatine kinase but have been replaced by troponin I and are seldom used.

118. (C) One of the potential consequences of chronic hepatitis B (and C) infection is the development of hepatocellular carcinoma, and the presence of the mass lesions with high levels of alphafetoprotein makes this extremely likely in this case and will be confirmed by the needle biopsy. Cholangiocarcinoma (choice A) is unusual in the United States but has a much higher incidence in Asia in association with infestation by the liver fluke, *C. sinensis*. Focal nodular hyperplasia (choice B) is a mass lesion of the liver, but is not a true neoplasm. It has a characteristic central scar and microscopically resembles cirrhosis. Liver cell adenoma (choice D) typically occurs in women taking oral contraceptives. Metastatic carcinoma (choice E) is certainly a possibility but given the clinical history of this case plus the high alpha-fetoprotein and the lack of any evidence for a primary malignant tumor elsewhere, hepatocellular carcinoma remains the most probable diagnosis.

119. (B) The clinical scenario describes a classic example of Duchenne muscular dystrophy. The weakness is symmetric and most often begins at the pelvic girdle. Fatty pseudohypertrophy with alternating muscle fiber atrophy and hypertrophy typify the histologic changes. Many patients die before reaching their 20s. The other diagnostic options, cerebral palsy (choice A), myositis ossificans (choice C), poliomyelitis (choice D), and trichinosis (choice E), do not fit the clinical picture.

120. (C) Figure 5-24 shows a clear cell adenocarcinoma, which is the most common histologic appearance for renal cell carcinoma. The patient’s age, gender, and clinical presentation are typical for this malignant neoplasm. Angiomyolipoma (choice A) is a benign renal tumor that displays a mixture of blood vessels, smooth muscle, and mature fat on microscopic examination. Oncocytoma (choice B) is a benign renal neoplasm constructed by monomorphic cells with granular eosinophilic cytoplasm. Transitional cell carcinoma (choice D) usually arises in the renal pelvis and histologically is composed of anaplastic transitional cells without a clear cell adenocarcinoma component. Xanthogranulomatous pyelonephritis (choice E) is a benign inflammatory condition of the kidney that may produce a mass effect. The gross appearance, but not the microscopic appearance, may be confused with renal cell carcinoma.

121. (E) This woman is suffering from senile, or postmenopausal, osteoporosis. In such patients, the calcium and phosphate levels will typically be within the reference range. The alkaline phosphatase will also usually be normal, but may be increased following fractures. Microscopic examination of affected bones will reveal loss of bone mass tending to affect horizontal more than vertical trabeculae. Bony necrosis with acute and chronic inflammation and granulomas (choice A) occurs in tuberculosis infection of the spine, where it is referred to as Pott disease. Disorganized interconnecting trabeculae of woven bone rimmed by osteoblasts (choice B) describes the appearance of an osteoblastoma, a benign bone tumor that is histologically very similar to and often described in conjunction with an osteoid osteoma. A characteristic difference between these two benign bone tumors is that osteoid osteomas are very painful lesions (excess prostaglandin E production) that respond dramatically to aspirin, while osteoblastomas produce a dull, achy pain that does not respond to aspirin. Thickened, irregular trabeculae with prominent cement lines (choice C) describe the morphology seen in Paget disease. Widened osteoid seams of peripheral trabeculae (choice E) reflect the appearance of unmineralized osteoid found in osteomalacia. Alkaline phosphatase levels are typically increased in osteomalacia (and rickets) and Paget disease.

122. (B) Glioblastoma multiforme is the most malignant astrocytoma and is also the most common intracranial primary neoplasm. It is typically a large tumor with areas of necrosis and hemorrhage and extends to the contralateral side of
the brain (butterfly tumor). Microscopically the tumor is very pleomorphic with giant cells, palisading necrosis, and endothelial proliferation. The prognosis is universally poor. Ependymoma (choice A) is somewhat more common in children and originates from the ependymal cells lining the ventricles and central canal of the spinal cord. It is a slow-growing tumor but has the ability to seed via the cerebrospinal fluid. Medulloblastoma (choice C) is principally a highly malignant tumor of childhood that originates in the cerebellum and has the well-known ability to metastasize via the cerebrospinal fluid. Meningioma (choice D) is a benign tumor arising from the arachnoid cap cells. However, it may involve the dura and calvaria making complete removal difficult. The tumor is only considered malignant if it grows into the underlying brain. Oligodendroglioma (choice E) occurs in adults and typically arises from the white matter of the cerebrum. Most of these tumors have areas of calcification which may be seen on x-ray. Many of these tumors are mixed tumors showing areas of astrocytoma.

123. (A) This patient’s symptoms are very consistent with a diagnosis of AD, the most common cause of dementia in patients over 55. Over the course of this disease, patients suffer progressive impairment in higher cognitive functioning, including memory loss, spatial disorientation, language deficits, and mood and behavior changes. In end-stage AD, patients become rigid, mute, and bedridden. Definitive diagnosis of AD requires histological examination of the brain; however, with proficient clinical evaluation postmortem findings agree with clinical diagnosis in approximately 90% of cases. Grossly, brains affected by AD demonstrate cortical atrophy with widening of the sulci; changes are usually most pronounced in the frontal, temporal, and parietal lobes. With advanced disease, parenchymal atrophy results in compensatory dilation of the ventricles (hydrocephalus ex vacuo). The most severe pathology is found in the hippocampus and the nucleus basalis of Meynert of the anterior forebrain, which represent the main source of cholinergic input to the cerebral cortex. The characteristic microscopic lesions in AD are neuritic plaques and NFTs. Plaques consist of focal, spherical deposits of aggregated amyloid beta (Aβ) fibrils surrounded by degenerating neuronal processes (dystrophic neuritis), reactive astrocytes and microglia; Aβ plays a major role in the pathogenesis of AD. NFTs represent twisted bundles of filaments within neuronal cell bodies that extend into dendrites. Their chief constituent is a hyperphosphorylated tau protein, an axonal microtubule-associated protein important for proper assembly and stability of microtubules, which are involved in the transport of essential molecules through the neuron. NFTs are also seen in neurodegenerative diseases other than AD. They are well demonstrated with silver stain and particularly affect pyramidal neurons (e.g., frontal cortex, hippocampus, amygdala) where they often have an elongated, flame-shaped appearance. Choice B refers to injury caused by thiamine deficiency in alcoholism; choice C describes the morphological appearance of a glioblastoma; choice D reflects changes seen in multiple sclerosis, and choice E describes biochemical changes that occur in cerebral ischemia.

124. (B) Goodpasture syndrome consists of antibodies against basement membrane material, recurrent pulmonary hemorrhage, and glomerulonephritis. The pathologic changes are due to a type II hypersensitivity reaction along the basement membranes of the lung and kidney. Steroids, plasmapheresis, and immunosuppressive medicines may help in a minority of cases. Fibrosing alveolitis (choice A) is a pulmonary disorder of unknown etiology. Glomerulonephritis and pulmonary hemorrhage are not observed clinically. Kartagener syndrome (choice C) is a hereditary disease of infancy due to a defect in respiratory ciliary action. Systemic lupus erythematosus (choice D) may present with renal insufficiency. Antibodies are directed against nuclear antigens. Wegener granulomatosis (choice E) may present clinically with pulmonary hemorrhages and renal insufficiency. There are antibodies against neutrophil components, not basement membrane material.
125. (E) Figure 5-25 shows a large tumor mass originating in the kidney. Wilms’ tumor (or nephroblastoma) is the most common primary renal tumor of childhood and the second most common malignancy overall after lymphoma/leukemia. It typically presents as a large abdominal mass discovered by a parent. An abscess (choice A) is a localized collection of pus that is not compatible with the solid mass shown here. A neuroblastoma (choice B) is most commonly primary in the adrenal and is unlikely to arise in the kidney. Renal cell carcinoma (choice C) is the most common primary renal tumor in adults, but is not expected in a child. Tuberculosis (choice D) would be identified by caseous necrosis, which has the appearance of amorphous crumbled cheese, not the solid appearance shown here.

126. (A) This clinical scenario describes secondary tuberculosis (TB). Upon initial exposure to the bacillus, an individual develops primary TB, where *M. tuberculosis* is phagocytosed by alveolar macrophages and transported to the hilar lymph nodes. As naïve macrophages are unable to kill the mycobacterium, bacteria multiply and lyse the host cell, at which time they infect other macrophages. T-cell immunity develops after a few weeks to control the initial infection. An epithelioid-cell granulomatous inflammation occurs at the site of original parenchymal infection, which, upon healing, results in scar formation, at times with late calcification that may leave a residual lesion potentially visible on chest x-ray. This parenchymal scar in association with an enlarged (and possibly calcified) hilar lymph node is known as the Ghon complex. In approximately 90–95% of immunocompetent individuals, complete healing occurs. Because *M. tuberculosis* may persist within macrophages for many years, reactivation may occur, although the mechanisms responsible for keeping the bacilli dormant as well as those leading to reactivation are unknown. Reactivation (or, on less frequent occasions, reinfection) of TB is known as secondary TB. Typical clinical symptoms include weight loss, low-grade fever, and drenching night sweats. Reactivated TB has a predilection for the upper lung zones, presumably due to the greater availability of oxygen in this area, which enhances multiplication of the aerobic bacilli. An enhanced delayed hypersensitivity reaction results in an amplified local inflammatory response with extensive caseous necrosis. Multiple, small granulomas coalesce to form a large solid mass of fibrocaseous granulomatous inflammation known as a tuberculoma. Caseous necrosis undergoes liquefaction, and with extension of disease may erode into a bronchus, which leads to cavitation of the tuberculoma and coughing up of infectious, potentially bloody sputum. Microscopically, granulomatous inflammation is demonstrated by a central area of amorphous, eosinophilic material surrounded by epithelioid cells, frequently with Langhans-type giant cells, and an outer rim of predominantly T-lymphocytes. Disorganized pleomorphic and hyperchromatic cells with rare mitotic figures (choice B) is a generic description for lung carcinoma. Numerous neutrophils and necrotic debris surrounded by a fibrous capsule (choice C) would be suggestive of a chronic abscess, while scattered macrophages interspersed with regenerating alveolar cells and sparse collagen deposition (choice D) would occur following a necrotizing lung infection (e.g., *S. aureus*). Sheets of small, uniform basophilic cells with large nuclei and scant cytoplasm (choice E) is the morphological description of undifferentiated small cell (oat cell) lung carcinoma.

127. (D) Kartagener syndrome is defined by the triad of bronchiectasis, sinusitis, and situs inversus that, in this patient, were apparent from the foul sputum, history of sinusitis, and location of the heart in the right chest. The cause of this syndrome is the lack of ciliary motility leading to poor clearing of the respiratory tract and susceptibility to infections. During embryogenesis, cilia assist with cell migration and the situs inversus is most probably the result of their lack of function. Abnormal neutrophilic function resulting in impaired degranulation (choice A) has been observed in different conditions including in HIV-infected patients but this cannot explain the situs inversus. Alpha-1 antiprotease deficiency (PiZZ phenotype)
(choice B) is a cause of emphysema and liver cirrhosis, but is not associated with the findings in this patient. Cell membrane defect resulting in abnormally viscous glandular secretions (choice C) is a description of cystic fibrosis that is associated, among other things, with recurrent lung infections but not situs inversus.

Hypersensitivity disease associated with c-ANCA and granuloma formation (choice E) is a description of Wegener granulomatosis which is associated with lung infections and sinusitis, but once again has no association with situs inversus.


Questions

1. Which of the following drugs acts primarily on an intracellular receptor?
   (A) abciximab
   (B) dexamethasone
   (C) insulin
   (D) propranolol
   (E) salmeterol

2. Which of the following receptor types is associated with the most rapid response time?
   (A) G-protein-coupled receptors (e.g., muscarinic receptors)
   (B) ion channel receptors (e.g., nicotinic receptors)
   (C) Jak-STAT receptors (e.g., for cytokines)
   (D) steroid receptors (e.g., for corticosteroids)
   (E) transmembrane enzyme receptors (e.g., for insulin)

3. Which of the following responses to sympathetic nerve discharge is mediated at the effector cell by acetylcholine?
   (A) decreased blood flow in the skin
   (B) increased blood fatty acids
   (C) increased blood glucose
   (D) increased heart rate
   (E) increased sweating

4. Which of the following drugs inhibit osteoclastic activity more than osteoblastic activity and have been beneficial in osteoporosis, hypercalcemia of malignancy, and Paget disease?
   (A) alendronate
   (B) calcitonin
   (C) fluoride
   (D) parathyroid hormone
   (E) vitamin D

5. The location of the lesion in Horner syndrome (either preganglionic or postganglionic) can be determined by the use of certain sympathomimetics. Which of the following agents would distinguish between a preganglionic versus a postganglionic lesion?
   (A) amphetamine
   (B) atenolol
   (C) epinephrine
   (D) isoproterenol
   (E) phenylephrine

6. Mifepristone has antagonist action at which of the following receptors?
   (A) beta adrenoceptors
   (B) dopamine receptors
   (C) insulin receptors
   (D) low-density lipoprotein receptors
   (E) progesterone receptors
7. A 50-year-old man presents with a blood pressure of 160/100. He is to be started on hydrochlorothiazide. Which of the following is a common adverse effect of hydrochlorothiazide?

(A) atrioventricular (AV) blockade
(B) constipation
(C) drug-induced lupus erythematosus
(D) potassium wasting
(E) tachycardia

8. A 57-year-old man presents with angina. He uses 1 or 2 nitroglycerin tablets sublingually when he experiences chest pain. Which of the following drugs may interact to cause serious hypotension if taken 6 hours or less before the nitrate?

(A) clonidine
(B) diltiazem
(C) metronidazole
(D) phentolamine
(E) sildenafil

9. Diltiazem as used in angina pectoris has several beneficial actions that contribute to the prevention of the anginal symptoms. Which of the following actions is detrimental in angina?

(A) reduced arterial blood pressure
(B) increased diastolic heart size
(C) reduced systolic myocardial fiber tension
(D) bradycardia
(E) slowed AV conduction

10. Which of the following beta-lactam drugs has good activity against beta-lactamase-producing organisms and penetrates readily into cerebrospinal fluid?

(A) amoxicillin
(B) cefazolin
(C) clavulanic acid
(D) imipenem
(E) ticarcillin

11. A 73-year-old patient has heart failure that has worsened over the past 12 months. Which of the following drugs is likely to slow progression even though it has no direct positive or negative effects on cardiac contractility?

(A) digoxin
(B) dobutamine
(C) losartan
(D) nesiritide
(E) propranolol

12. Antiarrhythmic drugs have a variety of adverse effects that must be monitored carefully. Which of the following drugs is associated with discoloration of the skin, photosensitivity, thyroid dysfunction, and pulmonary complications?

(A) amiodarone
(B) diltiazem
(C) ibutilide
(D) lidocaine
(E) procainamide

13. Which of the following drugs causes hyperchloremic metabolic acidosis and may cause hyperammonemia in a patient with cirrhosis?

(A) acetazolamide
(B) amiloride
(C) furosemide
(D) hydrochlorothiazide
(E) spironolactone

14. Serotonin (5-HT) is one of several mediators of the signs and symptoms of carcinoid tumor. When released from this neoplasm, most of the manifestations of 5-HT are the result of activation of the 5-HT₂ receptor. These manifestations are therefore likely to include which of the following effects?

(A) bronchospasm
(B) constipation
(C) skeletal muscle weakness
(D) tachycardia
(E) ulceration of the stomach or duodenum

15. Which of the following drugs is useful in asthma because it stabilizes mast cells?

(A) albuterol
(B) cromolyn
(C) ipratropium
16. Zolpidem is a newer sedative-hypnotic drug approved for use as a sleeping pill. Which of the following statements describes the major difference between zolpidem and older hypnotics such as barbiturates and benzodiazepines?

(A) associated with thrombocytopenia
(B) does not act on chloride channels in the CNS
(C) has significant anticonvulsant activity
(D) much longer duration of action
(E) reduced addiction liability

17. A child with absence seizures is being evaluated for therapy with ethosuximide. Which of the following is the most common adverse effect of ethosuximide in children?

(A) hemolytic anemia
(B) excessive sedation
(C) hepatic necrosis
(D) nephropathy
(E) torsade de pointe arrhythmia

18. A 70-year-old man presents with Parkinson's disease in an early stage. Which of the following drugs acts directly on dopamine receptors to reduce the signs and symptoms of Parkinson's disease?

(A) amantadine
(B) carbidopa
(C) entacapone
(D) orphenadrine
(E) pramipexole

19. Which of the following agents used in general anesthesia is least likely to cause postoperative nausea and vomiting?

(A) enflurane
(B) etomidate
(C) isoflurane
(D) morphine
(E) propofol

20. Which of the following is the only local anesthetic that causes vasoconstriction and may result in an increase in blood pressure?

(A) bupivacaine
(B) cocaine
(C) etidocaine
(D) lidocaine
(E) tetracaine

21. A 26-year-old woman with cerebral palsy complains of severe pain associated with spasms in her leg muscles. Which of the following drugs is used in cerebral palsy to reduce skeletal muscle spasticity by an action on cholinergic nerve endings?

(A) baclofen
(B) botulinum toxin
(C) dantrolene
(D) diazepam
(E) tubocurarine

22. A 35-year-old man has severe schizophrenia. He is institutionalized and maintained on antipsychotic medication. Which of the following drugs is most likely to cause parkinsonian adverse effects?

(A) clozapine
(B) fluphenazine
(C) haloperidol
(D) olanzapine
(E) quetiapine

23. Which of the following drugs is most dangerous in suicidal overdosage?

(A) bupropion
(B) citalopram
(C) fluoxetine
(D) imipramine
(E) phenelzine
24. A patient has been treated for bipolar disorder for several months. Which of the following is a common adverse effect of lithium carbonate?

(A) dry mouth
(B) hyperthyroidism
(C) leukopenia
(D) nephrogenic diabetes insipidus
(E) parkinsonian extrapyramidal symptoms

25. Methadone has been used in opioid addiction maintenance clinics with partial success. Its ability to reduce the use of heroin and morphine by recovering addicts can be ascribed to which of the following mechanisms?

(A) agonist effects at central dopamine D2 receptors
(B) antidepressant effects at serotonin (5-HT) receptors
(C) antagonist actions at the mu opioid receptor
(D) blockade of the metabolic activation of heroin and morphine to their active forms
(E) long-lasting saturation of the mu opioid receptor and development of tolerance

26. Which of the following drugs has opioid antagonist actions and also reduces nicotine and alcohol craving in persons dependent on those drugs?

(A) bupropion
(B) flumazenil
(C) nalbuphine
(D) naltrexone
(E) naltrexone

27. A known drug abuser is brought to the emergency room by the police. He is in restraints, combative, and hallucinating. His blood pressure, heart rate, and body temperature are elevated. Pupils are dilated and demonstrate both horizontal and vertical nystagmus. Which of the following drugs would cause this presentation?

(A) amphetamine
(B) heroin
(C) LSD
(D) phencyclidine
(E) scopolamine

28. Which of the following enzymes is inhibited by drugs of the class to which amoxicillin belongs?

(A) alanine racemase
(B) beta lactamase
(C) enolpyruvate transferase
(D) transglycosylase
(E) transpeptidase

29. Which of the following drugs is selectively antifungal because of the difference between cholesterol (in mammalian cell membranes) and ergosterol (in fungal membranes)?

(A) amphotericin B
(B) caspofungin
(C) fluconazole
(D) griseofulvin
(E) terbinafine

30. Which of the following antifungal drugs is strongly associated with drug interactions resulting from inhibition of CYP 3A4?

(A) amphotericin B
(B) caspofungin
(C) fluconazole
(D) ketoconazole
(E) flucytosine

31. Which of the following is useful in rheumatoid arthritis because it binds tumor necrosis factor-alpha (TNF-alpha)?

(A) leflunomide
(B) infliximab
(C) methotrexate
(D) paclitaxel
(E) trastuzumab

32. Which of the following agents used to prevent organ transplant rejection is most likely to cause significant decrease in creatinine clearance?

(A) antilymphocyte globulin
(B) cyclosporine
33. Which of the following antidiabetic agents acts on the peroxisome proliferator-activated receptor-gamma (PPAR-gamma) nuclear receptor?
(A) acarbose  
(B) glyburide  
(C) insulin lispro  
(D) metformin  
(E) pioglitazone

34. Which of the following mechanisms most accurately describes the blocking action of methimazole?
(A) iodine uptake by the thyroid  
(B) organification of iodine in the thyroid  
(C) peripheral conversion of T₄ to T₃  
(D) peripheral thyroxine (T₄) and T₃ receptors  
(E) thyroglobulin proteolysis

35. Which of the following adverse effects of chronic high-dose prednisone administration represents a mineralocorticoid effect?
(A) buffalo hump  
(B) easy bruising  
(C) edema  
(D) moon facies  
(E) psychosis

36. Which of the following drugs is used to accelerate pulmonary maturation in the fetus in women with premature labor?
(A) aminoglutethimide  
(B) betamethasone  
(C) mifepristone  
(D) misoprostol  
(E) prostacyclin

37. The increased risk of blood clots in women who use certain combined estrogen/progestin birth control pills is well established. Which of the following best explains this association?
(A) impaired glucose tolerance  
(B) increased Factor II, VII, IX, and X levels produced by estrogens  
(C) increased plasminogen levels produced by progestins  
(D) increased thyroxine-binding globulin  
(E) increased triglyceride levels produced by progestins

38. Which of the choices in the table below most accurately describes the actions of vitamin D and parathyroid hormone on calcium and phosphate in the blood?

<table>
<thead>
<tr>
<th>Choice</th>
<th>Vitamin D</th>
<th>Parathyroid Hormone</th>
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<tbody>
<tr>
<td>A</td>
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39. An unconscious man is brought to the emergency room. He was at home when discovered, but he works as a foreman in a chemical-packaging plant. His blood pressure and heart rate are normal. He is sweating profusely, has constricted pupils, and auscultation of the lungs indicates rales and wheezing. Widespread subcutaneous muscle twitches are apparent. He has had urinary and fecal incontinence. Which of the following chemicals is the most likely cause of this poisoning?
(A) isobutyl nitrite  
(B) metallic mercury  
(C) morphine  
(D) parathion  
(E) phencyclidine
40. Which of the following drugs is considered a first-line agent in the chronic treatment of rheumatoid arthritis and in the treatment of choriocarcinoma?
   (A) cyclosporine
   (B) hydroxychloroquine
   (C) methotrexate
   (D) sulfasalazine
   (E) thalidomide

41. Which of the following drugs reduces LDL cholesterol by inhibiting an intestinal transport protein?
   (A) atorvastatin
   (B) cholestyramine
   (C) ezetimibe
   (D) gemfibrozil
   (E) niacin

42. Which of the following drugs corrects the anemia of pernicious anemia and prevents the neurological consequences of the disease?
   (A) beta-carotene
   (B) ferrous sulfate
   (C) folic acid
   (D) hydroxocobalamin
   (E) vitamin E

43. Which of the following laxatives acts osmotically to increase the water content of the stool?
   (A) cascara
   (B) docusate
   (C) glycerine
   (D) magnesium hydroxide
   (E) senna

44. Which of the following drugs binds to, and prevents disassembly of, microtubules?
   (A) busulfan
   (B) cisplatin
   (C) mercaptopurine
   (D) paclitaxel
   (E) vinblastine

45. Which of the following drugs blocks the action of angiotensin II at the AT$_1$ receptor?
   (A) bradykinin
   (B) enalapril
   (C) losartan
   (D) ondansetron
   (E) prazosin

Questions 46 and 47

A 73-year-old woman complains of difficulty sleeping, exercise fatigue, and shortness of breath. Examination reveals mental confusion, swollen ankles, pulmonary rales, and dyspnea while supine.

46. Chronic treatment of this patient with an angiotensin-converting enzyme (ACE) inhibitor such as captopril may be beneficial because ACE inhibitors (in addition to other effects) are known to exert which of the following responses?
   (A) decrease both ventricular preload and afterload
   (B) increase coronary perfusion
   (C) increase efficiency of oxygen extraction by cardiac and skeletal muscle
   (D) produce a positive inotropic effect and negative chronotropic effect
   (E) promote ventricular remodeling and compensatory enlargement

47. Immediate treatment of the patient may be needed if signs and symptoms, especially those of pulmonary congestion, worsen rapidly. Which of the following would be most beneficial in treating acute, severe pulmonary edema?
   (A) amiloride
   (B) furosemide
   (C) hydrochlorothiazide
   (D) losartan
   (E) metoprolol

48. Which of the following descriptions best describes the molecular mechanism underlying the therapeutic actions of the statins such as atorvastatin?
(A) binding to peroxisome proliferator-activated receptor-alpha (PPAR-alpha) resulting in stimulation of lipoprotein lipase activity
(B) increased fecal excretion of bile acid resulting in increased conversion of cholesterol to bile acid
(C) inhibition of hepatic cholesterol synthesis resulting in increased expression of LDL receptors
(D) inhibition of hepatic VLDL secretion resulting in reduced production of IDL and LDL
(E) inhibition of lecithin:cholesterol acyltransferase activity resulting in decreased conversion of IDL to LDL

49. Additive and potentially dangerous sedative interactions may occur between sedative-hypnotic drugs and which of the following herbal preparations?

(A) echinacea
(B) gingko biloba
(C) ginseng
(D) kava
(E) St John’s wort

Questions 50–52

Figure 6-1 shows plasma concentrations of drug W in a patient following intravenous (IV) injection of a single dose of 10 mg of the drug, an agent eliminated from the body by renal excretion. At hour 12, the patient is treated with sodium bicarbonate (arrow).

50. Use the data before hour 12 to calculate the volume of distribution (Vd) for drug W.

(A) 1 L
(B) 10 L
(C) 25 L
(D) 50 L
(E) 100 L

51. Use the data before hour 12 to calculate the half-life (t_{1/2}) for drug W.

(A) 0.5 hour
(B) 1 hour
(C) 3 hours
(D) 7 hours
(E) 10 hours

52. The change in elimination rate after hour 12 when sodium bicarbonate was administered is expected if drug W is which of the following chemical types?

(A) nonelectrolyte
(B) strong acid
(C) strong base
(D) weak acid
(E) weak base

Questions 53 and 54

A patient calls 911 because of severe substernal crushing pain that has not responded to three nitroglycerin tablets taken sublingually. The paramedic team suspects that the patient has suffered an acute myocardial infarction. His blood pressure is 110/70 and his heart rate is 70, with occasional premature extra beats.

53. What drug should be administered immediately, even before the patient reaches the hospital?

(A) aspirin
(B) dobutamine
(C) lidocaine
(D) metoprolol
(E) streptokinase
54. After initial treatment in the hospital, the patient is found to be suffering from more severe hypotension (his blood pressure is now 70/40) and reduction of cardiac function with reduced left ventricular ejection fraction. His urine output is low and he has mental clouding. Which of the following is the pharmacologic treatment of choice for this condition in this patient?

(A) atenolol
(B) digoxin
(C) dopamine
(D) norepinephrine
(E) procainamide

55. A patient is being treated for metastatic prostate cancer. Which of the following agents is used parenterally in prostate cancer to reduce luteinizing hormone (LH) release from the pituitary even though it initially increases LH release?

(A) diethylstilbestrol
(B) finasteride
(C) flutamide
(D) ketoconazole
(E) leuprolide

56. A drug being developed as an antiarrhythmic agent was studied in the laboratory using microelectrode techniques for measuring the transmembrane potential. The results of this study are shown in Figure 6-2. Which of the following standard antiarrhythmic agents does the new drug most resemble?

(A) adenosine
(B) ibutilide
(C) lidocaine
(D) procainamide
(E) propranolol

57. A patient is admitted for acute coronary syndrome with signs of impending myocardial infarction. She undergoes angioplasty with double coronary stenting to maintain the patency of her coronary vessels. Which of the following drugs will probably be administered to prevent clotting in the region of the wire mesh stents?

(A) clopidogrel
(B) low-molecular-weight heparin
(C) regular heparin
(D) tissue plasminogen activator (t-PA)
(E) warfarin

58. Which of the following acts as a folate antagonist in the treatment of malaria?

(A) amodiaquine
(B) chloroquine
(C) mefloquine
(D) proguanil
(E) quinine

59. Which of the following antiviral drugs is correctly associated with the appropriate primary toxicity?

(A) amantadine—neutropenia
(B) didanosine—pancreatitis
(C) ribavirin—hepatitis
(D) ritonavir—hemolytic anemia
(E) zidovudine—CNS stimulation, GI complaints

60. Which of the following antiviral agents uses viral thymidine kinase as part of its activation pathway?

(A) acyclovir
(B) amantadine
(C) foscarnet
(D) saquinavir
(E) zidovudine
61. Resistance to which of the following drugs occurs when the bacterium expresses higher quantities of a drug-efflux pump?

   (A) amoxicillin
   (B) clarithromycin
   (C) doxycycline
   (D) gentamicin
   (E) vancomycin

62. Which of the following antitubercular agents is a strong inducer of hepatic cytochrome P450?

   (A) ethambutol
   (B) isoniazid
   (C) rifampin
   (D) streptomycin
   (E) sulfisoxazole

63. A 35-year-old woman with hypertension is planning to become pregnant. Which of the following is contraindicated in pregnancy?

   (A) clonidine
   (B) hydralazine
   (C) hydrochlorothiazide
   (D) losartan
   (E) methyldopa

64. A 35-year-old opera singer has been treated for hypertension with enalapril. Although his blood pressure has been reduced, he complains that he is now unable to perform because of a dry cough. Which of the following acts by a similar but not identical mechanism and is much less likely to cause cough?

   (A) captopril
   (B) clonidine
   (C) losartan
   (D) prazosin
   (E) propranolol

65. Which of the following agents used in treating testicular cancer, requires hydration and diuresis to prevent renal toxicity?

   (A) bleomycin
   (B) cisplatin
   (C) cyclophosphamide
   (D) 5-fluorouracil
   (E) paclitaxel

66. Which of the following chemotherapeutic agents’ mechanisms of action involve inhibition of thymidylate synthase and incorporation into RNA?

   (A) anastrozole
   (B) cytarabine
   (C) doxorubicin
   (D) 5-fluorouracil
   (E) imatinib

67. Which of the following chemotherapeutic agents’ mechanisms of action involves inhibition of topoisomerase II and results in DNA strand breakage?

   (A) dacarbazine
   (B) etoposide
   (C) lomustine
   (D) prednisone
   (E) vincristine

68. A 13-year-old boy with severe asthma has been treated for 6 months with good control of nocturnal wheezing. His parents now complain that he seems to be very fat around the face and shoulders, bruises easily, and has discolored streaks on his abdomen. Laboratory tests reveal moderate hyperglycemia. He has probably been receiving which of the following drugs?

   (A) ipratropium
   (B) prednisone
   (C) salmeterol
   (D) terbutaline
   (E) theophylline
69. Which of the following describes a possible adverse effect of long-term chronic treatment of schizophrenia with a phenothiazine such as fluphenazine?
   (A) diarrhea, nausea, and vomiting
   (B) reduced secretion of prolactin
   (C) tardive dyskinesia
   (D) Tourette syndrome
   (E) weight loss

70. Which of the following psychotropic drugs must be monitored for hematotoxic effects?
   (A) buspirone
   (B) clozapine
   (C) haloperidol
   (D) lithium carbonate
   (E) mirtazapine

71. Which of the following is used in treating major depression and has the greatest sedative effect?
   (A) bupropion
   (B) desipramine
   (C) fluoxetine
   (D) mirtazapine
   (E) venlafaxine

72. Which of the following is the drug of choice to reverse bronchoconstriction in an acute asthma attack?
   (A) albuterol
   (B) aminophylline
   (C) cromolyn
   (D) ipratropium
   (E) salmeterol

73. Which of the following drugs is useful in treatment of gout with recurrent renal urate stones because it decreases the excretion of uric acid?
   (A) allopurinol
   (B) aspirin
   (C) colchicine
   (D) indomethacin
   (E) sulfinpyrazone

74. Which of the following drugs can be used in rheumatoid arthritis with the lowest probable incidence of GI complications?
   (A) aspirin
   (B) celecoxib
   (C) ibuprofen
   (D) misoprostol
   (E) naproxen

Questions 75 and 76

In a study of cardiovascular drugs, normal volunteers were given drug X in a small bolus dose while blood pressure and heart rate were recorded. After recovery, a long-acting blocking agent, Y, was administered. The direct effects of Y were not recorded. After drug Y had equilibrated with the tissues of the body, drug X was repeated in the same dosage. The results are shown in Figure 6-3.

75. Drug X behaves most like which of the following?
   (A) bethanechol
   (B) epinephrine
   (C) isoproterenol
   (D) norepinephrine
   (E) phenylephrine

76. Drug Y behaves most like which of the following?
   (A) atropine
   (B) pralidoxime
   (C) prazosin
   (D) reserpine
   (E) timolol

77. Which of the following conditions is a primary indication for the use of esmolol?
   (A) arrhythmia associated with thyroid storm
   (B) chronic heart failure
(C) chronic hypertension
(D) diabetic nephropathy
(E) familial tremor

78. Which of the following agents would cause the greatest increase in heart rate in a functioning transplanted heart?
(A) amphetamine
(B) cocaine
(C) ephedrine
(D) isoproterenol
(E) terbutaline

79. Which of the following agents produces vasodilation by increasing nitric oxide synthesis in endothelial cells?
(A) diazoxide
(B) histamine
(C) minoxidil
(D) nitroprusside
(E) verapamil

80. Which of the following statements correctly associates a CNS drug with its mechanism of action?
(A) bupropion—activation of endocannabinoid receptors
(B) diazepam—facilitation of GABA-stimulated chloride channel opening
(C) fluoxetine—selective inhibition of presynaptic norepinephrine reuptake
(D) pentobarbital—inhibition of NMDA receptors
(E) tranylcypromine—inhibition of O-methylation of catecholamines

81. Which of the following agents is associated with numerous drug-drug interactions because of its inhibition of hepatic cytochrome P450 activity?
(A) atracurium
(B) cromolyn
(C) ketoconazole

(D) phenobarbital
(E) rifampin

82. A patient has completed a course of cancer chemotherapy and now has severe anemia, neutropenia, and thrombocytopenia. If only one intervention is possible, which of the following is the most appropriate therapy?
(A) epoetin (erythropoietin)
(B) filgrastim (G-CSF)
(C) growth hormone
(D) sargramostim (GM-CSF)
(E) testosterone

83. The most rapid onset of action of inhaled general anesthetics correlates with the smallest value for which of the following variables?
(A) blood-gas partition coefficient
(B) MAC
(C) molecular size
(D) oil–water partition coefficient
(E) onset of hepatic metabolism

84. Which of the following inhaled general anesthetic agents has an MAC that exceeds normal atmospheric pressure?
(A) enflurane
(B) halothane
(C) isoflurane
(D) nitrous oxide
(E) sevoflurane

85. Which of the following is the agent of choice for chronic treatment of simple hypothyroidism (myxedema)?
(A) desiccated thyroid
(B) levothyroxine (T4)
(C) liothyronine (T3)
(D) potassium iodide
(E) reverse T3
86. A 24-year-old woman presents with hypertension and hypokalemic metabolic alkalosis. Although these symptoms are normally indicative of hyperaldosteronism, this patient’s aldosterone levels are undetectable, and no other mineralocorticoid activity is found. A diagnosis of Liddle syndrome is made on the basis of the signs and symptoms and a family history. Liddle syndrome is caused by a genetic defect leading to excessive expression of the apical sodium channel in the principal cells of the cortical-collecting tubule and excess sodium transport in this part of the nephron. Which of the following agents is the best choice for treatment of the hypertension and hypokalemic metabolic alkalosis in this patient?

(A) amiloride  
(B) fludrocortisone  
(C) hydrochlorothiazide  
(D) lisinopril  
(E) spironolactone

87. Which of the following correctly describes the mechanism of action of streptokinase?

(A) combines with plasminogen to form an enzymatically active complex  
(B) competitively blocks binding of plasminogen to fibrin  
(C) converts plasmin to plasminogen  
(D) inhibits platelet cyclooxygenase (COX) activity  
(E) provides a template for combination of thrombin and antithrombin III

88. A 17-year-old patient suffers from tonic–clonic seizures. This condition has been well controlled with a regimen of phenytoin. Which of the following signs or symptoms indicates phenytoin toxicity?

(A) diplopia and abnormal gait  
(B) hyperprolactinemia  
(C) polydipsia and polyuria  
(D) postural hypotension  
(E) rigidity and tremor

89. Which of the following substances contains the highest concentration of molecules with estrogenic effects?

(A) ginseng  
(B) grapefruit juice  
(C) kava  
(D) saw palmetto  
(E) tomatoes

90. A 60-year-old man reports to the emergency room complaining of shortness of breath and a rapid, irregular heart beat. An ECG shows the pattern recorded in Figure 6-4, panel A. A diagnosis of atrial fibrillation, heart rate 140, is made. He is treated with an IV drug, which results in a change of the ECG, 1 hour after drug administration, to the pattern shown in panel B. This ECG was read as atrial fibrillation, heart rate 65. What drug was used?

(A) adenosine  
(B) diltiazem  
(C) disopyramide  
(D) ibutilide  
(E) quinidine

91. A patient with AIDS has bacterial meningitis and is being treated with an antimicrobial agent cleared by both hepatic metabolism and renal excretion. The volume of distribution is 10 L and the half-life for elimination is 7 hours in this patient. If the renal contribution to the plasma clearance of the drug is 8.3 mL/min, approximately what percentage of the drug’s elimination can be attributed to hepatic metabolism?
92. Calcium- and aluminum-containing antacids should be avoided by patients taking which of the following antimicrobial drugs?

(A) amoxicillin  
(B) erythromycin  
(C) isoniazid  
(D) minocycline  
(E) rifampin

93. A young boy was treated for 2 years with several antibacterial agents to eradicate tuberculosis. On entering school the following year, his teacher reports that he seems to be retarded. Upon investigation, he is found to have profound hearing loss. Which of the following agents may have been responsible for this hearing loss?

(A) ethambutol  
(B) isoniazid  
(C) pyrazinamide  
(D) rifampin  
(E) streptomycin

94. Which of the following drugs exerts its effects through inhibition of cyclic GMP phosphodiesterase?

(A) hydralazine  
(B) minoxidil  
(C) nitroprusside  
(D) prazosin  
(E) sildenafil

95. Which of the following insulin regimens most closely mimics insulin release from a normally functioning pancreas?

(A) prebreakfast and predinner injections of lente insulin plus an injection of regular insulin if blood glucose (measured by finger-stick) exceeds 150 mg/dL  
(B) premeal injections of insulin lispro plus morning and evening injections of detemir insulin  
(C) premeal injections of NPH insulin plus an injection of insulin lispro at bedtime  
(D) post-meal injection of lente insulin plus a prebreakfast injection of regular insulin  
(E) Post-meal injections of insulin glargine

96. Which of the following drugs or drug combinations is appropriate treatment for the P. aeruginosa infection in this diabetic patient?

(A) chloramphenicol  
(B) nafcillin plus kanamycin  
(C) sulfamethoxazole plus trimethoprim  
(D) tetracycline  
(E) ticarcillin plus tobramycin

97. A 20-year-old man suffers a broken arm in a bicycle accident. After a cast is applied, he is to be discharged from the emergency department with a prescription for an analgesic to be used if over-the-counter acetaminophen or nonsteroidal anti-inflammatory drugs (NSAIDs) are not effective in providing pain relief. Which of the following is the best choice for prescription pain relief in this case?

(A) codeine  
(B) diphenoxylate  
(C) meperidine  
(D) methadone  
(E) morphine
98. On the basis of their mechanisms of action, which of the following combinations of drugs produces a beneficial additive or synergistic effect in therapy when each agent is present at its maximum effective concentration?

(A) chlortetracycline plus amoxicillin
(B) clomiphene plus chorionic gonadotropin
(C) lovastatin plus cholestyramine
(D) pentazocine plus morphine
(E) succinylcholine plus atracurium

99. Figure 6-5 shows the quantal population dose–response curves for the therapeutic and toxic effects of drugs X and Y. Both drugs are agonists at the same receptor to produce the therapeutic response, and the maximum responses obtained with each agent are the same. The toxicity curve in the figure shows the superimposed toxic response curves for drugs X and Y; they are identical in terms of the concentration dependence. Which of the following statements is most correct?

(A) At $1 \times 10^{-5}$ M both drugs cause adverse effects in 90–100% of patients.
(B) Drug X has a larger therapeutic index than drug Y.
(C) Drug X is more efficacious than drug Y.
(D) Drug Y is more potent than drug X.
(E) Drug Y is safer than drug X.

100. A 78-year-old man has ankle edema, tachycardia, and shortness of breath on mild exercise. His blood pressure is 155/98. He has been diagnosed with hypertension and mild heart failure. Which of the following regimens is most appropriate for starting therapy?

(A) captopril plus dobutamine
(B) captopril plus hydralazine
(C) enalapril plus hydrochlorothiazide
(D) furosemide plus spironolactone
(E) losartan plus hydralazine

101. A 23-year-old woman is admitted to the hospital suffering from palpitations and syncopal episodes (fainting spells). She is found to be hypotensive and her ECG shows a very rapid AV nodal reentrant tachycardia. Which of the following drugs provides appropriate acute treatment for this condition?

(A) adenosine
(B) bethanechol
(C) isoproterenol
(D) metoprolol
(E) procainamide

102. A 38-year-old man has been treated for myasthenia gravis with pyridostigmine and propantheline for 8 years. He has had the “flu” for 10 days and his wife calls reporting that he now has serious muscle weakness. What should be administered after admitting this patient to the emergency department?

(A) atropine to reverse the effects of an overdose
(B) a test dose of edrophonium
(C) pralidoxime on the assumption that he inadvertently overdosed
(D) the daily dose of pyridostigmine on the assumption that he forgot to take his medication
(E) tubocurarine

103. A 75-year-old man has prostate cancer that has metastasized to bone. He is receiving hormonal therapy to slow progression of the neoplasm and codeine by mouth for pain when it is
absolutely required, but still complains of severe pain. What should be given to this patient to address his symptom?

(A) a strong NSAID such as naproxen as needed to supplement his codeine therapy
(B) additional codeine when he complains
(C) aspirin, and he should be told that additional narcotics cannot be used because he would become tolerant of their analgesic action
(D) morphine in a long-acting oral preparation on a regular schedule and parenteral morphine when pain breaks through
(E) parenteral morphine when pain requires it

104. In a study of a new drug, the agent was administered to anesthetized animals while blood pressure, heart rate, and salivation were recorded. The results of a typical experiment are shown in Figure 6-6. What is the best characterization of this new agent?

105. Carbidopa is often used in patients with Parkinson’s disease. Which of the following best describes the mechanism of action of carbidopa?

(A) activates D₂ receptors in the basal ganglia
(B) inhibits the metabolism of dopamine in the blood and peripheral tissues
(C) inhibits the metabolism of dopamine in the brain
(D) inhibits the metabolism of levodopa in peripheral tissues
(E) inhibits the metabolism of levodopa in the brain

106. Which of the following is a recombinant human antibody used in advanced breast cancer?

(A) adalimumab
(B) etanercept
(C) infliximab
(D) sirolimus
(E) trastuzumab

107. A patient is to receive chemotherapy for cancer. The oncologist plans to use ondansetron to reduce the nausea and vomiting associated with the chemotherapeutic agents. What is the mechanism of action of ondansetron?

(A) cannabinoid receptor agonist
(B) corticosteroid agonist
(C) dopamine antagonist
(D) H₁ histamine antagonist
(E) serotonin 5-HT₃ antagonist

108. Which of the following correctly describes the actions of baclofen?

(A) agonist at glutamate receptors
(B) antagonist at neuronal nicotinic receptors
(C) agonist at gamma-aminobutyric acid receptors
(D) agonist at glycine receptors
(E) antagonist at skeletal muscle ryanodine receptors
109. A patient has glaucoma following cataract surgery, a moderate elevation of intraocular pressure that often follows replacement of the crystalline lens. Which of the following is a rational choice for treatment and the correct mechanism for that drug?

(A) atracurium—increased outflow of aqueous humor
(B) dorzolamide—increased outflow of aqueous humor
(C) latanoprost—decreased synthesis of aqueous humor
(D) pilocarpine—decreased synthesis of aqueous humor
(E) timolol—decreased synthesis of aqueous humor

110. Which of the following quantitative comparisons of haloperidol (H) and olanzapine (O) is most accurate?

<table>
<thead>
<tr>
<th>Choice</th>
<th>Extrapyramidal Effects</th>
<th>Autonomic Effects</th>
<th>Oral Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A)</td>
<td>H &lt; O</td>
<td>H &lt; O</td>
<td>H &lt; O</td>
</tr>
<tr>
<td>(B)</td>
<td>H &gt; O</td>
<td>H = O</td>
<td>H = O</td>
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<tr>
<td>(C)</td>
<td>H = O</td>
<td>H &gt; O</td>
<td>H &lt; O</td>
</tr>
<tr>
<td>(D)</td>
<td>H &lt; O</td>
<td>H = O</td>
<td>H &gt; O</td>
</tr>
<tr>
<td>(E)</td>
<td>H = O</td>
<td>H &lt; O</td>
<td>H = O</td>
</tr>
</tbody>
</table>

113. Figure 6-7 illustrates a current concept of the control of gastric acid secretion. Which of the following drugs acts at the site labeled “ATPase”?

(A) aluminum hydroxide
(B) misoprostol
(C) omeprazole
(D) ranitidine
(E) sucralfate

114. Which of the following statements is most correct regarding the use of drugs in hypertension?

(A) ACE inhibitors are contraindicated if the patient is pregnant
(B) beta-blockers are contraindicated if hypertension is associated with heart failure
(C) calcium channel blockers are contraindicated if the patient also has obstructive pulmonary disease
(D) diuretics are contraindicated in hypertension associated with diabetes
(E) vasodilators are contraindicated in a patient taking a diuretic
115. Which of the following antidepressants is most selective in blocking reuptake of serotonin as compared with norepinephrine?
(A) amitriptyline
(B) citalopram
(C) desipramine
(D) imipramine
(E) trazodone

116. Calcium disodium edetate is most effective as an antidote for poisoning with which of the following?
(A) arsenic
(B) atropine
(C) iron
(D) lead
(E) mercury

117. Which of the following is the current drug of choice for treatment of roundworm (Ascaris) infections?
(A) diethylcarbamazine
(B) ivermectin
(C) mebendazole
(D) niclosamide
(E) praziquantel

118. Which of the following statements about the leukotrienes LTC₄, LTD₄, and LTE₄ is most correct?
(A) Their biosynthesis is inhibited by aspirin.
(B) They are chemotactic agents for polymorphonuclear leukocytes.
(C) They are potent bronchoconstrictor substances.
(D) They are synthesized and stored in platelet granules.
(E) They have few cardiovascular effects.

119. The mechanism of anesthetic action for lidocaine involves which of the following?
(A) blockade of axonal voltage-dependent calcium channels
(B) blockade of axonal voltage-dependent sodium channels
(C) hyperpolarization of axons via enhanced chloride influx
(D) hyperpolarization of axons via enhanced potassium efflux
(E) inhibition of nerve terminal pain receptors

120. Which of the following is the best treatment for uncomplicated primary syphilis?
(A) ciprofloxacin
(B) clarithromycin
(C) doxycycline
(D) gentamycin
(E) penicillin G

121. Which of the following associates the correct mechanism of action with a drug used in Type II (noninsulin-dependent) diabetes?
(A) acarbose—reduction of insulin resistance
(B) glipizide—inhibition of intestinal alpha-glucosidase
(C) metformin—inhibition of ATP-sensitive potassium channels
(D) repaglinide—modulation of pancreatic insulin release
(E) rosiglitazone—reduction in circulating glucagon levels

122. The table below provides several possible descriptions of the actions of nondepolarizing neuromuscular blockers such as tubocurarine. Which description is most accurate?

<table>
<thead>
<tr>
<th>Choice</th>
<th>Effect of Tetanic Stimulation</th>
<th>Posttetanic Potentiation</th>
<th>Reversal by Neostigmine</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Fade</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>B</td>
<td>Constant</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>C</td>
<td>Fade</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>D</td>
<td>Fade</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>E</td>
<td>Constant</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
123. Which of the following agents is most effective as a cardiac stimulant in the treatment of severe beta-blocker overdose?

(A) atrial natriuretic peptide
(B) epinephrine
(C) glucagon
(D) human growth hormone
(E) insulin

124. At a blood alcohol level of 200 mg/dL (0.2%), which of the following correctly describes the systemic elimination process for ethanol?

(A) constant clearance via liver, kidney, and lungs
(B) first-order elimination via pulmonary exhalation
(C) first-order elimination via renal excretion
(D) second-order elimination via biliary secretion
(E) zero-order elimination via hepatic metabolism

125. The mechanism of action for the therapeutic effect of saquinavir involves which of the following?

(A) incorporation into RNA
(B) inhibition of thymidylate synthase
(C) inhibition of viral DNA polymerase
(D) inhibition of viral protease
(E) inhibition of viral reverse transcriptase

126. The following are pharmacokinetic data for the drug propranolol in a 70-kg person: clearance, 50 L/h; volume of distribution, 270 L; effective plasma concentration, 20 ng/mL; oral availability (percentage), 25%. What is the oral maintenance dosing rate for propranolol in a 70-kg person?

(A) 10 μg/h
(B) 200 μg/h
(C) 1 mg/h
(D) 4 mg/h
(E) 54 mg/h
Answers and Explanations

1. (B) Dexamethasone, a corticosteroid, combines with a cytoplasmic steroid receptor, enters the nucleus, and alters gene expression. The other agents listed (choices A, C–E) act on membrane receptors.

2. (B) Response times for ion channel receptors are measured in milliseconds, for G protein-coupled receptors (choice A), transmembrane enzyme receptors (choice E), and Jak-STAT receptors (choice C) in seconds to minutes, and for steroid receptors (choice D) in hours or days.

3. (E) Thermoregulatory sweating is mediated by muscarinic receptors and is induced by the release of acetylcholine from cholinergic sympathetic nerve fibers. Therefore, sympathetic sweating can be mimicked by administration of muscarinic agonists such as bethanechol. Choices A through D are effects mediated by alpha- (choice A) or beta adrenoreceptors (choices B, C, D).

4. (A) Alendronate is a bisphosphonate, the class of drugs that has proved most effective in the treatment and prevention of osteoporosis. This class of drug is also useful in the management of hypercalcemia and certain neoplasms. Calcitonin (choice B) has been shown to slow bone loss in postmenopausal women and to treat postoperative pancreatitis. Fluoride (choice C) is used primarily in the prevention of dental caries. Parathyroid hormone (choice D), marketed as Forteo, is currently used in the clinic to treat osteoporosis. Vitamin D (choice E) has shown benefit in increasing bone deposition in osteoporotic patients. However, choices B–E do not have clinical use in the treatment of malignancy or Paget disease.

5. (A) Indirectly acting sympathomimetics (e.g., amphetamines, cocaine) are useful in this situation because their action requires the presence of intact postganglionic noradrenergic neurons. Thus administration of hydroxyamphetamine into the eye will cause mydriasis in a Horner patient if the lesion is preganglionic (postganglionic neuron intact), but not if the lesion is postganglionic. In contrast, direct-acting sympathomimetics (choices C, D, E) will have the same effect regardless of the location of the lesion. Beta antagonists (choice B) will not produce any effect on the pupil.

6. (E) Mifepristone, also known as RU 486, is an effective antagonist at progesterone and glucocorticoid receptors. It has no effect on the other receptors listed (choices A–D).

7. (D) Because thiazides decrease the reabsorption of sodium in the distal convoluted tubule, aldosterone secretion is increased and a compensatory response is evoked that releases potassium in response to increased sodium reabsorption in the cortical collecting tubule, therefore, potassium-wasting results. Other adverse effects of thiazides include increased blood glucose, uric acid, and lipids. None of the other choices (A–B, E) are adverse effects of thiazide administration.

8. (E) Nitrates release nitric oxide in smooth muscle and cause relaxation by facilitating the production of cGMP. Sildenafil (and related drugs for erectile dysfunction, tadalaﬁl and vardenafil) inhibit the inactivation of cGMP. When sildenafil and a nitrate are combined, excessive amounts of cGMP accumulate and may cause severe hypotension. The other drugs listed (choices A through D) have no significant interactions with nitrates.

9. (B) Calcium channel blockers cause a decrease in arterial pressure, heart rate, and cardiac contractility, all of which help to reduce myocardial
oxygen requirement and thereby reduce anginal pain. However, the reduction in contractility increases diastolic cardiac size, which increases oxygen requirement and is therefore detrimental. The other effects listed (choices A, C, and E) are all valid beneficial actions of calcium blockers in angina. Slowed AV conduction (E) occurs, but is of no significance in angina.

10. (D) Imipenem is the only drug listed that is effective against many beta-lactamase-producing organisms and penetrate the blood–brain barrier. Clavulanic acid (C) is an inhibitor of beta-lactamase and is used with an antibiotic but is not an antibiotic itself. None of the other drugs (choices A, B, D, and E) readily penetrate in the cerebrospinal fluid.

11. (C) Losartan, an AT1 angiotensin receptor antagonist, has been shown to slow the progression of heart failure, in common with the ACE inhibitors, beta blockers, and spironolactone, which also slow progression of this disease. Positive inotropic agents such as digoxin (choice A) and dobutamine (choice B) do not slow progression although they may be useful for reducing symptoms. Nesiritide (choice D) is a peptide that causes vasodilation and sodium diuresis and may have value in acute but not chronic failure. Propranolol (choice E) probably slows progression of heart failure but it has direct negative inotropic effects on the heart.

12. (A) Amiodarone is a large, insoluble molecule that deposits in skin (and the cornea) and causes photosensitivity. It contains two iodine atoms, which may be responsible for binding to thyroid receptors and the observed thyroid problems. It is associated with pulmonary fibrosis (sometimes fatal), but the mechanism is unknown. In spite of these adverse effects, it is extremely useful in arrhythmia treatment. Diltiazem (choice B) is associated with constipation and cardiac depression; ibutilide (choice C) with torsade de pointe arrhythmia, lidocaine (choice D) with convulsions, and procainamide (choice E) with torsade de pointe arrhythmia and drug-induced lupus.

13. (A) Acetazolamide acts in the proximal tubule to block carbonic anhydrase, greatly increasing bicarbonate excretion and alkalizing the urine while causing metabolic acidosis. In cirrhosis, ammonia is excreted in larger amounts because urea production in the liver is limited. If an acid urine (necessary for converting ammonia to ammonium ion) cannot be produced, the ammonia is promptly reabsorbed, causing hyperammonemia and hepatic encephalopathy. None of the other drugs (choices B–E) causes hyperammonemia in cirrhotic patients.

14. (A) 5-HT2 receptors mediate smooth muscle contraction and thus cause bronchospasm and diarrhea, not constipation (choice B). Skeletal muscle (choice C) and cardiac muscle (choice D) are relatively insensitive to 5-HT. Peptic ulceration (choice E) is not mediated in part by 5-HT; the autacoid actually reduces acid secretion.

15. (B) Cromolyn is a prophylactic agent for asthma that appears to stabilize mast cells. Albuterol (A) is a shorter acting beta-2-selective agonist that is used for acute, not prophylactic, therapy. Ipratropium (choice C) is an antimuscarinic drug. Salmeterol (D) has a long duration beta-2-agonist action that appears to have an anti-inflammatory action and is useful in prophylaxis of asthmatic attacks. It has a slow onset of action that makes it useless in treating acute attacks. Theophylline (choice E) is an intermediate duration agent that acts by inhibition of phosphodiesterase or adenosine receptors.

16. (E) Zolpidem has greatly reduced addiction liability compared to barbiturates and benzodiazepines even though it does act on chloride channels (choice B). Zolpidem does not have major anticonvulsant actions (choice C), a longer duration of action (choice D), or thrombocytopenic toxicity (choice A).

17. (B) Ethosuximide is usually a very safe drug, but can cause significant sedation. Aplastic anemia but not hemolytic anemia (choice A) has rarely been associated with the use of ethosuximide, and with carbamazepine and felbamate.
Hepatotoxicity (choice C) is a rare but potentially lethal adverse effect of valproic acid that occurs most commonly in children under the age of 2 and those taking multiple drugs. Authorities recommend monitoring liver function tests when starting this drug. Nephropathy (choice D) is not usually reported with antiseizure drugs. Torsade de pointe arrhythmia (choice E) has not occurred with significant frequency during use of anticonvulsant drugs.

18. (E) Pramipexole is a dopamine receptor agonist unrelated to levodopa or ergot derivatives such as bromocriptine and pergolide (which are also useful dopamine agonists). Amantadine (choice A) acts to facilitate the release or slow the reuptake of dopamine, but does not act on the dopamine receptor. Carbidopa (choice B) blocks the peripheral conversion of levodopa to dopamine, it does not act on dopamine receptors. Entacapone (choice C) blocks the peripheral metabolism of levodopa by catechol-O-methyltransferase.

19. (E) Propofol may reduce blood pressure through vasodilating and negative inotropic effects on the heart, but is notable for rapid recovery and its freedom from postoperative nausea and vomiting. For this reason, it is extremely popular for day surgery. None of the other anesthetics (choices A–D) are free from causing postoperative nausea.

20. (B) Cocaine is the only local anesthetic that causes sympathomimetic effects (by inhibiting reuptake of norepinephrine into sympathetic nerve endings); it therefore regularly causes local vasoconstriction and may increase blood pressure. All the other local anesthetics (choices A, C–E) cause vasodilatation and lower blood pressure.

21. (B) Botulinum toxin acts on cholinergic nerve endings (including skeletal muscle motor nerve endings) to reduce acetylcholine release. Baclofen (A) acts in the CNS to activate GABA_B receptors; some sedation may result. Dantrolene (C) acts within the skeletal muscle cell to reduce calcium release from the sarcoplasmic reticulum; reduction of muscle spasm results without central nervous system depression. Diazepam (choice D) facilitates GABAergic transmission in the brain and spinal cord; it does not act on cholinergic transmission. Tubocurarine (choice E) causes profound skeletal muscle paralysis by blocking acetylcholine receptors in the neuromuscular junction. Unlike the other drugs listed, it is not useful in cerebral palsy.

22. (C) Haloperidol is a very potent and efficacious antipsychotic but also manifests the highest incidence of extrapyramidal effects. Clozapine (choice A), olanzapine (choice D), and quetiapine (choice E) are newer, atypical antipsychotic agents with much lower incidence of extrapyramidal toxicity. Fluphenazine (choice B) is a potent phenothiazine with an intermediate tendency to produce parkinson-like effects.

23. (D) Imipramine and other tricyclics are the most dangerous antidepressants when taken in overdosage because of their cardiotoxic (arrhythmias) and neurologic (seizures) effects. Bupropion (choice A), the selective serotonin reuptake inhibitors (SSRIs) (choices B and C), and MAO inhibitors (choice E) are considerably less dangerous.

24. (D) Nephrogenic diabetes insipidus is a common adverse effect of lithium at therapeutic dosage. Dry mouth (choice A) and other anticholinergic toxicities are common with tricyclic antidepressants and some phenothiazines. Lithium may induce hypothyroidism, but not hyperthyroidism (choice B). Similarly, lithium increases rather than decreases white blood cell count (choice C). Finally, lithium often causes tremor, but not parkinsonism (choice E).

25. (E) Methadone is a typical strong agonist at opioid mu receptors and differs from morphine chiefly in its long duration of binding to the receptor and long elimination half-life. It therefore produces a prolonged opioid effect that causes tolerance to the euphoric action of
short-acting heroin and morphine. Methadone has no opioid antagonist action (choice C), nor does it act on metabolic pathways (choice D), serotonin receptors (choice B), or dopamine receptors (choice E).

26. (E) Naltrexone is a very long-acting opioid antagonist that has also been shown to reduce craving and dependence in smokers and alcoholics. The mechanisms for the latter effects are not fully understood. Bupropion (choice A) is an antidepressant that has some efficacy in tobacco dependence. It is not an opioid antagonist. Flumazenil (choice B) is a benzodiazepine antagonist that is useful in BDZ overdose. It has no opioid antagonist effect. Nalbuphine (choice C) is an opioid partial agonist that has analgesic effects but can also antagonize the actions of strong agonists like morphine. Naloxone (choice D) is a short-acting opioid antagonist but has not been shown to have efficacy in tobacco or alcohol dependence.

27. (D) Phencyclidine, an NMDA receptor antagonist, is a more violent hallucinogen than most other drugs in this class (LSD, mescaline, scopolamine). It causes sympathetic discharge and muscle twitching; nystagmus is very common. Amphetamine (choice A) is a sympathomimetic stimulant that can produce hallucinations or toxic psychosis in overdose, but is not usually associated with nystagmus. Heroin (choice B) is a depressant drug and does not present with combative stimulation. Pupils are constricted by opioids. LSD (choice C) is a classical hallucinogen, but does not commonly cause combativeness or nystagmus. Scopolamine (choice E) similarly does not usually cause combativeness or nystagmus. Both LSD and scopolamine cause mydriasis.

28. (E) All of the beta-lactam antibiotics (penicillins, cephalosporins, carbapenems, monobactams) inhibit one of the final steps in the synthesis of the bacterial cell wall, cross-linking of peptidoglycan chains by transpeptidase. Alanine racemase (choice A) is inhibited by cycoloserine, which is used in the treatment of *M. tuberculosis*. Beta lactamase (choice B) is inhibited by drugs (e.g., clavulanic acid, sulbactam, tazobactam) used to prevent resistance by bacteria that possess it. Enolpyruvate transferase (choice C) is inhibited by fosfomycin, which is used for urinary tract infections. Transglycosylase (choice D), another enzyme important in cell wall cross linking, is inhibited by vancomycin.

29. (A) Amphotericin B binds selectively to ergosterol and forms artificial pores in fungal membranes. These pores result in loss of homeostasis and death of the fungal cell. Caspofungin (choice B) is a member of the echinocandins, the newest antifungal antibiotics. These agents disrupt the fungal cell wall by inhibiting the synthesis of beta(1-3) glucan. Fluconazole (choice C) and other azoles (ketoconazole, itraconazole, voriconazole, posaconazole) inhibit ergosterol synthesis. Griseofulvin (choice D) interferes with microtubule function and cell division in fungi. Terbinafine (choice E) inhibits squalene epoxidase in fungi and reduces ergosterol synthesis.

30. (D) Ketoconazole is a potent inhibitor of the cytochrome P450 enzyme, CYP 3A4. Because CYP 3A4 is involved in the metabolism of almost 50% of the drugs in use, ketoconazole is implicated in many pharmacokinetic drug interactions. Amphotericin B (choice A) causes nephrotoxicity and may therefore interfere with the excretion of other drugs. Caspofungin (choice B) appears to be free of most drug interactions. Fluconazole (choice C), although a member of the same (azole) group as ketoconazole, is much less potent as a CYP 3A4 inhibitor and is associated with far fewer drug interactions. Flucytosine (choice E) is associated with few pharmacokinetic drug interactions, but by metabolism to fluorouracil it is toxic to the bone marrow and other rapidly dividing cells.

31. (B) Infliximab is a chimeric monoclonal antibody that binds TNF-alpha and is useful in rheumatoid arthritis, ulcerative colitis, and several other immune diseases. Leflunomide (choice A) inhibits ribonucleotide synthesis and thereby reduces T-cell proliferation. Methotrexate (choice C) is an antimetabolite
that inhibits cell proliferation. It is useful in rheumatoid arthritis. Paclitaxel (choice D) is a microtubule-binding agent that is cytotoxic in certain neoplasms and slows restenosis in coronary stents. It is not used in autoimmune diseases. Trastuzumab (choice E) is an antibody to the human epidermal growth factor receptor and is useful in metastatic breast cancer.

32. (B) Cyclosporine and tacrolimus (not listed) are associated with nephrotoxicity as a major adverse effect. Antilymphocyte globulin (choice A) is associated with foreign protein reactions, including anaphylaxis. Mycophenolate mofetil (choice C) causes GI disturbances and myelosuppression. Prednisone (choice D) causes a variety of chronic toxicities conveniently summarized as “Cushingoid effects” but has little acute toxicity. Sirolimus (choice E) is associated with bone marrow suppression.

33. (E) The glitazone drugs (pioglitazone, rosiglitazone) reduce insulin resistance in peripheral tissues by activating the PPAR-gamma receptor, which promotes glucose uptake and utilization. Acarbose (choice A) interferes with the action of intestinal alpha-glucosidases and reduces absorption of glucose. Glyburide (choice B) and other sulfonylurea hypoglycemic drugs block the ATP-activated potassium channel in pancreatic cells and cause increased insulin release. Insulin lispro (choice C) is a modified insulin with rapid onset and offset of action. All insulins act by causing insertion of glucose transporters into cell membranes and several other mechanisms. The mechanism of action of metformin (choice D) and similar biguanide antidiabetic drugs is still unclear but may involve reduction of glucagon release, stimulation of glycolysis in peripheral tissues, or decreased hepatic and renal gluconeogenesis.

34. (B) Methimazole (and other thioamides) act primarily by inhibiting thyroid peroxidase, the critical enzyme in iodine organification. They also inhibit coupling of iodotyrosines in thyroglobulin. They do not block iodine uptake by the gland. Block of iodine uptake by the thyroid (choice A) is a property of antithyroid anions such as thiocyanate (SCN⁻) and perchlorate (ClO₄⁻). Inhibition of peripheral conversion of T₄ to T₃ (choice C) is the mechanism of beta blockers and iodine-containing radio-opaque drugs such as ipodate. Block of peripheral thyroid receptors (choice D) is not a mechanism of any currently available drug. Block of thyroglobulin proteolysis and reduced release of thyroxine from the gland (choice E) is a property of iodide ion.

35. (C) Edema and hypertension will occur with any corticosteroid that has mineralocorticoid properties if given in high dosage over a long period. Prednisone, though much less potent than cortisol as a mineralocorticoid, retains some salt-retaining potency. Newer glucocorticoids, such as dexamethasone and triamcinolone, are much less likely to retain salt and water. Buffalo hump (choice A) and moon facies (choice D) reflect the fat metabolism effects of glucocorticoid activity. Easy bruising (choice B) and striae reflect the catabolic action of glucocorticoids on proteins. The mechanism of central nervous system dysfunction (choice E) is not understood, but it is associated with glucocorticoid, not mineralocorticoid, activity.

36. (B) Glucocorticoids help accelerate maturation of the lungs in the fetus at the end of term. In preterm labor, these drugs help prevent respiratory failure in the newborn. Betamethasone is the preferred corticosteroid for this purpose because it is poorly bound in the maternal serum and transfers into the fetal circulation more readily. The other drugs listed (choices A, C–E) are of no value in this setting.

37. (B) Increased clotting factor synthesis (and decreased antithrombin III synthesis) caused by estrogens are the major factors responsible for increased incidence of thromboembolic phenomena. Glucose tolerance is impaired (choice A) in some women by progestins and would not be expected to affect clotting. Plasminogen (choice C) is increased by estrogens, not progestins, but would decrease clotting. Thyroxine-binding globulin (choice D) is also increased by estrogen, but would have little effect on clotting. Triglycerides (choice E)
are increased by estrogens and would have little or no effect on clotting.

38. (D) Although there are several forms of vitamin D and both vitamin D and parathyroid hormone act on the intestine, kidney, and bone, the net effect of vitamin D is to increase serum calcium and phosphate, while parathyroid hormone increases serum calcium and decreases phosphate. None of the other options (choices A–C, E) correctly reflects the actions of vitamin D or parathyroid hormone.

39. (D) When a person who is exposed to chemicals in the workplace is intoxicated, both drugs of abuse and workplace exposures must be considered. The signs of this patient’s intoxication match the classic picture of cholinesterase inhibitor poisoning as summarized by the mnemonic “dumbells:” diarrhea, urination, miosis, bronchospasm, excitation, lacrimation, and sweating and salivation. Isobutyl nitrite (choice A), an industrial chemical also used as a recreational drug for sex enhancement, causes tachycardia, methemoglobinemia, and signs of tissue hypoxia. Mercury (choice B) causes chemical pneumonitis and pulmonary edema. Chronic mercury exposure causes behavioral abnormalities. Morphine (choice C) causes miosis but reduces gastrointestinal activity. Phencyclidine (choice E) causes hallucinations, combativeness, and sympathetic discharge.

40. (C) Methotrexate in very low dosage has proven effective in slowing the progression of rheumatoid arthritis and has low toxicity. It is also one of the most effective (in much higher dosage) antimetabolite cancer chemotherapeutic drugs used in choriocarcinoma. Cyclosporine (choice A) is not used in either condition but is a first-line drug in transplant immunopharmacology. Hydroxychloroquine (choice B) is a disease-modifying antirheumatoid arthritis drug, but has no efficacy in the treatment of cancer. It is more toxic and less effective in rheumatoid arthritis than methotrexate. Sulfasalazine (choice D) is also effective in slowing the progression of joint damage in rheumatoid arthritis but has no efficacy in cancer. Thalidomide (choice E) is effective in erythema nodosum leprosum and multiple myeloma but has not been demonstrated to be effective in rheumatoid arthritis or choriocarcinoma.

41. (C) Ezetimibe is an important newer drug that inhibits cholesterol and bile acid absorption from the gut by inhibiting the epithelial transport protein NPC1L1. Atorvastatin (choice A) reduces both LDL and triglycerides, but does not inhibit VLDL secretion. Cholestyramine (choice B) inhibits the reabsorption of bile acids and cholesterol from the gut and actually increases triglycerides in some patients. Gemfibrozil (choice D) activates lipoprotein lipase in peripheral tissues and reduces VLDL levels and triglycerides. It does not reduce hepatic secretion of VLDL. Niacin (choice E) is the most effective drug available for reducing triglycerides and also reduces LDL cholesterol by reducing the hepatic secretion of its precursor, VLDL particles.

42. (D) Hydroxocobalamin, is one of two forms of vitamin B₁₂, the specific drug that reverses both the macrocytic anemia and the neurologic defects of pernicious anemia. (Cyanocobalamin is equivalent.) Beta carotene (choice A) and vitamin E (choice E) are of no value in anemia, nor do they reverse the neurological defects of pernicious anemia. Ferrous sulfate (choice B) is the first-line drug for the treatment of iron-deficiency anemia, the most common type of anemia. It is of no value in pernicious anemia. Folic acid (choice C) is effective in reversing the anemia of vitamin B₁₂ deficiency, but does not prevent the neurological complications of the disease.

43. (D) Magnesium hydroxide is an osmotic laxative that retains water in the lumen of the colon. Cascara (choice A) is a naturally occurring plant product that stimulates the bowel and causes evacuation within 6–12 hours when given orally. Docusate (choice B) is a stool-softening agent that acts entirely within the lumen. Glycerine (choice C), given by suppository, is a stool softener. Senna (choice E) is a stimulant and bulk-forming agent that increases the volume of the stool and stimulates evacuation.
44. (D) Paclitaxel (choice D) is a plant alkaloid that interferes with microtubule disassembly. Busulfan (choice A) and cisplatin (choice B) are alkylating agents that interfere with DNA mobilization and replication. Mercaptopurine (choice C) is an antimetabolite that interferes with purine synthesis. Vinblastine (choice E) and vincristine and vinorelbine are mitotic poisons that prevent cancer cell division by interfering with microtubule assembly and thus immobilizing the mitotic spindle apparatus. Their indications and toxicities are quite different from those of paclitaxel.

45. (C) Losartan and several other drugs block the action of angiotensin II at its primary cardiovascular target, the AT1 receptor. They are therefore useful in hypertension and heart failure. Bradykinin (choice A) is a vasodilator peptide. It is not therapeutically useful because of undesirable side effects. Enalapril (choice B) is an ACE inhibitor and reduces the production of angiotensin II from angiotensin I. Ondansetron (choice D) is a 5-HT3 receptor antagonist used to prevent chemotherapy-induced and postoperative vomiting. Prazosin (choice E) is an alpha-1-selective blocker used in hypertension and benign prostatic hyperplasia.

46. (A) ACE inhibitors decrease ventricular preload and afterload through the inhibition of ACE and the consequent decrease in production of the pressor peptide angiotensin II, along with prolongation of the actions of the vasodilator peptide bradykinin (which is normally degraded by ACE). ACE inhibition also reduces angiotensin II-dependent augmentation of sympathetic nervous system activity. Choice B is incorrect in that ACE inhibitors exert no direct effects on coronary perfusion. Choice C is incorrect because efficiency of oxygen extraction by muscle is unaffected by ACE inhibitors. Choice D is incorrect because ACE inhibitors exert no direct effects on cardiac force or rate. Use of ACE inhibitors reduces ventricular remodeling and compensatory enlargement (choice E), a very valuable effect in heart failure.

47. (B) Rapid worsening of pulmonary congestion is suggestive of life-threatening acute cardiac decompensation (acute heart failure). Furosemide, a loop diuretic, is one of the most effective agents available because it has powerful diuretic action and also reduces pulmonary vascular pressures. Amiloride (choice A) is a much less efficacious diuretic with primary action in the collecting tubule of the nephron and little or no effect on pulmonary vessels. Hydrochlorothiazide (choice C) is a diuretic of intermediate efficacy that acts in the distal convoluted tubule. Losartan (choice D) is an angiotensin receptor blocker and is not effective in acute reduction of congestive symptoms. Metoprolol (choice E) is a beta-adrenoreceptor blocker that is valuable in the long-term, chronic therapy of HF, but not effective (and usually contraindicated) in acute decompensation.

48. (C) Hepatic intracellular cholesterol levels are tightly controlled through regulation of endocytotic uptake of cholesterol within LDL particles, de novo synthesis of cholesterol, incorporation into VLDL particles, and loss due to conversion to bile acids. Inhibition of cholesterol biosynthesis through statin inhibition of the enzyme 3-hydroxy-3-methylglutaryl-CoA reductase (HMG-CoA reductase) lowers intracellular cholesterol levels. This lowering results in increased expression of the genes for the LDL receptor and HMG-CoA reductase. Increased expression of LDL receptors leads to increased endocytic uptake of LDL particles from the blood and consequent reduction of circulating levels of LDL cholesterol. Choice D is incorrect because the statins do not affect hepatic VLDL secretion. Inhibition of VLDL secretion is probably the mechanism of action for nicotinic acid in lowering VLDL and LDL. Choice E is incorrect because the statins do not affect lecithin:cholesterol acyltransferase (LCAT) activity. Binding to PPAR-alpha and activation of lipoprotein lipase (choice A) appears to be the mechanism for lowering elevated VLDL levels by the fibric acids such as gemfibrozil. Bile acid-binding resins such as cholestyramine promote increased fecal excretion of bile acids (choice B) and ultimately lead to increased expression of hepatic LDL receptors.
49. **(D)** Unregulated herbal preparations are in heavy use by the public and several have been documented to interact with regularly prescribed drugs. Kava (choice D) has sedative actions and interacts additively with sedative-hypnotics and sedative-antihistaminics. Echinacea (choice A) has no reported drug interactions to date but many preparations contain alcohol, which may increase sedation with alcohol-containing beverages. Gingko biloba (choice B) has antiplatelet activity and should not be used with aspirin or other antiplatelet drugs. Ginseng (choice C) may cause CNS stimulation and should not be used by patients with epilepsy and those taking psychoactive drugs. St John’s wort (choice E) may inhibit metabolism of certain drugs.

50. **(B)** The apparent volume of distribution is calculated using the equation \( V_d = \frac{X}{C} \), where \( V_d \) is the volume of distribution, \( X \) is the amount of drug present in the body, and \( C \) is the plasma (or blood) concentration. We must use time 0 for our calculations because this is the only time at which we know the amount of drug in the body; after administration it is immediately subjected to elimination. The curvature seen in the early data points results from distribution of the drug from blood into tissue compartments. The linear portion of the data reflects the elimination process and must be extrapolated back to time 0 to determine the plasma concentration that would have been obtained if distribution had been instantaneous. The administered dose of 10 mg divided by the extrapolated plasma concentration of 1000 ng/mL (1 mg/L) yields an apparent \( V_d \) of 10 L. Volume of distribution is a useful parameter that describes the relationship between the administered dose and the resulting plasma concentration. It is used for calculating loading doses.

51. **(C)** Using the extrapolated linear portion of the data, the concentration at time 0 is 1000 ng/mL. By definition, the elimination half-life is the time interval for a 50% reduction in concentration for single-dose drug disappearance under conditions when the drug disappearance is controlled by the elimination process. The plasma concentration of 500 ng/mL is achieved after 3 hours. The elimination half-life provides information necessary for calculation of the dosing interval for maintenance dosing regimens that achieve and maintain the plasma concentration at a specified concentration without excessive swings in the concentration. Half-life can also be calculated if both volume of distribution and clearance are known from the equation \( t_{1/2} = V_d \times 0.693 \) per CL, where 0.693 is the natural logarithm of 2.

52. **(D)** By inspection of the graph, it is observed that administration of sodium bicarbonate increases the rate of elimination of the drug (the slope of the line increases and the half-life is shortened). Sodium bicarbonate causes alkalinization of the urine. Alkalinization causes increased ionization of weak acids and accelerates their urinary excretion because the ionized (charged) forms cannot be easily reabsorbed through the tubular epithelium, whereas the uncharged forms of many weak acids are readily reabsorbed. Urinary alkalinization is a strategy sometimes used to hasten the excretion of weak acids, such as aspirin, in overdose situations. Excretion of a nonelectrolyte (choice A) is unaffected by changes in urinary pH because the polarity of nonelectrolytes is insensitive to pH. A strong acid (choice B) is fully ionized (unprotonated) at all attainable urinary pH values so that alteration of urinary pH has no effect on its excretion. A strong base (choice C) is similarly fully charged at all attainable urinary pH values so that alteration of urinary pH has no effect on its excretion. Excretion of a weak base (choice E) is slowed by alkalinization of urinary pH because the uncharged form of a base is readily reabsorbed from the tubular urine predominates.

53. **(A)** Immediate administration of one aspirin tablet by mouth (choice A) has been shown to reduce morbidity and mortality from myocardial infarction. Because this dose is essentially free from adverse effects, this therapy is appropriate even before the diagnosis is confirmed by ECG or other means. Dobutamine (choice B) is a beta-1-selective agonist that has positive inotropic action. It is not appropriate at this
time because there is no evidence of heart failure. Lidocaine (choice C), an antiarrhythmic, is not appropriate at this time because the patient is in sinus rhythm with only occasional arrhythmic beats. Metoprolol (choice D), a beta-blocking drug, is often used after the acute period of a myocardial infarction, but is inappropriate until the patient’s condition is stabilized. Streptokinase (choice E), a thrombolytic agent, is inappropriate because coronary thrombosis has not been confirmed and this IV drug is given in the hospital setting.

54. (C) The description of the patient’s reduced cardiac function and elevated left ventricular filling pressure, with reduced peripheral perfusion (clouded mentation, reduced urine output) indicates cardiogenic shock, decreased blood pressure due to decreased cardiac output. In cardiogenic shock, a drug is needed that increases myocardial contractility without increasing heart rate and peripheral resistance. In addition, renal artery dilation is desirable to prevent renal shutdown. Dopamine (choice C), an agonist at dopamine, beta-, and alpha-adrenoceptors, increases myocardial contractility with little increase in peripheral resistance and lower renal arterial resistance. Atenolol (choice A), a beta-1-selective blocker, is inappropriate in the setting of reduced cardiac function, although it may be quite appropriate later when the patient’s condition is stabilized. Digoxin (choice B), a cardiac glycoside, may increase cardiac contractility but has a slow onset of action and may exacerbate arrhythmias. Norepinephrine (choice D) increases myocardial contractility but also greatly increases peripheral resistance, a situation that must be avoided in cardiogenic shock. Procainamide (choice E), a group IA antiarrhythmic agent, is not indicated because the patient does not have an arrhythmia.

55. (E) Leuprolide is a GnRH agonist that when given in pulsatile fashion stimulates pituitary LH release, but when given continuously, or in a depot preparation, suppresses LH release and reduces plasma testosterone levels to castration levels. Because it is a peptide, it must be given parenterally. It is used extensively in the treatment of metastatic prostate cancer. Diethylstilbestrol (choice A) is an oral nonsteroidal synthetic estrogen that is now rarely used in the treatment of prostate cancer. Use of this agent produces undesirable feminization and is reserved for cases unresponsive to other agents. Finasteride (choice B) is an orally active inhibitor of the 5-alpha-reductase that converts testosterone to dihydrotestosterone in the prostate. Because conversion of testosterone to dihydrotestosterone is essential for the androgenic effects in the prostate, inhibition of the 5-alpha-reductase decreases the stimulation of the prostate. Unfortunately, the drug has limited efficacy in prostate malignancy. Finasteride is used for the treatment of benign prostatic hyperplasia because it produces a moderate decrease in prostate size and improvement in urinary flow. It is also used for the treatment of androgenic hair loss. Flutamide (choice C) is a nonsteroidal antiandrogen occasionally used in the treatment of prostate cancer that is unresponsive to leuprolide. It is active orally. Ketoconazole (choice D) is an oral antifungal agent that has the property of inhibiting the cytochrome P450 isoforms involved in steroid biosynthesis. It has been used in the treatment of prostate cancer with mixed results.

56. (B) The recorded transmembrane potential indicates that the new drug has no effect on the upstroke velocity but prolongs the action potential duration of the ventricular muscle fiber. This effect is characteristic of blocking potassium (I\textsubscript{K}) channels that open during repolarization, actions shown by group III antiarrhythmic drugs such as ibutilide. Adenosine (choice A) hyperpolarizes AV nodal cells and blocks propagation of impulses through this part of the heart. It does not prolong the action potential. Lidocaine (choice C) is a group IB drug and slows upstroke velocity as well as prolongs the action potential. Propranolol (choice E), a beta blocker, is a group II drug and has little effect on ventricular cell action potentials at clinically relevant concentrations.
57. (A) Foreign material (such as a stent) in blood vessels invites clotting and the stented vessel will rapidly occlude if clotting is not prevented. The primary process in the formation of this arterial clot is platelet aggregation, so an antiplatelet drug such as clopidogrel is suitable (choice A). Abciximab and tirofiban are also sometimes used in this setting. Heparin (both forms, choices B and C) and warfarin (choice E) are useful in the prevention of venous thrombosis. t-PA (choice D) is useful in accelerating the dissolution of a fibrin clot (e.g., after myocardial infarction), but is not useful in this situation.

58. (D) Proguanil is a prodrug that is converted to cycloguanil, an inhibitor of malarial dihydrofolate reductase. Amodiaquine (choice A) and chloroquine (choice C) are similar and probably interfere with metabolism of heme in the vacuoles of the parasite. Mefloquine (choice C) and quinine (choice E) have unknown mechanisms of action but are not folate antagonists.

59. (B) Didanosine causes pancreatitis in a significant number of patients treated for AIDS. Amantadine (choice A) is used in the prevention and treatment of influenza and causes CNS stimulation and light headedness. Ribavirin (choice C) is used for the treatment of respiratory syncytial virus in infants and causes dose-dependent hemolytic anemia in about 10% of patients. Ritonavir (choice D), a protease inhibitor used in AIDS, causes hepatitis. Zidovudine (choice E), another drug used in AIDS, causes neutropenia as its primary dose-limiting effect.

60. (A) Acyclovir is an acyclic guanine nucleoside analog that undergoes activation by phosphorylation by herpesviral thymidine kinase (but not the host thymidine kinase) to form the acyclovir triphosphate form and causes DNA chain termination. Amantadine (choice B) is a tricyclic amine that inhibits uncoating of influenza A virus. It is also used for the treatment of parkinsonism. Foscarnet (choice C) is a pyrophosphate analog that inhibits herpesvirus nucleic acid synthesis at the level of the viral DNA polymerase. Saquinavir (choice D) is an HIV protease inhibitor. Zidovudine (choice E) is an antiretroviral thymidine analog. The triphosphate is a competitive inhibitor of reverse transcriptase and a DNA chain terminator. The monophosphate is a competitive inhibitor of thymidine kinase.

61. (C) Resistance to tetracyclines such as doxycycline (choice C) is associated with production of an efflux pump or alteration of the 30S ribosomal-binding site. Resistance to beta lactams such as amoxicillin (choice A) usually results from production of beta lactamase. Macrolides such as clarithromycin (choice B), erythromycin, and azithromycin bind to the 50S ribosome in susceptible organisms and prevent protein synthesis. Simple methylation of the binding site prevents the bacteriostatic action of these drugs and many bacteria have such mutation. Resistance to aminoglycosides such as gentamicin (choice D) is usually due to synthesis of inactivating enzymes by the bacteria. Resistance to vancomycin (choice E) is still unusual but can occur through the modification of the D-ala-D-ala-binding site in peptidoglycan.

62. (C) Rifampin selectively inhibits bacterial DNA-dependent RNA polymerase. It is very useful in treating mycobacterial infections since it can penetrate cells and kill intracellular organisms. It is one of the most potent inducers of cytochrome P450 known, leading to increased hepatic clearance of many other drugs including the oral anticoagulants, cyclosporine, propranolol, digitoxin, corticosteroids, and oral contraceptives. Ethambutol (choice A) is often combined with isoniazid in antitubercular regimens. Clearance is primarily via renal excretion. Isoniazid (choice B) is the most widely used antitubercular agent. It functions by inhibiting mycolic acid biosynthesis. Isoniazid is cleared by metabolism via N-acetylase and hydrolytic activity. Streptomycin (choice D) was the first effective drug for the treatment of tuberculosis, but, because of its ototoxicity and nephrotoxicity and the development of less toxic agents, use of streptomycin is limited to more severe forms of the disease. Sulfisoxazole (choice E) may rarely be used in
antitubercular regimens in combination with other drugs. Clearance is primarily via glomerular filtration.

63. **(D)** Losartan causes renal damage in the fetus, and renal impairment in renovascular disease. It is contraindicated in pregnancy. Clonidine (choice A) causes some sedation and rebound hypertension when stopped suddenly, but is not contraindicated in pregnancy. Hydralazine (choice B) causes a reversible type of lupus erythematosus. Hydrochlorothiazide (choice C) may cause hypokalemia, dilutional hyponatremia, elevated lipids, hyperuricemia, and glucose intolerance. Methyldopa (choice E) causes sedation and formation of red blood cell antibodies, but has been shown to be safe in pregnancy.

64. **(C)** Losartan, an AT<sub>1</sub> receptor-blocking agent, has effects in hypertension similar to those of ACE inhibitors but causes a much lower incidence of cough. Captopril (choice A) and other ACE inhibitors cause a dry cough in 5–20% of patients. This may be due to accumulation of bradykinin as a result of ACE inhibition; ACE also metabolizes bradykinin. The cough disappears with cessation of ACE inhibitor treatment. Pretreatment with aspirin reduces its frequency and severity in some patients. Clonidine (choice B), the centrally acting alpha-2-receptor agonist, produces sedation and xerostomia but not cough. The alpha-1-receptor antagonist prazosin (choice D) produces postural hypotension but not cough. The beta-blocker propranolol (choice E) may produce a variety of side effects including precipitating heart failure and asthma in susceptible patients. It does not cause cough. Propranolol has been used by musicians to control palpitations associated with stage fright.

65. **(B)** Cisplatin binds to DNA where it forms intra- and interstrand crosslinks. Cisplatin is particularly effective in testicular and ovarian cancers in combination with other antitumor agents. Cisplatin exerts a renal toxicity that may be prevented by the infusion of saline to maintain a high urine flow. Ootoxicity involving high-frequency hearing loss is an effect that is not prevented by hydration. The natural product bleomycin (choice A) binds to DNA and causes single- and double-strand breaks, leading to cytotoxicity. The drug is particularly useful against Hodgkin lymphoma and testicular tumors. Bleomycin has the serious toxicity of pulmonary fibrosis. Cyclophosphamide (choice C) is widely used in combination regimens. Nausea and vomiting are the most common toxicities. Hemorrhagic cystitis may be minimized by hydration and use of the drug mesna. Note that this toxicity is not at the level of the kidney. The pyrimidine analog 5-fluorouracil (5-FU) (choice D) is used to treat a wide variety of carcinomas. Toxicity from 5-FU is expressed as GI disturbances (anorexia, nausea, stomatitis, and diarrhea) and myelosuppression. Paclitaxel (choice E) is particularly useful in treating metastatic breast and ovarian cancer. The primary toxicity of paclitaxel is bone marrow suppression.

66. **(D)** The pyrimidine analog 5-fluorouracil (5-FU) is metabolized by ribosylation and phosphorylation to the nucleotide level (F-UMP). F-UMP is further metabolized to F-dUMP, an inhibitor of thymidylate synthase. Cells then become starved for TTP and incorporate F-dUTP and dUTP in its place in DNA. 5-FU also becomes incorporated in RNA, leading to inhibition of RNA processing. Anastrozole (choice A) is a nonsteroidal inhibitor of aromatase, an enzyme required for synthesis of estrogens. This drug is useful against advanced estrogen or progesterone receptor-positive breast cancer. Cytarabine (cytosine arabinoside, ara-C, choice B), is an S-phase-specific antimetabolite that is metabolized to the triphosphate form, which blocks DNA synthesis. It is used exclusively in acute myelogenous leukemia. Doxorubicin (choice C) is an anthracycline antibiotic that intercalates into DNA causing strand breakage and blockage of both DNA and RNA synthesis. This agent is widely used in combination regimens for breast, endometrial, ovarian, testicular, and thyroid carcinomas, and several sarcomas and lymphomas. Imatinib (choice E) is an inhibitor of the tyrosine kinase activity of the Bcr-Abl oncogene product. It is a drug of choice in chronic myelogenous leukemia with the Philadelphia chromosome translocation.
67. (B) Etoposide is a semisynthetic derivative of podophyllotoxin, a constituent of the mandrake plant. Etoposide is an inhibitor of topoisomerase II, an enzyme that relaxes supercoiled DNA by breaking one strand and passing the second strand through the break before closing the break. Etoposide inhibits the closure step and results in an accumulation of DNA strand breaks, leading to cell death. Etoposide is used to treat testicular tumors and small cell carcinoma of the lung in combination with cisplatin. Leukopenia is the dose-limiting toxicity seen with this drug. Dacarbazine (choice A) is a synthetic prodrug activated in the liver to a metabolite that alkylates DNA leading to cytoxicity. The drug is useful against melanoma and Hodgkin lymphoma. Lomustine (CCNU, choice C) is a lipid-soluble nitrosourea agent that acts as an alkylating agent. The nitrosoureas are unusual in having relatively good access to the CNS and are therefore useful in treating brain tumors. Prednisone (choice D) is a potent, orally active corticosteroid with good lymphotoxic potency. Its mechanism is not fully understood but may involve activation of apoptotic pathways in lymphocytes. Vincristine (choice E) is a natural product isolated from the vinca plant. It is classified as a spindle poison and inhibits mitosis by inhibiting microtubule assembly. This drug is particularly useful in treating acute leukemias in children and Hodgkin lymphoma.

68. (B) This patient’s presentation is typical of glucocorticosteroid toxicity (iatrogenic Cushing syndrome). Prednisone is an effective corticosteroid frequently used by mouth to control severe asthma that is not responsive to inhaled corticosteroids. High doses of prednisone, given chronically, very predictably cause signs and symptoms of hypercorticism. Ipratropium (choice A) is an antimuscarinic agent used in asthma by inhalation. Salmeterol (choice C) is a long-acting beta-2-selective agonist used by inhalation. Terbutaline (choice D) is a short-acting beta-2-selective agonist, also used by inhalation. Theophylline (choice E) is an oral drug that causes CNS stimulation (including convulsions in toxic overdosage), but not hypercorticism.

69. (C) Long-term treatment of schizophrenia with potent dopamine D2 receptor antagonists is associated with a high incidence of the irreversible extrapyramidal dystonias called tardive dyskinesia. The phenothiazines (and haloperidol) are D2 receptor antagonists in the CNS; their success in the treatment of schizophrenia resulted in the hypothesis that the antipsychotic effect requires D2 blockade. Data from newer, atypical antipsychotic agents casts some doubt on this hypothesis because drugs, such as clozapine and risperidone, have a low affinity for D2 receptors. Older drugs in the phenothiazine class (e.g., chlorpromazine) have both antimuscarinic and antiemetic action; thus diarrhea, nausea, and vomiting (choice A) are very unlikely. Because prolactin secretion (choice B) from the anterior pituitary is inhibited by dopamine, blockade of D2 receptors by fluphenazine increases prolactin secretion. This may result in breast engorgement and galactorrhea in women. Tourette syndrome (choice D) involves tics and other involuntary movements and obscene vocalizations. The neuroleptic agent haloperidol is the current drug of choice for the treatment of this disease. Weight loss (choice E) is associated with the use of selective SSRIs, not phenothiazines. In fact, the phenothiazines are often associated with weight gain.

70. (B) Clozapine causes agranulocytosis in a small but consistent fraction of patients; monitoring is mandatory. Buspirone (choice A) is an antianxiety agent with minimal sedative action. Haloperidol (choice C) is an older, highly potent antipsychotic drug used in schizophrenia. Lithium carbonate (choice D) is an important antimanic drug. It apparently acts by interfering with inositol phosphate cycling and second messenger synthesis in neurons. Mirtazapine (choice E) is a third-generation antidepressant related to antihistaminics and has significant sedative action.

71. (D) All of the agents listed are useful antidepressants but only mirtazapine has significant sedative effects.

72. (A) Inhaled albuterol (or other beta-2-selective receptor agonists including bitolterol,
metaproterenol, pirbuterol, and terbutaline) are the usual agents of choice for treating bronchoconstriction in an acute asthma attack. These beta-2-selective agonists produce bronchial relaxation by stimulating cyclic AMP (cAMP) formation in bronchiolar smooth muscle and cause less tachycardia than nonselective beta agonists. Unfortunately, they do cause some tachycardia and skeletal muscle tremor. Aminophylline (choice B) and other methylxanthines are rarely used to terminate acute episodes of asthma because they must be administered parenterally for rapid onset of effect. Cromolyn sodium (choice C) must be used prophylactically to prevent acute episodes and probably acts by stabilizing mast cells. It is not a smooth muscle relaxing agent and is not effective in reversing bronchospasm. Inhaled ipratropium (choice D) has less general efficacy in acute attacks than beta agonists. Salmeterol (choice E) is an effective beta-2-selective agonist but has a slow onset and long duration of action. Therefore, it is used for prophylaxis, not treatment of acute attacks.

73. (A) Allopurinol and its metabolite alloxanthine inhibit xanthine oxidase, thus preventing conversion of xanthine and hypoxanthine to uric acid. Although xanthine and hypoxanthine then accumulate, these compounds are more soluble than uric acid and less likely to deposit in joints or precipitate in the urine. Most doses of aspirin (choice B) increase retention of uric acid, especially low doses. Colchicine (choice C) is an inhibitor of microtubule function that brings relief in an acute gout attack by inhibiting the motility of granulocytes and preventing the formation of mediators of inflammation by leukocytes. Because of its toxicity at higher doses, it is now used chiefly at low doses to prevent acute attacks. Indomethacin (choice D) is an NSAID that inhibits COX and reduces formation of prostaglandins and eicosanoids involved in gouty arthritis. It has no effect on the formation of uric acid and very little on its excretion. Sulfisopyrazone (choice E) and probenecid are uricosuric agents—they increase the excretion of uric acid by the kidney. Renal uric acid excretion is determined by the balance between the amount filtered plus that actively secreted and the amount undergoing passive and active reabsorption. At very low doses, these agents inhibit active secretion and thus promote retention of uric acid. At higher (clinical) doses, both active secretion and active reabsorption are inhibited, with the result that excretion is enhanced.

74. (B) A through C and E are NSAIDs. NSAIDs have long been drugs of first choice in arthritis treatment. Their primary mechanism of action in arthritis appears to be inhibition of COX, an enzyme required for the synthesis of inflammatory and other prostaglandins. Two forms of COX are present in the body: COX-1, which is required for synthesis of several useful prostaglandins (e.g., PGE1, a cytoprotective agent in the stomach), and COX-2, the isoform responsible for synthesis of prostacyclin as well as most of the damaging prostaglandins. Celecoxib is more selective for COX-2 and thus has a lower incidence of adverse GI effects. The older NSAIDs (choices A, C, and E) inhibit both COX-1 and COX-2 with less selectivity and thus reduce protective prostaglandins, resulting in a high incidence of GI disorders, especially peptic ulceration. Misoprostol (choice D) is a PGE1 analog that is used with NSAIDs to reduce peptic ulceration; unfortunately it causes a high incidence of diarrhea.

75. (D) Elevated blood pressure typically evokes a compensatory baroreceptor reflex with slowing of heart rate. Thus, the decrease in heart rate shown in the initial data can be interpreted as a reflex bradycardia. Bethanechol (choice A) is a muscarinic agonist and typically causes vasodilation, with a drop in blood pressure and a compensatory tachycardia. Epinephrine (choice B), an alpha-1-, alpha-2-, beta-1-, and beta-2-agonist, causes hypertension at high doses, but usually also causes tachycardia. Isoproterenol (choice C) is a beta-1-, beta-2-agonist, and does not cause hypertension or bradycardia. Norepinephrine (choice D) and phenylephrine (choice E) can both cause hypertension and reflex bradycardia. However, norepinephrine has beta-1-agonist action, whereas phenylephrine has only alpha effects. Thus, in the presence of an alpha-blocking agent,
norepinephrine causes a beta-1-mediated tachycardia; phenylephrine has no effect on heart rate.

76. (C) As noted in the answer to question 75, the agonist drug in the data presented is the alpha and beta-1 agonist norepinephrine. Prazosin (choice C) is an alpha blocker that prevents the pressor effects of alpha agonists such as norepinephrine and phenylephrine. If norepinephrine’s alpha-agonist effects on the vessels are blocked, its beta-agonist action on the heart becomes evident, causing tachycardia. Phenylephrine, on the other hand, has no beta-agonist effects, and tachycardia does not result. Atropine (choice A) is a muscarinic blocker and does not prevent hypertension due to alpha agonists. Pralidoxime (choice B) is a cholinesterase regenerator used in the treatment of organophosphate insecticide toxicity. Reserpine (choice D) is a blocker of postganglionic sympathetic nerve function (it prevents storage of norepinephrine in transmitter vesicles and depletes the nerve ending of its transmitter stores); it has no effect in the experiment described. Timolol (choice E), a beta blocker, does not prevent the pressor effects of alpha agonists.

77. (A) Esmolol is a very short-acting, parenteral-only beta-blocking drug. Transient arrhythmias such as those occurring during thyrotoxicosis are frequently responsive to the drug. Because the drug must be given parenterally and has duration of action of only 15 minutes, it is unsuited for any chronic condition (choices B–E).

78. (D) The transplanted heart lacks functional innervation for at least 2 years after surgery, and possibly longer. Because the nerves are cut in the procedure, nerve endings degenerate (Wallerian degeneration) and transmitter stores are lost. Adrenoreceptors on the denervated myocardial cells are normal or even increased in sensitivity, so responses to direct-acting beta-adrenoreceptor agonists such as isoproterenol are retained. Indirectly acting sympathomimetics, on the other hand, are relatively ineffective (choices A, B, and C) because they act through the release or amplification of endogenous norepinephrine. Terbutaline (choice E), a selective beta-2 agonist, has less beta-1-agonist activity, and causes less tachycardia than isoproterenol.

79. (B) Histamine activates nitric oxide synthase by binding to H₁ receptors in the endothelium. Nitric oxide synthesis is increased, and this molecule rapidly diffuses into the adjoining smooth muscle, where it causes vasodilation. Diazoxide (choice A) is a powerful vasodilator used in hypertensive emergencies. It acts by opening potassium channels in vascular smooth muscle and hyperpolarizing these cells. Minoxidil (choice C), another vasodilator used in severe hypertension, is converted to the sulfate metabolite, which similarly opens potassium channels and hyperpolarizes vascular smooth muscle. Nitroprusside (choice D) contains nitric oxide that is spontaneously released in the blood. Stimulation of endothelial synthesis is not involved. Verapamil (choice E) blocks calcium channels in vascular smooth muscle and thereby causes relaxation.

80. (B) The benzodiazepine agents, including diazepam, facilitate the actions of the inhibitory neurotransmitter GABA, which acts on GABAₐ receptors to open chloride ion channels. Bupropion (choice A) is probably an inhibitor of norepinephrine and dopamine uptake and does not act on GABA receptors. Fluoxetine (choice C) is a selective inhibitor of serotonin uptake. Pentobarbital (choice D) is a modulator of the same GABA-sensitive chloride channel affected by benzodiazepines, although its mechanism of action is slightly different. Tranylcypromine (choice E) is an inhibitor of MAO rather than catechol-O-methyltransferase (COMT).

81. (C) Ketoconazole is a potent inhibitor of cytochrome P450 isozymes; its antifungal action is the result of inhibition of fungal P450. Atracurium (choice A) is used to produce skeletal muscle relaxation during surgery. Atracurium is eliminated by a spontaneous chemical reaction and by plasma cholinesterases, and is not a substrate or inhibitor of cytochrome P450. Cromolyn sodium (choice B) is not a substrate or inhibitor of cytochrome P450. The extremely
small amounts of this drug that are absorbed are excreted unchanged in the urine and bile. Phenobarbital (choice D) is eliminated by cytochrome P450 metabolism, and is an inducer of drug metabolism activity. Rifampin (choice E) similarly produces many drug interactions because of its ability to induce (rather than inhibit) cytochrome P450 activity.

82. (D) A patient who is anemic, neutropenic, and thrombocytopenic requires stimulation of all three major cell lines in the bone marrow. The only drug currently available that accomplishes this broad-spectrum stimulant effect is sargramostim (granulocyte–macrophage colony stimulating factor [GM-CSF]). Epoetin (choice A) is a more selective stimulant of erythrocyte production and is useful in simple anemia. Filgrastim (choice B) is a somewhat selective stimulant of leukocyte production and has much less effect on erythrocytes and platelet production than sargramostim. Growth hormone (choice C) and testosterone (choice E) have both been tried in the treatment of anemia with negligible success.

83. (A) The blood-gas partition coefficient is a measure of the solubility of the inhalation anesthetic in the blood relative to its solubility in the inspired air. Circulating blood provides the means of anesthetic delivery to the brain and the partial pressure determines the rate of transfer into the CNS. The solubility of an agent in blood determines how rapidly the partial pressure rises in the blood. Agents with high solubility (large blood-gas partition coefficients) require large amounts of the anesthetic to dissolve in the blood before the partial pressure in the blood increases enough to effectively deliver them to the brain. Thus, agents with lower blood solubilities (small blood-gas partition coefficients) have more rapid rates of onset of anesthesia. Desirable properties for inhalation anesthetic agents include high potency and low blood solubility. The halogenated hydrocarbons, such as desflurane and sevoflurane, fit these criteria and are used extensively. The MAC value (median alveolar anesthetic concentration) required for anesthesia (choice B) is a measure of the potency of the agent, but does not give an indication of the rate of onset of anesthesia. Molecular size (choice C) may play a role in determining the blood-gas partition coefficient, but it is only a partial determinant. The oil–water partition coefficient (choice D) is a measure of the lipid solubility of the anesthetic agent. This correlates with the potency as measured by the MAC. Hepatic metabolism (choice E) plays no role in onset of action, but may be important in terms of possible liver and kidney damage resulting from the production of toxic metabolites from some of the halogenated inhaled anesthetic agents.

84. (D) The MAC value for nitrous oxide is 105–110 % (i.e., 5–10% greater than atmospheric pressure), meaning that for nitrous oxide to be used as the sole anesthetic agent, hyperbaric conditions would have to be used to deliver both the nitrous oxide for anesthesia and oxygen needed for life. The other commonly used inhaled agents, including the halogenated hydrocarbons enflurane, isoflurane, halothane, and sevoflurane (choices A, B, C, and E) have MAC values of 6% or less. Although these data might be interpreted to imply that nitrous oxide is not useful in anesthesia, nitrous oxide is very valuable because of its very low toxicity and additive effects with more potent (but more toxic) agents. It is therefore commonly combined with other inhaled agents, especially the halogenated hydrocarbons. For example, 0.5% MAC of nitrous oxide plus 0.5% MAC of isoflurane delivers a full anesthetic concentration of gases to the lungs but requires <60% of the inspired air partial pressure, so oxygen can utilize the other 40%.

85. (B) The agent of choice in treating simple hypothyroidism is levothyroxine (T4). Administered thyroxine is bound in plasma in the same way and metabolized to tri-iodothyronine in the same manner as native thyroxine. Although liothyronine (tri-iodothyronine [T3] choice C) is more active than T4 as an agonist at thyroid hormone receptors, its shorter half-life of 1 day as compared with the 6–7-day half-life of T4 means that thyroxine has a longer duration of action and provides smoother control. The use
of desiccated thyroid (choice A) has been abandoned in the United States because of variations in potency. $T_4$ ($3,5,3',5'$-tetraiodothyronine) is converted by deiodinases to the active $T_3$ ($3,5,3'$-triiodothyronine) and the inactive reverse $T_3$ ($3,3',5'$-triiodothyronine [choice E]) in equal amounts. $T_3$ is used in therapy under special circumstances when immediate thyroid effect is required, but it is not generally used to treat hypothyroidism because of its higher cost and shorter duration of action. At high concentrations, iodide in the form of potassium (choice D) or other salts is an inhibitor of thyroid gland function and is used in hyperthyroidism. Iodide inhibits its own uptake into thyroid cells and inhibits the release of thyroxine and $T_3$ from the gland. Iodide treatment is useful in preparation for surgical thyroidectomy because the gland becomes firmer and vascularity is reduced.

86. (A) Treatment of Liddle syndrome consists of direct inhibition of the abnormally expressed sodium channel by either amiloride (choice A) or triamterene, both of which are classified as potassium-sparing diuretics. Triamterene is less useful than amiloride because of its low potency and low solubility, which may lead to the formation of stones. Fludrocortisone (choice B) is a synthetic mineralocorticoid used for replacement therapy in hypoaldosteronism. Although aldosterone levels are reduced in this patient, administration of a mineralocorticoid will exacerbate rather than relieve the hypertension and hypokalemic metabolic alkalosis. Hydrochlorothiazide (choice C), a thiazide diuretic, will exacerbate the problem because inhibition of the $Na^+/Cl^-$ symporter in the distal convoluted tubule results in delivery of more sodium to the cortical collecting duct, where the hyperactivity of the sodium channel and resulting potassium extrusion along with increased proton exchange from type A intercalated cells results in greater hypokalemia and alkalosis. Lisinopril (choice D) is an ACE inhibitor used in the treatment of essential hypertension. Spironolactone (choice E) is a selective antagonist at the aldosterone receptor. It is used as a potassium-sparing diuretic. In the case of Liddle disease, spironolactone has no utility; aldosterone does not play a causative role and its levels are already depressed.

87. (A) Streptokinase has no intrinsic enzymatic activity, but instead forms a stable complex with the patient’s plasminogen, making it enzymatically active in cleaving free plasminogen to plasmin. The streptokinase–plasminogen complex is not inhibited by antiplasmin. The other thrombolytic agents—t-PA, reteplase, tenecteplase, and urokinase—activate plasminogen directly. Competitive blocking of binding of plasminogen to fibrin (choice B) is a property of aminocaproic acid (AMICAR), a lysine analog used to inhibit fibrinolysis. Conversion of plasmin to plasminogen (choice C) is incorrect; it is plasminogen that is converted to plasmin in the thrombolytic action. Inhibition of cyclooxygenase activity (choice D) is a property of the NSAIDs that contributes to prevention of platelet aggregation and thrombosis. Heparin exerts its anticoagulant actions by providing a template for the combination of thrombin and antithrombin III (choice E).

88. (A) Diplopia, abnormal gait, and other signs of cerebellar dysfunction are important symptoms of phenytoin toxicity. Other manifestations of toxicity include gingival hyperplasia, nystagmus, and vertigo. Hyperprolactinemia (choice B) is an adverse effect of antipsychotic dopamine antagonists such as the phenothiazines; dopamine inhibits prolactin secretion by the anterior pituitary. Polydipsia and polyuria (choice C) are symptoms of diabetes insipidus. These symptoms may be produced by lithium toxicity during treatment of bipolar depression, and are not associated with phenytoin toxicity. Postural hypotension (choice D) is not an adverse effect of phenytoin but often occurs with levodopa treatment of Parkinson’s disease. Rigidity and tremor (choice E) are symptoms of parkinsonism. These symptoms may be produced by dopamine antagonists such as antipsychotic agents, but are not associated with phenytoin toxicity.

89. (D) Saw palmetto is promoted by purveyors of herbs and “alternative medicines” as therapy
for prostatic hyperplasia and does have weak estrogenic activity. Ginseng (choice A) is known as an adaptogen, which means it increases resistance to physical, chemical, and biological stress and builds up energy and general vitality, including the mental and physical capacity for work. Grapefruit juice (choice B) and tomatoes (choice E) are used therapeutically in a treatment regimen referred to as “raw juice therapy.” Raw juices of fruits and vegetables are extremely rich in vitamins, minerals, trace elements, enzymes, and natural sugars. Kava (choice C) is used in herbal therapy to treat anxiety, nervousness, insomnia, stress, and restlessness. Only saw palmetto is known to have any estrogenic activity.

90. (B) The initial atrial fibrillation ECG shows a very rapid ventricular rate, which decreases cardiac output and explains the patient’s shortness of breath. After administration of the drug, the ventricular rate markedly slowed, but QRS duration and QT interval were not altered. This pattern of effects is observed with drugs that selectively slow AV conduction (i.e., beta blockers [antiarrhythmic group 2] and calcium channel blockers [group 4]). Adenosine (choice A) slows or blocks AV conduction but has a very short duration of action (seconds). Disopyramide (choice C) and quinidine (choice E) are group 1A antiarrhythmic drugs and prolong the QRS and QT intervals. Ibutilide (choice D) is a group 3 drug and prolongs the QT interval. Cardiac glycosides such as digoxin also slow AV conduction (through their parasympathomimetic action), but have a slower onset of action than parenteral calcium channel blockers or beta blockers.

91. (C) The total plasma clearance of the drug can be calculated from the relationship $CL = 0.693 \times \frac{Vd}{t_{1/2}}$. The total clearance is therefore $6.93 \times 10 \text{ L} / 7 \text{ h}$ or $0.99 \text{ L} / \text{h}$ (which is equal to 16.5 mL/min). Because we know that the renal clearance is 8.3 mL/min, hepatic metabolism must account for the remaining 8.2 mL/min. Thus, hepatic metabolism accounts for about 50% of the total drug elimination.

92. (D) Tetracyclines such as minocycline chelate cations, such as aluminum and calcium, and may precipitate in the gut, greatly reducing antibiotic bioavailability. The other drugs listed (choices A–C, E) have no significant interactions with antacids.

93. (B) The agents listed are the primary drugs used in the treatment of tuberculosis. Streptomycin (choice E) and other aminoglycosides cause eighth nerve damage, which is often irreversible and may take the form of auditory or vestibular dysfunction. Isoniazid and rifampin are the most efficacious and least toxic, but even when used together are insufficient in many cases to prevent the development of resistance. Therefore, most cases of tuberculosis are treated with three or even four agents in an effort to eradicate the infection before resistance develops. Because each drug has different toxicities, it is sometimes possible to achieve a cure without severe toxicity. Ethambutol (choice A) causes visual dysfunction and possible retinal damage, not hearing loss. Isoniazid (choice B) causes peripheral neuropathies and hepatic damage. Fortunately, hepatitis is uncommon in children treated with this drug. Pyrazinamide (choice C) causes joint pains and swelling, GI upset, and rash. Rifampin (choice D) causes proteinuria, rash, and thrombocytopenia.

94. (E) Vasodilators act by one of three mechanisms: increasing cyclic GMP (cGMP) levels in vascular smooth muscle cells; opening potassium channels; or blocking calcium channels. The organic nitrates and nitroprusside (nitrovasodilators) increase cGMP synthesis by generating nitric oxide (NO), which subsequently activates a soluble form of guanylyl cyclase. Activation of muscarinic receptors on vascular endothelial cells results in formation of NO (earlier identified as endothelium-derived relaxing factor) that diffuses to smooth muscle cells and relaxes them through increased cGMP levels. Erection of the penis involves neuronally regulated formation of NO, increased cGMP levels in the corpus cavernosum, and relaxation of cavernosal and vascular smooth muscle in erectile tissue. Rather than stimulating guanylyl cyclase, sildenafil (Viagra) acts as a selective inhibitor of cGMP phosphodiesterase type 5 to increase the half-life of cGMP.
in the tissues. The fact that sildenafil acts downstream of NO stimulation of guanylyl cyclase accounts for the toxic interactions between it and nitrovasodilators. The mechanism for relaxation of vascular smooth muscle by hydralazine (choice A) is unknown, but may involve NO. Minoxidil (choice B) is metabolized to minoxidil sulfate, which activates an ATP-sensitive potassium channel in smooth muscle. Nitroprusside (choice C) is a nitrovasodilator that spontaneously releases NO by a mechanism distinct from that of the organic nitrates. Prazosin (choice D) produces vasodilation by inhibiting alpha-1-adrenoreceptors on arteriolar smooth muscle.

95. (B) A normally functioning endocrine pancreas provides a low basal level of circulating insulin and spikes of insulin release in response to the ingestion of food and subsequent elevation of blood sugar. In a diabetic, use of morning and evening injections of a very long-acting form such as lente, glargine, or detemir insulin provides a low basal level of circulating insulin. Premeal injections of rapid-acting insulin provide the spikes of circulating insulin needed to deal with the dietary glucose load. Regular insulin or insulin lispro, glulisine, or aspart is needed for this purpose. Insulin detemir and glargine are very long-acting recombinant insulins that are used to provide basal levels. They are of no value for controlling transient hyperglycemic spikes.

96. (E) *P. aeruginosa* is an aerobic gram-negative bacterium that is frequently the causative agent in diabetic malignant external otitis. Increased susceptibility to infection in diabetics with poor glycemic control probably arises through impairment of leukocyte function. Such serious *P. aeruginosa* infections are best treated parenterally with a broad-spectrum beta-lactam cell wall synthesis inhibitor such as ticarcillin in combination with an aminoglycoside such as tobramycin. Chloramphenicol (choice A) is a protein synthesis inhibitor. *P. aeruginosa* is resistant to chloramphenicol. Nafcillin plus kanamycin (choice B) is a combination of a penicillinase-resistant penicillin plus a limited-spectrum aminoglycoside. Nafcillin is useful in treating penicillinase-producing staphylococcal infections, but does not possess a broad-enough antibacterial spectrum to eradicate *P. aeruginosa*. Kanamycin is ineffective against *P. aeruginosa* and is used orally or topically, not parenterally as needed here. Sulfamethoxazole plus trimethoprim (choice C) is a combination of a folate synthesis inhibitor and a dihydrofolate reductase inhibitor that is effective in treating urinary tract infections. *P. aeruginosa* is resistant to this combination. Tetracycline (choice D) is a bacteriostatic protein synthesis inhibitor. When first introduced, tetracycline was effective in treating *Pseudomonas*, but now all strains are resistant.

97. (A) Excellent analgesia and significant addictive properties are associated with drugs that act at mu-type opioid receptors. Of the analgesics listed, codeine is a weak agonist at mu-receptors, whereas the other opioid analgesics listed (choices C, D, and E) are full agonists. Therefore codeine (choice A) is less efficacious but also has the lowest addiction and abuse liability; it is therefore the agent of choice within this list. Diphenoxylate (choice B) is a congener of meperidine (and the primary component of Lomotil) that is used to control GI motility in diarrhea. At therapeutic dose levels, neither analgesia nor addiction is observed. Meperidine (choice C) is a synthetic mu-opioid receptor agonist with high-addiction liability. Methadone (choice D) is a mu-opioid receptor agonist with good oral efficacy and a long plasma half-life (15–40 h). It is used in the treatment of opioid addiction and for severe cancer pain. Morphine (choice E) is the prototype mu-opioid receptor agonist and possesses high addiction liability.

98. (C) The hydroxymethylglutaryl-CoA (HMG-CoA) reductase inhibitor lovastatin and the bile acid-binding resin cholestyramine (choice C) lower the concentration of cholesterol in the blood by different mechanisms. Because they act by different mechanisms, combination therapy is at least additive. The combination of chlorotetracycline and amoxicillin (choice A) results in antagonism of amoxicillin’s antibacterial action. The beta-lactam cell wall synthesis inhibitors
such as the penicillins and cephalosporins are bactericidal, but are effective primarily when the bacteria proliferate rapidly. Tetracyclines are bacteriostatic agents that slow or inhibit the growth of bacterial cells by inhibiting protein synthesis. The combination of clomiphene and chorionic gonadotropin (choice B) does not produce any beneficial additive action. Both agents are used to treat female infertility. Clomiphene is an estrogen-receptor partial agonist that functions at the level of the hypothalamus to stimulate release of gonadotropin-releasing hormone (GnRH). The increased release of GnRH results in increased release of the gonadotropins LH and FSH from the anterior pituitary. This results in stimulation of ovulation. Administration of chorionic gonadotropin also stimulates ovulation. Because both preparations function through increases in gonadotropin levels and both are present at their maximum effective concentrations, a beneficial additive effect is unlikely. The combination of pentazocine and morphine (choice D) does not produce a beneficial interaction. Pentazocine exerts its pain-relieving activity by a weak (partial) agonist action at mu-opioid receptors. Morphine is a full agonist at the same receptors. When the two analgesic agents are combined, pentazocine acts as an antagonist for morphine at mu-receptors. The result is precipitation of withdrawal in addicted patients, and dysphoria and loss of morphine analgesia in non-addicted patients. Succinylcholine and atracurium (choice E) are both skeletal muscle-relaxing agents that block muscle contraction by actions at the neuromuscular junction. Succinylcholine is a depolarizing blocker that acts as an agonist at the nicotinic receptor. Atracurium is a competitive antagonist at the same receptor. Because they both act at the same receptor and are present at their effective concentrations, atracurium interferes with the action of succinylcholine.

99. (B) Drug X has a larger therapeutic index (calculated as TD_{50}/EC_{50}) than drug Y. At a concentration of 1 \times 10^{-5} M (choice A), both drugs produce adverse effects in about 50%, not 90–100% of patients. Drug X is not more efficacious than drug Y (choice C); quantal dose–response data provide no information about maximum efficacy and the question stem states that both drugs produce the samemaximum responses. Drug Y is not more potent than drug X (choice D); it is less potent (it has a higher EC_{50}). Drug Y is not safer than drug X (choice E) from the data presented; if anything, more adverse effects are produced by drug Y at its EC_{50} than by drug X at its EC_{50}.

100. (C) The combination of an ACE inhibitor and a diuretic is rational for this patient with hypertension and mild heart failure as both drugs are effective for both conditions. Furthermore, ACE inhibitors have been shown to slow or stop the progression of heart failure and thiazide diuretics have been shown to be among the cheapest and most effective agents for hypertension. If this combination is not sufficiently active to control the heart failure, a loop diuretic might be substituted for the thiazide. Dobutamine (choice A) is a parenteral drug for acute failure. Hydralazine (choices B, E) is a vasodilator that causes tachycardia and usually requires concurrent administration of a beta blocker. Use of two diuretics (choice D) is probably unnecessary in this early stage of failure and is not the most effective therapy for hypertension.

101. (A) The current drug of choice for acute AV nodal reentrant tachycardia (a supraventricular tachycardia [SVT]) is the nucleoside adenosine. This agent, when given as a bolus, causes marked hyperpolarization of AV node tissue and transiently blocks conduction of AV node action potentials. This abolishes the reentrant impulse and allows normal sinus rhythm to be reestablished. The half-life of adenosine is about 3 seconds and the duration of action of the dose used is about 15 seconds, so toxicities from this therapy are minimal. Calcium channel blockers such as verapamil and diltiazem are also effective in SVT. Bethanechol (choice B) is a muscarinic agonist and produces hypotension and other muscarinic effects. It is ineffective in SVT. Isoproterenol (choice C) is a beta-selective adrenoreceptor agonist that causes hypotension and reflex sympathetic discharge to the heart, along with direct stimulation. It is more likely to cause than to abolish
arrhythmias. Metoprolol (choice D) slows AV conduction and might abolish the AV reentrant rhythm. However, beta blockers are not very effective in converting preexisting SVT. Procainamide (choice E) and related group 1A antiarrhythmic drugs are not as effective as adenosine in converting SVT to normal sinus rhythm and much more toxic.

102. (B) Myasthenia gravis is an autoimmune disease attributable to an impairment of nicotinic receptor function at the neuromuscular junction by antireceptor antibodies. Treatment consists of increasing the junctional concentration of acetylcholine with a carbamate anticholinesterase such as pyridostigmine. Infections such as influenza may change the anticholinesterase dose requirement in myasthenia either up or down. As in this patient, the problem is to distinguish whether the muscle weakness is attributable to myasthenic crisis (too little medication) or cholinergic crisis (too much medication); both conditions cause muscle weakness. The safest definitive method is to administer a small dose of the short-acting anticholinesterase edrophonium (choice B). If the patient is in myasthenic crisis, an immediate improvement in muscle function should be evident. If the patient is in cholinergic crisis, the patient's condition may worsen, but because the duration of action for edrophonium is only 5–10 min, this test provides less risk than other alternatives. Parenteral atropine should be available to treat excess parasympathetic activity. Atropine for symptoms of parasympathetic overdose (choice A) is inappropriate because this patient is being treated with the muscarinic antagonist propantheline and atropine will have no effect on his muscle weakness. Administration of pralidoxime (choice C) is incorrect because pralidoxime is useful for reactivation of cholinesterase only in the case of recent organophosphate intoxication. Administration of pyridostigmine (choice D) is unwise because a patient in cholinergic crisis is put at risk of exacerbation and extension of the toxic episode for a significant period of time. Administration of a test dose of a long-acting agent such as tubocurarine (choice E) to elicit muscle weakness is a provocative test that is dangerous and does not provide definitive evidence for diagnosis.

103. (D) Pain of malignancy is still a badly under-treated condition, due to misunderstanding of the nature of opioid tolerance and addiction and an unwillingness to deal with the complications of prescribing controlled substances. Codeine has limited maximum efficacy, so additional doses of this drug (choice B) are unlikely to control this patient’s pain. It was previously thought that regular use of strong opioids for any purpose inevitably led to tolerance and a loss of analgesic effect, as well as addiction (choice C). However, excellent clinical studies have shown that this is not the case. Regular use (as opposed to as-needed use) of small to moderate doses of opioids effectively controls pain in most cases without causing tolerance or addiction. In fact, restricting opioids to use only when absolutely needed results in larger total analgesia requirements and greater toxicity. Use of NSAIDs (choice A) should be started early, when pain is mild and supplemented with oral opioids, such as codeine, as soon as it becomes necessary. NSAIDs are not adequate at this stage of this patient’s disease. Parenteral morphine, given when necessary (choice E), is not as effective as regularly scheduled morphine and leads to greater drug toxicity.

104. (D) Salivary glands contain muscarinic receptors, primarily of the M₃ subtype, that receive parasympathetic innervation. Direct-acting agonists such as bethanechol and indirect agents such as neostigmine mimic parasympathetic nerve stimulation. Blood vessel endothelial cells contain M₃ receptors that are not innervated, but respond to circulating direct-acting muscarinic agonists. When these endothelial receptors are activated, nitric oxide synthesis is stimulated and smooth muscle relaxation occurs promptly with vasodilation and a drop in blood pressure. Because no nerve endings are present, indirect-acting cholinomimetics such as cholinesterase inhibitors do not have this vasodilating effect. In the presence of hypotension induced by a direct-acting muscarinic agonist, a strong compensatory reflex originates in
the baroreceptors and results in tachycardia. In the case of cholinesterase inhibitors, the normal heart rate slowing effect of the vagus is amplified and at normal doses, bradycardia results. The effect of the new drug illustrated in Figure 6-6 is most consistent with a direct-acting muscarinic agonist (choice D). Alpha receptor ligands (choices A and B) have little effect on salivation, although indirectly acting agents like ephedrine can cause a sensation of dry mouth. However, ephedrine causes increased blood pressure. A ganglionic stimulant drug (choice E) causes increased salivation but also increases sympathetic discharge to the blood vessels and results in increased, not decreased, blood pressure.

105. (D) Carbidopa is a peripheral inhibitor of dopa decarboxylase. Dopa decarboxylase is an enzyme present in large amounts in the GI tract and peripheral tissues, and in smaller amounts in the nerve terminals of dopaminergic neurons in the basal ganglia. It is required for the conversion of DOPA to dopamine in the biosynthesis of dopamine and norepinephrine. However, when the prodrug levodopa is used for parkinsonism, over 90% is metabolized in the periphery by the enzyme to dopamine and inactive products and only about 3% of the administered dose enters the brain. Because dopamine does not cross the blood–brain barrier, dopamine formed outside the brain is of no value in treating parkinsonism. When carbidopa is given with levodopa, less levodopa is metabolized in the gut and other peripheral tissues, so more (about 10%) is available to enter the CNS. Carbidopa does not cross the blood–brain barrier, so it does not prevent conversion of levodopa to active dopamine in the basal ganglia. Combination therapy thus reduces the peripheral effects of levodopa-dopamine and allows patients to receive more benefit and less toxicity from a given dose of levodopa. Choices A–C and E are incorrect.

106. (E) Trastuzumab is a human antibody that reacts with the epidermal growth factor receptor HER-2/neu and is effective in slowing progression of breast cancer. Adalimumab (choice A) and etanercept (choice B) are IgG1 antibodies to TNF-alpha and are used in advanced rheumatoid-alpha and are used in advanced rheumatoid arthritis. Infliximab is a chimeric antibody to TNF-alpha that is used in rheumatoid arthritis and several other autoimmune diseases. Sirolimus (choice D) is an inhibitor of B lymphocyte proliferation and immunoglobulin production. It is used to prevent transplanted organ rejection.

107. (E) All of the mechanisms listed are valid mechanisms of antiemetic drugs that are used in cancer chemotherapy. Ondansetron is a 5-HT3 antagonist. Dronabinol is a cannabinoid agonist (choice A). Dexamethasone is a corticosteroid (choice B). Metoclopramide is a dopamine antagonist (choice C). Diphenhydramine is a histamine antagonist (choice D). In the prevention of nausea and vomiting caused by chemotherapeutic agents, a cocktail of three, four, or more of these agents is often used. Ondansetron is also effective in reducing postsurgical vomiting. Several congeners of ondansetron are available (granisetron, dolasetron).

108. (C) Baclofen is an agonist at GABA_B receptors and is useful in the treatment of chronic muscle spasm. Glutamate is an important excitatory transmitter in the CNS; agonists (choice A) are not used clinically. Antagonists at neuronal nicotinic receptors (choice B) are ganglion blockers; baclofen has no effect on these receptors. Glycine (choice D) is an important spinal inhibitory transmitter, but baclofen has no effect on its receptors. Dantrolene is an antagonist at skeletal muscle ryanodine receptors (choice E); baclofen has no effect at this site.

109. (E) Beta blockers such as timolol reduce intraocular pressure by reducing synthesis of aqueous by the ciliary epithelium. Atracurium (choice A) is a nondepolarizing neuromuscular blocking agent that is of no value in glaucoma. Dorzolamide (choice B) is a topically active carbonic anhydrase inhibitor that inhibits the synthesis, not the outflow, of aqueous humor. Latanoprost (choice C) is a PGF-2 alpha analog used topically to increase aqueous outflow. Pilocarpine (choice D) is a muscarinic cholinomimetic that increases aqueous outflow.
110. **(B)** Haloperidol is an older oral and parenteral antipsychotic drug with high extrapyramidal but low autonomic toxicity. Olanzapine is a new oral antipsychotic agent with low extrapyramidal and autonomic activity.

111. **(E)** The oral anticoagulants, such as warfarin, block the vitamin K-dependent step in the hepatic synthesis of coagulation factors VII, IX, X, and prothrombin. Carboxylation of descarboxyprothrombin to form prothrombin containing gamma-carboxyglutamate residues requires the reduced form of vitamin K as a cofactor. Vitamin K epoxide is formed as a product. KH₂ must be regenerated by an NADH-dependent epoxide reductase for the next round of carboxylation. It is the epoxide reductase step that is blocked by oral anticoagulants. Heparin exerts its anticoagulant actions by acting as a template for combining thrombin and antithrombin III (choice A). Warfarin has no degradative effect (choice B) on the thrombin molecule. The thrombolytic agent streptokinase becomes active in fibrinolysis by forming an active complex with plasminogen (choice C). The oral anticoagulants do not inhibit calcium binding to coagulation factors (choice D), but calcium binding is reduced because of the absence of gamma-carboxyglutamate residues within the sequences of the coagulation factors VII, IX, X, and prothrombin.

112. **(C)** Hydrochlorothiazide causes potassium wasting and may lead to hypokalemia requiring dietary potassium supplementation. Potassium wasting is characteristic of diuretics that present more sodium to the collecting tubule, where sodium is conserved in exchange for potassium under the control of aldosterone. Therefore, diuretics that act in the proximal convoluted tubule (carbonic anhydrase inhibitors), ascending limb of the loop of Henle (loop diuretics), and distal convoluted tubule (thiazides) cause potassium wasting and may lead to dangerous hypokalemia. Angiotensin antagonists (because they interfere with aldosterone secretion) and aldosterone inhibitors have the opposite effect. Amiloride (choice A) and spironolactone (choice E) are aldosterone antagonists; captopril (choice B) and losartan (choice D) are angiotensin antagonists. The latter agents cause potassium retention and may cause hyperkalemia, not hypokalemia.

113. **(C)** Omeprazole is a proton pump inhibitor (like lansoprazole, esomeprazole, pantoprazole, and rabeprazole) and irreversibly inhibits the H⁺/K⁺-ATPase proton pump. Proton pump inhibitors are the most efficacious agents available for the treatment of acid-peptic disease. Aluminum hydroxide (choice A) is an antacid that may reduce symptoms of peptic disease, but is inconvenient to use and constipating. Misoprostol (choice B) is an orally active PGE₁ analog that is used in the treatment or prevention of NSAID-induced ulcers. Ranitidine (choice D) is an H₂-receptor antagonist. Gastric acid secretion involves activation of H₂-receptors, and peptic disorders such as duodenal ulcer often respond to treatment with H₂-receptor antagonists. Sucralfate (choice E) is a sucrose-aluminum-sulfate compound that polymerizes in an acid environment and is able to form a protective coating over an ulcer bed. It must be taken four times a day, so it is less convenient than H₂-blockers or proton pump inhibitors.

114. **(A)** ACE inhibitors are absolutely contraindicated in pregnancy because they cause renal malformations or agenesis in the fetus. Beta blockers (choice B) are very useful in chronic heart failure with or without hypertension. Calcium channel blockers (choice C) have no detrimental effects in obstructive pulmonary disease. Diuretics are extremely useful in most forms of hypertension (choice D). Because strong vasodilators (choice E) evoke powerful compensatory responses (salt and water retention, tachycardia), drugs like minoxidil are almost always used together with drugs such as diuretics that prevent the compensatory responses.

115. **(B)** Citalopram is one of the highly selective SSRIs, as is its (S) isomer, escitalopram. Most older, tricyclic, and heterocyclic antidepressants block—to varying degrees—reuptake of both norepinephrine and serotonin amine neurotransmitters into the presynaptic nerve...
terminals. Different agents are relatively selective for one or the other amine. Amitriptyline (choice A), desipramine (choice C), imipramine (choice D), and trazodone (choice E) are members of the tricyclic/heterocyclic group and all have mixed effects on both norepinephrine and serotonin reuptake. Desipramine (choice C) is the most selective agent for blocking uptake of norepinephrine. The selective serotonin uptake inhibitors offer the advantage that they do not produce sedation or autonomic side effects, in contrast to many of the tricyclic and heterocyclic antidepressants.

116. (D) Chronic lead poisoning results in multiple toxicities including headache, hypertension, infertility, anemia, and renal insufficiency. Mental and growth retardation occur in children. Acute lead intoxication usually presents as encephalopathy or severe abdominal colic, sometimes masquerading as pancreatitis. When blood lead levels exceed 50 mcg/dL, chelation treatment is indicated. The calcium ion in calcium disodium edetate (EDTA) is readily displaced by lead, forming a lead chelate that is excreted in the urine. Arsenic poisoning (choice A) is treated with chelation therapy using dimercaprol, succimer, or penicillamine. Atropine (choice B) is a lipophilic muscarinic receptor antagonist that blocks parasympathetic function and at toxic levels produces hallucinations and psychosis. Treatment of atropine intoxication consists of symptomatic management or administration of the lipid-soluble anti-cholinesterase physostigmine. Toxicity from iron (choice C) may arise from ingestion of iron supplements (as with children swallowing adult preparations) or hemolytic diseases such as thalassemia. Treatment consists of the use of the iron-chelating agents deferoxamine or deferasirox. EDTA does not chelate mercury (choice E). Inorganic mercury poisoning is treated by using chelation therapy with dimercaprol, succimer, or penicillamine. Organic mercury poisoning is more difficult to treat because of the lipophilic nature of organomercury compounds.

117. (C) Mebendazole is a broad-spectrum antihelmintic that is effective against a variety of nematodes including ascarids, hookworm (*Necator, Ancylostoma*), whipworm (*Trichuris*), threadworm (*Strongyloides*), and pinworm (*Enterobius*). Adverse effects are rare. Diethylcarbamazine (choice A) was developed as a treatment for filariasis. Because of adverse effects that include nausea, vomiting, headache, leukocytosis, and proteinuria, it has been largely supplanted by other antifilarial agents, except in the case of *Loa loa*, where it remains the drug of choice. Ivermectin (choice B) is used to treat *Onchocerca volvulus*, the agent responsible for river blindness in west and central Africa. Niclosamide (choice D) and praziquantel (choice E) are agents with primary efficacy against flukes and tapeworms. In the case of *Fasciola hepatica* (sheep liver fluke), however, bithionol or triclabendazole (a veterinary drug) are drugs of choice; in cysticercosis, albendazole is the drug of choice.

118. (C) The leukotrienes LTC₄, LTD₄, and LTE₄ are 5'-lipoxygenase metabolites of arachidonic acid. When lung tissue is challenged with antigen in sensitive individuals, LTC₄ is formed and subsequently metabolized to LTD₄ and LTE₄. These leukotrienes are not stored but produce bronchoconstriction, increased capillary permeability, and increased mucus formation for an extended time because of their slow tissue clearance. Because the first enzyme in synthesis of leukotrienes from arachidonic acid is 5'-lipoxygenase rather than COX, aspirin (choice A) does not inhibit their biosynthesis. Another leukotriene, LTB₄, is a potent chemotactic agent for polymorphonuclear leukocytes (choice B), but the cysteine-linked leukotrienes LTC₄, LTD₄, and LTE₄ do not share this property. Platelets do not contain 5'-lipoxygenase (although they do contain 12'-lipoxygenase), and leukotrienes are not stored in platelet granules (choice D). The COX product of arachidonic acid, TXA₂, is critical in platelet physiology, and acetylation of COX by aspirin accounts for the effect of this drug in inhibiting platelet function. The leukotrienes possess significant cardiovascular effects (choice E); they produce hypotension by decreasing intravascular volume and reducing cardiac contractility by constricting coronary vessels, thus reducing coronary blood flow.
119. (B) Local anesthetic agents such as lidocaine inhibit nerve conduction through state- and use-dependent blockade of voltage-dependent fast sodium channels. As a result, the threshold of excitability of the nerve is increased, and the ability of the nerve to propagate an action potential is decreased. Ultimately, transmission of sensory stimuli to the CNS is suppressed, and motor function involving small fibers in the vicinity of the injection is also lost. Inhibition of nerve conduction via blockade of calcium channels (choice A) is not a mechanism for local anesthetic agents. Hyperpolarization of neurons via enhanced chloride influx (choice C) is not a mechanism for local anesthetic agents, but is the mechanism for inhibition of repetitive neuronal firing by the benzodiazepines, barbiturates, and other GABA-mimetic and -enhancing agents that act on the GABA<sub>A</sub> receptor-chloride channel of neurons. Enhanced potassium efflux (choice D) does not occur with local anesthetics. Inhibition of pain receptors (choice E) is not a mechanism for currently available analgesic agents. Hyperpolarization of neurons via enhanced chloride influx (choice C) is not a mechanism for local anesthetic agents. Hyperpolarization of neurons via enhanced chloride influx (choice C) is not a mechanism for local anesthetic agents. Hyperpolarization of neurons via enhanced chloride influx (choice C) is not a mechanism for local anesthetic agents. Hyperpolarization of neurons via enhanced chloride influx (choice C) is not a mechanism for local anesthetic agents.

120. (E) Penicillin is still the treatment of choice for treponemal infections due to continuing sensitivity in most areas and low toxicity. The other drugs listed (choices A–D) offer no advantages and greater risk of lack of responsiveness and greater toxicity.

121. (D) Pancreatic beta cells are electrically polarized. Depolarization causes entry of calcium and activation of insulin exocytosis. In hypoglycemia, the negative resting potential is maintained by the activity of an ATP-sensitive hyperpolarizing potassium channel and insulin secretion is inhibited. When extracellular glucose levels are high, glucose enters the beta cells via the GLUT2 transporter and is metabolized to yield ATP. The increased ATP levels cause closure of the potassium channel, allowing the cell to depolarize and secrete insulin. Modulation of insulin release (choice D) is the mechanism of action of the meglitinides such as repaglinide. Although the details are not fully understood, these drugs share one binding site with sulfonylureas and have a second, independent binding site. Acarbose (choice A) is an inhibitor of intestinal alpha-glucosidase and thus reduces absorption of glucose. Sulfonylureas such as glipizide (choice B) bind to a cell-surface protein to cause inhibition of the hyperpolarizing potassium channel, thereby allowing the beta cell to depolarize and secrete insulin. Metformin (choice C) and other biguanides are poorly understood, but do not inhibit the potassium channel that is the target of sulfonylureas. Rosiglitazone (choice E) and pioglitazone do not act by reduction of circulating glucagon; this is one proposed mechanism for the biguanides. These thiazolidinediones or “glitazones” appear to act by a peripheral mechanism that reduces insulin resistance, probably mediated by the peroxisome proliferator-activated receptor-gamma (PPAR-gamma) nuclear receptor.

122. (D) Nondepolarizing neuromuscular blockers are heavily used in anesthesia because they produce full surgical relaxation without causing significant cardiovascular depression. They act as nicotinic cholinoreceptor blockers at the neuromuscular nicotinic receptor, with little or no ganglionic blockade. They have some effect on presynaptic cholinoreceptors of motor nerves and it is believed that this site of action is the cause of alterations in the response of the motor nerve–muscle system to rapid stimulation. A train of four stimulations, a form of tetanic stimulation, is used by anesthesiologists to monitor the level of neuromuscular block in the anesthetized patient and consists of a brief period of stimulation. In the absence of drugs, as well as in the presence of a depolarizing blocker, the twitches during train of four are well maintained in strength. However, after a nondepolarizing blocker the contraction strength fades during the sequence (choices A, C, or D). In the absence of drugs, rapid tetanic stimulation results in moderate increase in contraction during the tetanus and a marked increase in strength of the muscle twitch following the end of the train due, at least in part, to a buildup of calcium in the motor nerve terminal. This post-tetanic potentiation is enhanced by nondepolarizing blockers (choices B, D, or E). Finally,
nondepolarizing blockade results from competitive blockade of cholinoreceptors, so increasing the amount of acetylcholine in the synapse by means of a drug like neostigmine can reverse the blockade (choices C, D, or E). Thus, only choice D meets all three requirements.

123. (C) The cardiac manifestations of beta-blocker intoxication can be very severe, resulting in bradycardia, AV blockade, and markedly reduced force of contraction and cardiac output. Hypotension is common. However, the heart has glucagon receptors that are linked to stimulation of adenylyl cyclase independent of beta adrenoreceptors, which mediate marked increases in rate and force and substitute for the blocked beta response. (Glucagon also plays a primary role in raising blood glucose levels through activation of glycolysis and gluconeogenesis.) Atrial natriuretic peptide (choice A) is released from the cardiac atria and causes vasodilation through activation of membrane-bound guanylyl cyclase in arteriolar smooth muscle, and sodium excretion in the urine through an increase in glomerular filtration rate and consequent increase in filtration fraction. It is of no value in beta-blocker overdose. If the beta-blocker overdose is sufficient, administration of beta agonists such as epi-nephrine (choice B) is inadequate to overcome the blockade. Human growth hormone (choice D) is a peptide hormone produced by the anterior pituitary. It stimulates growth at open epiphyses through production of insulin-like growth factors. It has no direct effect on cardiac function. Insulin (choice E) activates entry of glucose into most tissues and promotes glycogen and triglyceride storage. It has no direct effects on cardiac function.

124. (E) At a blood alcohol level of 200 mg/dL, most individuals are grossly inebriated; a level of 80–100 mg/dL (0.08–0.1%) is considered the legal threshold for intoxication in most states. Ethanol is metabolized by alcohol dehydrogenase (and to a lesser extent by the microsomal ethanol oxidizing system) to acetaldehyde, primarily in the liver. At most ethanol concentrations, the metabolizing system is saturated. As a result, zero-order kinetics are observed. A typical adult shows a constant elimination rate manifested as a decline in blood level of 16–22 mg/dL/h. As blood alcohol levels drop below about 100 mg/dL, elimination has characteristics intermediate between zero and first order. Only at concentrations below 1 mg/dL is the elimination truly first order. Constant clearance (choice A) requires first-order elimination. Pulmonary excretion (choice B) of ethanol accounts for only a minor component of elimination. Breath analyzers are used to estimate the blood alcohol level in drivers suspected of driving under the influence of alcohol. Renal excretion (choice C) also accounts for only a minor component of systemic elimination of alcohol. Because of the small size of the ethanol molecule, most of the alcohol undergoing filtration at the glomerulus is reabsorbed. Biliary secretion (choice D) is not significant in ethanol elimination. At a concentration of 200 mg/dL, blood alcohol is eliminated at zero-order kinetics via hepatic alcoholic dehydrogenase.

125. (D) Saquinavir is an HIV protease inhibitor. Viral protease cleavage of a polyprotein is necessary for production of the viral coat protein. The HIV protease inhibitors include ritonavir, indinavir, nelfinavir, and amprenavir in addition to saquinavir. Currently available HIV protease inhibitors are not sufficient for monotherapy because of the rapid emergence of resistance due to mutations in the viral protease. Combination therapy using saquinavir with two reverse transcriptase inhibitors such as zidovudine, lamivudine, abacavir, or didanosine is currently effective in reducing viral load. Incorporation into RNA (choice A) is part of the mechanism of action for the antitumor agent 5-fluorouracil (5-FU). Inhibition of thymidylate synthase (choice B) is another part of the mechanism of action for the antitumor agent 5-FU. 5-FU is converted to 5-FdUMP, a potent inhibitor of thymidylate synthase. Inhibition of viral DNA polymerase (choice C) is a mechanism of action for the antiviral agent acyclovir, valacyclovir, famciclovir, and ganciclovir. These agents are metabolized to their nucleotide triphosphate forms, which competitively inhibit the herpesvirus polymerase. Acyclovir and valacyclovir also cause DNA chain termination.
Inhibition of viral reverse transcriptase (choice E) is a property of the nucleosides zidovudine (AZT), didanosine (ddI), lamivudine (3TC), stavudine (d4T), and zalcitabine (ddC). These nucleosides are metabolized to the triphosphate forms that competitively inhibit reverse transcriptase. Nonnucleoside reverse transcriptase inhibitors include nevirapine, delavirdine, and efavirenz. Combinations of agents are used because resistance, through mutations in the reverse transcriptase sequence, frequently arises during monotherapy.

126. (D) The maintenance dosing rate \( \frac{D}{T} \) is calculated using the formula \( \frac{D}{T} = \text{target} \times \frac{\text{CL}}{F} \), where \( D \) is the dose administered, \( T \) is the time interval between doses, the target is the desired steady-state plasma concentration (for which the effective plasma concentration is used), \( \text{CL} \) is the systemic clearance, and \( F \) is the fractional absorption. After multiplying the clearance (50 L/h) times the effective plasma concentration (0.02 mg/L), the resulting product of 1 mg/h must be divided by the fractional absorption of 0.25, giving a dosing rate of 4 mg/h. Note that the units for clearance and target concentration must be consistent with respect to volume. The extensive first-pass metabolism of propranolol means that to achieve the same systemic concentration, an oral dose four times larger than the IV dose must be administered.
BIBLIOGRAPHY


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1. A 72-year-old woman is brought to the clinic by her family because she is exhibiting confusion. Upon mental status examination, the patient demonstrates fluctuating levels of awareness. For example, she seems lucid 1 minute, then becomes somnolent or stuporous the next. Which of the following is most likely?

(A) delirium  
(B) dementia  
(C) factitious illness  
(D) malingering  
(E) stupor

2. An elderly patient, known to suffer from dementia, was found walking aimlessly in the fields in hot weather for several hours before being brought to the clinic. Which of the following would be the most useful laboratory test?

(A) electrocardiogram  
(B) electroencephalogram  
(C) pneumoencephalogram  
(D) serum electrolyte levels  
(E) urinalysis

3. A family reports that their mother’s mental status has been deteriorating for the past several years, during which time she has had episodes of transient weaknesses of the arms and legs. Which of the following is the most likely diagnosis?

(A) Alzheimer’s disease  
(B) Korsakoff syndrome  
(C) multi-infarct dementia  
(D) old age  
(E) vitamin deficiency

4. A 23-year-old woman complains of depression and anxiety. While describing her symptoms, she looks dazed. A minute later, she looks around the room slowly, and says, in a heavily accented voice with a different tone, “Where am I?” Which of the following does this presentation suggest?

(A) adjustment disorder  
(B) catatonia  
(C) dissociative identity disorder  
(D) major depression  
(E) schizophrenia

5. Which of the following is an id function?

(A) aggression  
(B) cognition  
(C) conscience  
(D) perception  
(E) psychological defense mechanisms
6. Your patient reports being frightened by heart palpitations and dizziness. Further evaluation reveals that the patient has used a substance heavily, but stopped about 3 days prior to experiencing symptoms, which of the following is the most likely substance used?
(A) alprazolam
(B) cannabis
(C) cocaine
(D) dextroamphetamine
(E) heroin

7. Your patient reports that she is suffering from dizziness and persistent feelings that she is going to die. You inquire as to whether she has been using any illicit substances lately to which she indicates that she has not. She indicates that she has been curtailing going outside, especially in open spaces, because she is afraid that she might have one of those attacks and become immobilized, which of the following is the most likely diagnosis?
(A) acute anxiety attack
(B) agoraphobia with panic attack
(C) agoraphobia without panic attack
(D) anxiety secondary to a medical condition
(E) cocaine withdrawal

8. Which of the following implies the multiaxial diagnostic system in psychiatric disorders?
(A) All psychiatric disorders are personality disorders.
(B) Psychiatric disorders and other diseases can coexist.
(C) Psychiatric disorders are a subset of medical diseases.
(D) Psychiatric disorders are complex.

9. A 72-year-old man is discovered wandering in the hot sun by hospital staff several hours after being reported missing. Recommended testing involves analysis of serum electrolytes. The assay revealed the following serum values: Na+ 150 mEq/L, K+ 5.2 mEq/L. Which of the following is the most likely diagnosis?
(A) Alzheimer’s disease
(B) delirium
(C) lewy body dementia
(D) secondary dementia
(E) seizure disorder

10. Which of the following is the most characteristic element of managed care?
(A) Capitated payment.
(B) That it emphasizes prevention and health promotion.
(C) That it is a fee-for-service system.
(D) That it provides primary care.
(E) That physicians may be salaried.

11. Which of the following represents the average age for puberty?
(A) 11 for boys and 13 for girls
(B) 11 for girls and 13 for boys
(C) 14 for boys and 16 for girls
(D) 14 for girls and 16 for boys
(E) 15 for both girls and boys

12. Which of the following statements is true concerning infant mortality in the United States?
(A) Infant mortality in the United States is high compared to other developed nations.
(B) Prenatal care, disappointingly, has not been shown to reduce infant mortality.
(C) The leading cause of infant mortality in the United States is tetanus.
(D) The mortality rate for white infants is greater than that of black infants.
(E) Very few Asian Americans receive prenatal care as compared to African Americans or Hispanic Americans.

13. Taking a careful history of a 20-year-old female patient suffering from dissociative identity disorder is likely to reveal which of the following?
(A) a history of criminal behavior during childhood
(B) an excellent school record
14. Which of the following is the earliest developmental phase according to Piaget?
(A) concrete operations
(B) formal operations
(C) Oedipus complex
(D) preoperational phase
(E) sensorimotor period

15. According to Erikson, which of the following is a major developmental task for most children around 15 years of age?
(A) developing a clear identity
(B) developing a sense of integrity
(C) developing intimate relationships
(D) learning about sex
(E) learning to be independent

16. Which of the following is a normal sexual function?
(A) anorgasmia
(B) dyspareunia
(C) masturbation
(D) pedophilia

17. An elderly patient with multi-infarct dementia also suffers from urinary incontinence and ataxia. Which of the following therapeutic procedures may be considered for this type of patient?
(A) benzodiazepines
(B) electroconvulsive therapy
(C) megavitamin therapy
(D) urocholine
(E) ventriculoperitoneal shunt

18. All patients who have trisomy of autosome 21 who survive to adulthood develop which one of the following conditions?
(A) Alzheimer’s disease
(B) Lewy body dementia
(C) multi-infarct dementia

19. Your patient confides in you that she has been losing weight with loss of appetite, has been unable to concentrate, and has had difficulty sleeping through the night. She has also been thinking of the means of killing herself. Which of the following is the most likely diagnosis?
(A) borderline personality disorder
(B) factitious disorder
(C) generalized anxiety disorder
(D) hypochondriasis
(E) major depression

20. Which of the following is the most treatable dementing disease?
(A) Alzheimer’s disease
(B) Creutzfeldt-Jakob disease
(C) multi-infarct dementia
(D) Pick disease
(E) Wernicke syndrome

21. Which of the following is the most common type of substance dependency in the United States?
(A) alcohol
(B) cannabis
(C) cocaine
(D) heroin
(E) tobacco

22. Robert is 9 years old and has been suspended from school for failing to control his disruptive behavior in the classroom. His parents take him to a psychologist and report that he has been hyperactive and impulsive since the age of 5. Which of the following is the drug of choice for the treatment of this child?
(A) buspirone
(B) clomipramine
(C) dextroamphetamine
(D) nefazodone
(E) paroxetine
23. A 52-year-old woman tells her doctor that she is experiencing pains in the abdomen and thighs and insists that she is suffering from some form of cancer. A physical examination reveals only the presence of extensive varicose veins. While collecting additional patient history, you find that the woman has become increasingly anxious, with a sense of impending doom, and intensifying abdominal discomfort. You decide to do further medical workup to rule out cancer. Which of the following malignancies is most likely in this patient?

(A) carcinoma of the pancreas
(B) glioblastoma
(C) carcinoma of the stomach
(D) Kaposi sarcoma
(E) pancoast tumor

24. Which of the following ratios represents the estimated likelihood that a physician will become addicted to narcotics during his/her career?

(A) 1 in 10
(B) 1 in 100
(C) 1 in 1000
(D) 1 in 10,000
(E) 1 in 100,000

25. Which of the following has a triphasic abstinence syndrome, the first phase being the “crash”?

(A) alcohol
(B) barbiturates
(C) cannabis
(D) cocaine
(E) opiates

26. The activity of which structure in the pons is suppressed by opioids, alpha-2-agonists, and gamma-aminobutyric acid (GABA), and produces most of the noradrenergic input to the brain?

(A) anterior Cingulate Gyrus
(B) locus ceruleus
(C) mammillary bodies
(D) nucleus pulposus
(E) nucleus solitarius

27. Unmyelinated C fibers are thought to carry which of the following pain sensations?

(A) aching
(B) burning
(C) dull
(D) gnawing
(E) pricking

28. Which theory concerning pain postulates that non-pain sensations, such as vibration or pressure, may affect the transmission and perception of pain sensation?

(A) bradykinin theory
(B) gate control theory
(C) pattern theory
(D) peptide theory
(E) specificity theory

29. Which of the following drugs is useful for the treatment of panic disorder?

(A) bupropion
(B) olanzapine
(C) phenobarbital
(D) sertraline
(E) valproic acid

30. A physician is treating a patient whom he suspects of factitious disorder. If the physician learns that the patient would have been incarcerated for a criminal offense if he had not been hospitalized, which of the following diagnoses becomes most likely?

(A) antisocial personality disorder
(B) borderline personality disorder
(C) malingering
(D) Munchausen syndrome
(E) sick-role addiction

31. According to Piaget, in which of the following do children of middle teenage years typically engage?

(A) abstract thinking
(B) circular reactions
(C) cognitive map
(D) concrete operations  
(E) preoperational activities

32. Which of the following personality traits would most likely result from anal-phase fixation? 
(A) dependency  
(B) fierce competitiveness  
(C) parsimony  
(D) narcissism

33. Nancy was tending the goose eggs when they hatched. The young goslings started following Nancy, even when the mother was calling them. Which of the following phenomenon is this an example of? 
(A) cognitive map  
(B) imprinting  
(C) instinctual behavior  
(D) maternal bonding  
(E) operant conditioning

34. A 48-year-old woman comes to the doctor complaining of vague pains in the abdomen, legs, and thighs. Physical examination reveals no obvious signs of injury or trauma to account for the reported symptoms. If the woman told the doctor, “In spite of what you say, doctor, I know that I have a serious illness, probably cancer,” which of the following would be the most appropriate next step in treatment? 
(A) ask why she thinks she has cancer  
(B) tell her that she does not have cancer  
(C) tell her that she has anxiety  
(D) tell her that she has depression  
(E) tell her to see a psychiatrist

35. “Executive monkeys” as described by Brady tended to develop bleeding ulcers. Which of the following statements best characterizes them? 
(A) Alpha monkeys that have the highest level of testosterone in the colony.  
(B) Beta-male monkeys having too many decisions to make.  
(C) Male monkeys that had too many available females.  
(D) Monkeys that had to keep pressing bars to avoid shock.  
(E) Monkeys that had to press a bar to get a pellet of food.

36. James is 3 years old and he will not part with his filthy terrycloth blanket. Whenever it is taken away from him, he throws a temper tantrum to get it back. He holds it, sucks on it, and seems content when he has it. Of which of the following is this an example? 
(A) childhood fetishism  
(B) codependence  
(C) displacement  
(D) separation anxiety  
(E) transitional object

37. Sara is a 15-year-old healthy female. With which of the following would one expect a girl of her age to spend a lot of time? 
(A) a mixed group of peers  
(B) adults  
(C) animals  
(D) furry toys  
(E) older females

38. Which of the following is true concerning factitious disorder? 
(A) It is a form of psychosis.  
(B) It is an integral part of borderline personality.  
(C) It is an intentional antisocial act.  
(D) It is a sick-role addiction.  
(E) all of the above

39. According to psychoanalytic theory, which of the following is a function of the superego? 
(A) curiosity  
(B) guilt  
(C) music appreciation  
(D) perception  
(E) sexual urge
40. A 7-year-old child has been exhibiting impulsivity and disruptive behaviors at school. When further evaluation reveals that the child has been unable to sleep at night for at least 3 months out of fear that his parents may divorce, which of the following is an important diagnostic possibility?

(A) anaclitic depression  
(B) attention deficit hyperactivity disorder  
(C) conduct disorder  
(D) generalized anxiety disorder  
(E) separation anxiety disorder

41. A 50-year-old man is brought to the emergency room by the police because he was on the street screaming that the air was being poisoned. The man is very agitated, and requires restraint by the attendants. As you, the on-call physician, try to interview him, he tries to hit you and screams at you. Which of the following is the most appropriate first step in management?

(A) administer amobarbital by mouth  
(B) give him an injection of haloperidol  
(C) give him an injection of naloxone  
(D) perform a physical examination  
(E) reason with him that the air is not poisoned

42. Naloxone would be contraindicated in an apparently psychotic patient if one were to also discover which of the following?

(A) The patient had a psilocybin-induced psychosis.  
(B) The patient has hypertension.  
(C) The patient has just suffered a fracture.  
(D) The patient is a placebo responder.  
(E) The patient is an alcohol abuser.

43. A patient has begun exhibiting signs of paranoia and psychosis within the past week. In considering the diagnosis of schizophrenia, which of the following is a crucial piece of information?

(A) The patient does not smoke.  
(B) The patient has a history of similar psychotic episodes in the past.  
(C) The patient has a history of substance abuse.  
(D) The patient is a toxicologist.  
(E) The patient is single.

44. A 25-year-old man is admitted to the hospital after coming to the doctor carrying a bottle containing bloody urine. All tests were negative, and he was observed stealing a test tube of blood from the laboratory technician’s cart. Which of the following is the most likely diagnosis?

(A) antisocial personality disorder  
(B) factitious disorder  
(C) malingering  
(D) schizophrenia  
(E) somatization disorder

45. A 48-year-old woman comes to the doctor complaining of vague pains in the abdomen, legs, and thighs. On physical examination, the only positive findings are varicose veins of 20 years’ duration. The patient, upon being told of this, insists on being operated on for the varicose veins immediately. Which of the following is most likely to underlie this wish for immediate surgery?

(A) anxiety  
(B) depression  
(C) drug dependence  
(D) psychosis

46. Your patient is convinced that she has cancer. She is clearly agitated and is complaining of pain in her abdomen. A workup for cancer is negative, yet your patient refuses to accept the diagnosis and becomes increasingly anxious and expresses an intense sense of impending doom. Which of the following drugs is most appropriate for the treatment of this patient?

(A) carbamazepine  
(B) methylphenidate  
(C) olanzapine  
(D) paroxetine  
(E) valproic acid
47. A young woman presents to the physician with the chief complaint of palpitations. She also complains of feelings that she is going to die, with feelings of dizziness. Which of the following is the most useful question to ask?

(A) Are you anxious?
(B) Do you have a heart disease?
(C) Has anything like this happened before?
(D) What drugs do you use?
(E) Why do you think you will die?

48. If laboratory tests determine that the patient has a general medical condition that underlies the symptoms, which of the following is most likely?

(A) Addison disease
(B) cancer of the pancreas
(C) hyperparathyroidism
(D) hyperthyroidism
(E) hypothyroidism

49. Sean is 8 years old. He is referred by his school because he is habitually disruptive in class. Which of the following is the most useful area to explore at this point?

(A) his attention span
(B) his criminal record
(C) his relationship with his mother
(D) history of cruelty to animals
(E) history of enuresis

50. Thomas is a 9-year-old child of normal physical stature and health. He is unruly at school and refuses to abide by instructions given to him by his teachers. In addition, he has had inattention, hyperactivity, and impulsivity since the age of 5. Which of the following is the most likely diagnosis?

(A) anaclictic depression
(B) attention deficit hyperactivity disorder
(C) conduct disorder
(D) generalized anxiety disorder
(E) separation anxiety disorder
Answers and Explanations

1. (A) Fluctuating levels of awareness are characteristic of delirium, which is indicative of an encephalopathy due to metabolic derangement of the brain, such as anoxia, electrolyte imbalance, or hypoglycemia. Although delirium may be superimposed on dementia, at this point there is no evidence that the patient has the more stable cognitive deficits characteristic of dementia (choice B). Coma (choice D) and stupor (choice E) refer to more severe disturbance of sensorium. Factitious illness (choice C) is unlikely unless there is evidence of self-induced metabolic derangement.

2. (D) An elderly woman exposed to hot sunlight for hours may be dehydrated, and testing serum electrolyte levels may confirm this suspicion. Although the other tests (choices A, B, C, and E) may be indicated at some point, they are not the most urgent tests in this case.

3. (C) Multi-infarct dementia is caused by repeated cerebrovascular ischemia, indicated in this case by periods of transient paralysis. Alzheimer’s disease (choice A) is the most common primary dementia in the elderly. Old age (choice D) alone is no cause for dementia. Korsakoff syndrome (choice B), which is characterized by confabulation, is associated with alcohol withdrawal and thiamine deficiency (choice E). There is no evidence of either in this case.

4. (C) Dissociative identity disorder (multiple personality disorder) is often associated with memory disturbance and an alternate personality, who may have a different speech tone, accent, or voice. Schizophrenia (choice E) is unlikely; there is no sign of psychosis. Major depression (choice D) is unlikely; there is no sign of depression. Catatonia (choice B) refers to muscle rigidity and mutism, and adjustment disorder (choice A) is a broad diagnostic category that does not include this presentation.

5. (A) The id is the collection of psychological functions having to do with basic instincts, such as sex and survival. Aggression is a basic instinct, therefore, an id function. The ego functions to mediate between the personality system on one hand and the demands of external reality and the superego on the other hand. Thus, psychological defense mechanisms (choice E), perception (choice D), and cognition (choice B) are all ego functions. Superego is the part of the personality system that encompasses conscience (choice C).

6. (A) Benzodiazepine withdrawal is often associated with anxiety symptoms. Cocaine (choice C) may cause a “crash” with anxiety soon after cessation of use, but by day 3 there is more likely to be dysphoria than anxiety. Although withdrawal from other substances (choices B, D, and E) can cause similar anxiety, benzodiazepine withdrawal is the most common cause of this type of symptomatology.

7. (B) The symptoms of panic associated with fear and avoidance of being in places where escape may be difficult or embarrassing call for the consideration of agoraphobia with panic attack. Choices A, C, D, and E are not associated with the phenomenon described here.

8. (B) Axis I of the multiaxial system is for clinical psychiatric disorders such as schizophrenia and mood disorders. Axis II is for personality disorders and mental retardation. Axis III is for general medical conditions (such as myocardial infarction). Axis IV is for psychosocial and environmental problems and Axis V is for global assessment of functioning. This classificatory system clearly indicates that psychiatric disorders (Axis I) and general medical disorders (Axis III) often do coexist and may influence each other. Choices A, C, and D are not part of the multiaxial system.
9. (B) The hypernatremia and hyperkalemia are indicative of dehydration, which is a common cause of delirium. Choices A, C, D, and E do not explain this phenomenon.

10. (A) Managed care involves an entity (company, state, organization) managing health care through a capitated (head count) payment system. Within the managed care system, there are various models including specialized care and fee for service in addition to capitation.

11. (B) The onset of puberty varies, but girls usually enter puberty 12–18 months earlier than boys. The average age is 11 (range, 8–13) for girls and 13 (range, 10–14) for boys. Choices A, C, and E are incorrect because they do not distinguish between girls and boys. Choice D is above the upper limit for both girls and boys.

12. (A) The infant mortality rate in the United States is 8.9 deaths per 1000 live births as of 1989, which ranks the United States behind 11 other developed countries. The leading causes of infant death are congenital anomalies, respiratory distress syndrome, and sudden infant death syndrome; therefore, choice C is incorrect. Choices B, D, and E are incorrect because prenatal care does reduce infant mortality, but only 80% of Caucasian women receive prenatal care, followed by 75% of Asian American women, 65% of African American women, and 60% of Native American women. The infant mortality rate for black infants is greater than that of white infants.

13. (C) Dissociative identity disorder (multiple personality disorder) is often associated with a history of severe emotional, physical, or sexual abuse in childhood. The dissociation may serve an adaptive function that enables the patient to tolerate an intolerable situation. The patient’s school record is often poor due to memory disturbance associated with the disorder. Choices A and D are associated with antisocial personality, and choice A is unlikely because dissociation often causes inattention and poor school grades.

14. (E) Piaget described the development of intelligent thinking in stages. The first is the sensorimotor period, 18 months–2 years. This is followed by preoperational phase, 2–7 years (choice D); and the phase of concrete operations, 7–11 years (choice A), and the period of formal operations from adolescence through adulthood (choice B). Oedipus complex (choice C) is not a Piagetian stage, but is characteristic of ages 3–5.

15. (A) Erikson describes adolescence as the period of identity formation. In this period, a person develops a sense of inner sameness and continuity, a sense of direction and self. Career choices are also made during this phase. Failure of identity formation in this period results in “role confusion.” Choices B and C refer to other developmental periods or non-Eriksonian task (choice D & E).

16. (C) Masturbation is virtually universal among men and women of all cultures. It is common among married as well as single people. Many sex therapists recommend self-stimulation as an auxiliary treatment technique for a variety of sexual dysfunctions. Choices A, B, and D are sexual dysfunctions.

17. (E) Normal pressure hydrocephalus is associated with the symptoms of dementia, ataxia, and urinary incontinence. On brain imaging, the ventricles are often enlarged, but cerebrospinal fluid (CSF) pressure is normal. A ventriculoperitoneal shunt is often therapeutic for this condition. Choices A, B, C, and D are inappropriate.

18. (A) Down syndrome is a congenital mental retardation associated with trisomy of autosome 21. All patients with Down syndrome who survive into adulthood develop the brain pathologies of Alzheimer’s disease, rendering support to the notion that at least one form of Alzheimer’s disease may be associated with an autosome 21 abnormality. Choices B, C, D, and E are not associated with trisomy of autosome 21.

19. (E) Depression is often accompanied by vague physical symptoms. When a depressed patient presents to a primary physician, it is important that the presence of depression be ascertained by careful history; depressed patients
are often suicidal, and about 70% of successful suicides have seen their physician in the previous month. Choices A, B, C, and D are not supported by the signs presented.

20. (E) Wernicke syndrome is caused by thiamine deficiency associated with alcohol withdrawal, and can be treated effectively. Alzheimer’s disease (choice A) is the most common primary dementia in the elderly. About 50% of brains of demented patients show evidence of Alzheimer’s disease. Creutzfeld-Jakob (choice B) disease and kuru are slow virus infections that show clinical and histologic features similar to Alzheimer’s disease. Multi-infarct dementia (choice C) is secondary to repeated cerebrovascular accidents (CVAs) in patients with underlying atherosclerosis or hypertension. It is more common among men than women. Pick disease (choice D) is a rare cause of cortical dementia. The presence of unilateral cortical atrophy in Pick disease contrasts with the bilateral atrophy evident in Alzheimer’s disease. Microscopically, Pick bodies composed of densely packed neurofilaments are seen within diseased neurons.

21. (E) Tobacco addiction is the most common type of drug dependency in the United States. Nicotine is extremely addictive. Since the Surgeon General’s report in 1964 that identified the health risks of tobacco smoking, there has been an encouraging trend in the United States. Approximately 42% of the US adult population smoked cigarettes in 1965. The rate was 37% in 1975 and 30% in 1985. The reduction rate of smoking has been more pronounced in males than in females. Choices A, B, C, and D are incorrect.

22. (C) Dextroamphetamine and methylphenidate are effective in treating ADHD. Paroxetine (choice E) and nefazodone (choice D) are antidepressants, clomipramine (choice B) is a tricyclic that has special use in obsessive-compulsive disorders, and buspirone (choice A) is an antianxiety agent.

23. (A) Carcinoma of the tail of the pancreas often presents with symptoms of depression. Although other carcinomas and neoplasms (choices B, C, D, and E) may also cause depression, pancreatic cancer has to be ruled out first in a patient with severe depression.

24. (B) Because of easy drug availability and their high-stress occupation, physicians are at high risk for narcotic drug addiction; the incidence is estimated to be 1 in 100, which is 30 to 100 times greater than that of the general population. Choices A, C, D, and E are incorrect.

25. (D) The abstinence syndrome to cocaine is triphasic. Phase 1 is called “crash,” phase 2 is a withdrawal phase with protracted dysphoria, and phase 3 is an “extinction” phase that follows the resolution of withdrawal anhedonia. Choices A, B, C, and E do not show this type of triphasic syndrome.

26. (B) The locus ceruleus, located in the pons, produces most of the noradrenergic input to the brain, and has receptors for opioids and autoreceptors for norepinephrine (á-2) as well as GABA. The locus ceruleus seems to be involved in alertness and anxiety response. Choices A, C, D, and E refer to structures elsewhere.

27. (B) It is now believed that specific pain receptors (free nerve endings) are stimulated mainly by chemicals such as bradykinin, and that two types of pain sensations (“pricking” and “burning”) are transmitted by different types of nerves. The burning pain sensation is transmitted by small C-fibers, and the pricking pain sensation is transmitted by larger, myelinated A-delta fibers. The pain fibers eventually terminate in the thalamus in a somatotopical fashion. Choices A, C, D, and E are incorrect.

28. (B) The theories involving pain perception are: (1) the specificity theory (choice E), postulating that there are specific pain receptors transmitting specific pain signals through specific neurons to specific areas of the brain; (2) the pattern theory (choice C), postulating the existence of “reverberating circuits” to explain phantom pain; and (3) the gate control theory (choice B), postulating an interaction between
pain sensation and other sensations competing for transmission at the spinal cord level. Choices A and D do not postulate the interaction with non-pain sensations.

29. (D) In addition to SSRIs such as sertraline, paroxetine and fluoxetine, tricyclic antidepressants, MAOIs, and high-potency benzodiazepines such as alprazolam and clonazepam may be effective in panic disorder. Olanzapine (choice B) is an atypical antipsychotic and has not been shown to be effective in panic disorder. Bupropion, an antidepressant (choice A), phenobarbital, a CNS depressant (choice C), and valproic acid, an anticonvulsant and antimanic drug (choice E) are also ineffective in panic disorder.

30. (C) When there is an external incentive for causing the symptom or injury, malingering is more likely than factitious disorder (Munchausen syndrome), the motivation for which is often quite unclear. Although there may be concomitant personality disorders, malingering is not diagnostic of any specific personality disorder. Choices A, B, D, and E are less likely because there seems to be an obvious and conscious motivation in this case.

31. (A) According to Piaget, at about the time of puberty (which is on the average about age 11 in girls), the final stage of maturation in cognitive functioning, the period of formal operations, occurs. The individual’s thought processes become more flexible, and transcend the here and now. Propositional thinking and hypothesis testing are prominent features of this stage.

32. (C) The anal phase of development occurs around age 2, around the time of toilet training. Developmental difficulty around this time may result in “anal-phase fixation,” in which some characteristics of this phase may unduly influence the adult personality. Such characteristics include struggles over the issue of control. Excessive cleanliness and orderliness, or the opposite, as well as parsimony and hoarding may occur. Dependency (choice A) is characteristic of oral phase, and fierce competitiveness (choice B) may be characteristic of the Oedipal phase. Narcissism (choice D) is a complex phenomenon that develops from very early life and not confined to any particular stage of development.

33. (B) Imprinting is an ethologic term that indicates a critical period in a newborn animal’s life. For example, if goslings are exposed to humans rather than geese shortly after hatching, they will follow humans rather than their own mother.

34. (A) When a patient presents with a conviction that she has a serious illness, it is important to find out more about why the patient has the notion, because in the process the doctor may be able to diagnose emotional distress in the form of anxiety, depression, or simple misperception, as well as hypochondriasis. All the other choices (B, C, D, and E) bring about a premature closure.

35. (D) Monkeys that were placed in a highly complex operant conditioning program to avoid electric shock developed bleeding gastric ulcers, while yoked controls who received the same amount of shock, but did not have to perform the complex task, did not. The lack of a confirmatory feedback (such as a safe light or food to indicate a shock-free interval) seems to be especially ulcerogenic in Brady’s “executive monkeys.” Choices A, B, C, and E are incorrect.

36. (E) Transitional objects are “mother substitutes” such as a blanket or a soft toy, to which a child may become attached and that she or he may carry around all the time. This is a normal developmental phenomenon and not a sign of pathology. Choices A, B, C, and D do not refer to this phenomenon.

37. (A) An adolescent veers away from childish toys and develops an interest in the opposite sex. Peer relationships include members of the opposite as well as the same sex.

38. (D) The caring environment of hospitalization and exemption from normal responsibilities accompanying the sick-role may be the
unconscious motivation for many patients with factitious disorders to undergo very uncomfortable and often painful procedures or self-inflicted injuries to become a patient. There is no clear-cut learning, psychosis, or personality disorder that accompanies this condition; choices A, B, and C are incorrect.

39. (B) The superego is the collection of functions having to do with conscience, social expectations, and guilt, which arises from failing to meet the demands of conscience. Id is the reservoir of basic instinctual drives, where sexual urge belongs (E). Ego is the collection of functions that mediate relations between the demands of the id and the constraints of social reality and conscience, as well as some innate, nonconflictual spheres of existence such as perception and movement. Choices A, C, and D are ego functions.

40. (E) Separation anxiety disorder involves excessive anxiety concerning separation from the home or someone to whom the child is attached. The disturbance must continue for more than 4 weeks, with onset before age 18. Choices A, B, C, and D are not particularly indicated by the new information provided.

41. (B) The management of acute psychosis involves use of parenteral antipsychotic drugs, such as haloperidol. Reasoning with a delusional patient (choice E) is usually futile, and an agitated and uncooperative patient is unlikely to permit a physical examination (choice D) or take an oral medication (choice A). Unless you know that the patient is intoxicated with opiates, naloxone (choice C) is unlikely to be of benefit.

42. (C) Naloxone is an opiate antagonist, and would be contraindicated in a patient with fracture who would require rapid pain relief. The placebo analgesic effect seems to be endorphin mediated, and naloxone would block it. The other choices do not deal with naloxone’s specific anti-opioid activity.

43. (B) Although all the other items (choices A, C, D, and E) may be significant, schizophrenia cannot be diagnosed if the patient has never had an episode of psychotic symptoms lasting for at least 6 months.

44. (B) The essential feature of factitious disorder is the intentional production of physical signs or symptoms in the absence of an external incentive as a motivation. If there is an external incentive for fabricating an illness, then malingering is diagnosed (choice C). Antisocial personality disorder (choice A) requires a pattern of antisocial behavior. Somatization disorder (choice E) is characterized by multiple physical symptoms that are not explained by tissue damage. Schizophrenia (choice D) is incorrect because there is no evidence of psychotic symptoms even though the behavior may be bizarre.

45. (A) Anxiety or concomitant stress is a common trigger for help-seeking behavior, especially if the symptom or sign is of long duration. Although depression (choice B) can cause vague discomfort and precipitate help seeking, insisting on an operation immediately seems to indicate anxiety rather than depression, which is more likely to cause indecision or inaction. A drug-dependent person (choice C) is more likely to insist on drugs. There is no evidence of psychosis (choice D).

46. (D) Paroxetine is a selective serotonin reuptake inhibitor (SSRI), an antidepressant, and is the drug of choice for treating this patient’s depression. Carbamazepine (choice A), like valproic acid (choice E), is an anticonvulsant and mood stabilizer which may be used to treat bipolar disorder. Methylphenidate (choice B) is a CNS stimulant; olanzapine (choice C) is an atypical antipsychotic.

47. (C) The patient presents with acute anxiety symptoms that might be due to panic or other acute situations. Panic disorder usually is recurrent and history of previous episodes would be extremely helpful. Choice A is inappropriate; the patient is obviously anxious. Choices B, D, and E may be useful but not yield as much information.

48. (D) Hyperthyroidism is often associated with anxiety and panic symptoms. Although these
symptoms may also occur with any of the other medical conditions (choices A, B, C, and E), depression and slowed mentation are more common in hypothyroidism, hyperparathyroidism, and Addison disease; cancer of the pancreas is often associated with severe depression.

49. (A) A common cause of disruptiveness is attention deficit hyperactivity disorder (ADHD), which is characterized by inattention and hyperactivity. Enuresis (choice E), cruelty to animals (choice D), and trouble with the law (choice B) are often found in the childhoods of those who are eventually diagnosed as having an antisocial personality, but disruptiveness in class is more indicative of hyperactivity. Exploring Sean’s relationship to his mother (choice C) may be useful, but not as much as assessing his attention span.

50. (B) The diagnostic criteria for ADHD include inattention, hyperactivity, and impulsivity in various areas, and the symptoms must have been present before the age of 7. The specific history of inattention and hyperactivity tend to rule out choices A, C, D, and E, although there may be some elements of conduct disorder.
1. Addition of 5-azacytidine to cultures of growing cells would be expected to result in which of the following?
   (A) decreased mutagenesis
   (B) hypermethylation
   (C) hypomethylation
   (D) increased mutagenesis
   (E) inhibition of replication

2. A throat swab was collected from a patient in which cytomegalovirus (CMV) infection was suspected. It must be sent to a state laboratory located in a city 250 miles from the medical center. How should this specimen be treated after collection?
   (A) It is safe to store it at room temperature until it is mailed off.
   (B) It should be frozen at −20°C until mailed.
   (C) It should be frozen at −70°C and shipped on dry ice.
   (D) It should be stored at 4°C until mailed.
   (E) Such a sample should not be collected if the specimen could not be processed at the local medical center laboratory.

3. A 47-year-old fireman is admitted to the emergency room for extensive burns received while battling a fire. A few hours after admission, he develops pregangrenous changes in multiple digits in hands, his left foot, and his nose. A short time later, he experiences bleeding from his mucous membranes and IV site, as well as the development of multiple petechiae. Which of the following is the major initiating mechanism of this clinical scenario?
   (A) antithrombin III deficiency
   (B) multiple air emboli
   (C) release of thromboplastin
   (D) supervening infection
   (E) tissue hypoxemia

4. A new drug, code named “X,” is being studied in Phase I clinical trials. Drug X, when administered as a single-bolus IV dose of 100 mg to a 70-kg (154-lbs) patient, yields the plasma values shown in Figure 8-1 as a function of time after injection. What is the apparent volume of distribution of drug X?

![FIG. 8-1](https://example.com/fig8-1.png)

   (A) 0.25 L
   (B) 4.0 L
   (C) 14 L
   (D) 30 L
   (E) 100 L
5. You determine that your young patient has an enlarged right side of the heart due to significant shunting of blood from the left to the right atrium. You suspect that this interatrial septal defect is due to an abnormally large foramen ovale resulting from incomplete development of which of the following?

(A) the muscular interventricular septum  
(B) the ostium primum  
(C) the ostium secundum  
(D) the septum primum  
(E) the septum secundum

6. A 2-year-old boy was brought to the clinic because of fever, chest congestion, rhinorrhea, and a “barking cough” for 3 days. His medical history was significant only for recurrent otitis media. On examination, his temperature was 39°C. He had audible obstructive upper airway sounds. The clinical impression was that he had croup. Two weeks later the laboratory reported identification of an agent from a nasopharyngeal specimen. Which of the following is the most likely etiologic agent in this case?

(A) *Haemophilus influenzae*  
(B) influenza virus  
(C) parainfluenza virus  
(D) respiratory syncytial virus  
(E) *Streptococcus pneumoniae*

7. Based on your understanding of the role of insulin in the body, which of the following enzymes would be expected to be reduced in expression as a consequence of the actions of insulin?

(A) acetyl CoA carboxylase  
(B) hepatic glucokinase  
(C) lipoprotein lipase  
(D) PEP carboxykinase  
(E) pyruvate kinase

8. A 55-year-old man, who has been a construction worker his entire adult life, comes to see you complaining of colicky abdominal pain, constipation, and frequent headaches. Physical examination reveals a wrist drop and a dark line along the gingival margins. Additional findings usually associated with this condition include which of the following?

(A) fatty change of the liver with extensive necrosis  
(B) interstitial nephritis with lymphocytic infiltration  
(C) microcytic anemia with basophilic stippling  
(D) pulmonary edema with hyperemia

9. Referring to Figure 8-1 in Question 4, which of the following is most nearly equal to the elimination half-life for drug X?

(A) 0.25 hour  
(B) 2.0 hour  
(C) 8.0 hour  
(D) 12.0 hour  
(E) 28.0 hour

10. A 12-year-old boy is diagnosed with congenital coarctation (constriction) of the aorta. A posterior-to-anterior chest film reveals a characteristic notch in the aortic knob in the superior aspect of the left border of the cardiovascular shadow. This points to a constriction just past the origin of the left subclavian artery. Radiographic examination also reveals characteristic notching of the lower border of the upper ribs, most pronounced along the posterior segments. You perform simultaneous examination of the radial and posterior tibial pulses on the 12-year-old boy. What is the expected relationship of the posterior tibial pulse to the radial pulse?

(A) It is delayed and of greater volume than the radial pulse.  
(B) It is delayed and of lesser volume than the radial pulse.  
(C) It is in sequence with and equal in volume with the radial pulse.  
(D) It is in sequence with, but of greater volume than, the radial pulse.  
(E) It is in sequence with, but of lesser volume than, the radial pulse.
11. A 42-year-old woman states that for the past 2 or 3 weeks she has felt tired, short of breath, and feverish, her chest feels sore, and occasionally her heart “skips a beat.” Physical examination reveals moderate ankle edema and ventricular arrhythmia. Chest x-ray shows cardiomegaly and ECG shows nonspecific ST-T changes. An endomyocardial biopsy is done and three pieces of tissue are retrieved. One appears to be fairly normal, one shows some edema and nonspecific changes, while the third reveals an infiltrate of lymphocytes, macrophages, and a few plasma cells with interstitial edema and isolated myofiber lysis. Which of the following is the most likely cause of this patient’s clinical and pathological findings?

(A) acute infective endocarditis  
(B) acute rheumatic fever  
(C) hypertrophic cardiomyopathy  
(D) myocardial infarction  
(E) viral myocarditis

12. Which of the following is a mechanism for resistance to erythromycin by *S. pneumoniae*?

(A) acquisition of altered forms of dihydrofolate reductase through plasmid transfer  
(B) changes in the porins of the bacterial cell wall  
(C) expression of altered forms of the transpeptidase involved in cell wall synthesis  
(D) expression of beta-lactamase activity  
(E) mutating ribosomal subunits to reduce drug binding

13. A 39-year-old woman presents with pain and swelling of her neck. On physical examination, her thyroid is enlarged and tender and she is febrile. Her past medical history is negative except for excision of a benign breast mass 5 years ago and influenza a few weeks ago. If you were to examine her thyroid microscopically, which of the following would you expect to see?

(A) cells with clear nuclei arranged in papillary structures  
(B) dense fibrosis replacing thyroid and involving surrounding structures  
(C) macrophages and giant cells surrounding colloid fragments  
(D) severe lymphocytic invasion and lymphoid follicles with germinal centers  
(E) polygonal cells arranged in nests and sheets with stromal amyloid

14. Which of the following activities, relating to glucose homeostasis, is directly attributable to the actions of glucagon-like peptide-1 (GLP-1)?

(A) decreased fatty acid release from adipose tissue  
(B) decreased glucagon release from the pancreas  
(C) increased transit of carbohydrates through the intestines  
(D) stimulated degradation of hepatic glycogen stores  
(E) unmasking of GLUT-4 transporters in skeletal muscle
15. In Figure 8-2, a healthy volunteer received a continuous infusion of physiological gastrin concentrations before and after treatment with peptide X. The production of gastric acid and pancreatic bicarbonate secretion was monitored before and after administration of peptide X (at arrow). Which of the following hormones is most likely to produce the changes observed?

(A) angiotensin II
(B) cholecystokinin
(C) motilin
(D) secretin
(E) somatostatin

16. Diltiazem is a drug that, at the dosages used clinically, blocks calcium channels in sinoatrial (SA) nodal tissue. Which of the following will be the most likely effect of this drug?

(A) depolarization of SA node cells
(B) increase in heart rate
(C) increase in amplitude of the SA node cell action potential
(D) no alteration of the action potential in the SA node
(E) slowing of the heart rate

17. A 62-year-old man with a 25-year history of cigarette smoking presents to his primary care physician with a 3-week history of a gradually enlarging, painless mass in his left preauricular facial area. Physical examination demonstrates a small, well-circumscribed 5-cm mass on the peripheral left face; inspection of the mouth reveals protrusion of the mass into the left tonsillar pillar. Past medical history is significant for laryngeal carcinoma in the patient’s late forties, which was treated with surgical excision and radiation. A biopsy of the mass is shown in Figure 8-3. Based on this information, what is the most likely diagnosis?

(A) chronic sialoadenitis
(B) mucocele
(C) pleomorphic adenoma
(D) recurrent laryngeal carcinoma
(E) Warthin tumor

18. The thermodynamics of oxygen binding to hemoglobin are highly ordered. Which of the following reflects the physical characteristics relating the binding of O₂ to hemoglobin?

(A) causes a large shift of the surrounding secondary structures leading to decreased affinity of the deoxy subunits for CO₂
(B) is cooperative, meaning that after the first O₂ binds, the other subunits are more readily oxygenated
(C) occurs with equal affinity at all four subunits
(D) results in a release of the heme from the interior to the exterior of the alpha subunits leading to an increase in O₂ affinity of the beta subunits

(E) results in a release of the heme from the interior to the exterior of the beta subunits leading to an increase in O₂ affinity of the alpha subunits

19. Carbon monoxide (CO) poisoning is a significant cause of mortality in the United States. Which of the following statements about CO is correct?

(A) competes with CO₂ for a common binding site on hemoglobin

(B) competes with O₂ for a common binding site on hemoglobin

(C) has a lower affinity for hemoglobin than does O₂

(D) irreversibly binds to hemoglobin

(E) is normally a perfusion-limited gas

20. A baby girl is born with ambiguous genitalia and diagnosed with severe classical congenital deficiency of adrenal 21-beta-hydroxylase enzyme. Without any treatment, which of the following would you expect in the girl’s future?

(A) delayed puberty

(B) hypernatremia

(C) hypopigmentation

(D) salt wasting crises

(E) tall stature

21. In selected cases of chronic renal failure, kidney transplantation is performed. The renal artery and vein from the transplanted kidney are attached to which of the following vessels in the patient recipient?

(A) external iliac artery and vein

(B) inferior vena cava

(C) internal iliac artery and vein

(D) lumbar artery and vein

(E) renal artery and vein

22. A patient with severe angina is to be started on prophylactic therapy. He has cardiac conduction pathway abnormalities on ECG. Which of the following drugs is most likely to cause AV blockade?

(A) atenolol

(B) atorvastatin

(C) clonidine

(D) isosorbide mononitrate

(E) nifedipine

23. A routine Pap smear on a 27-year-old woman is reported as a low-grade squamous intraepithelial lesion with prominent koilocytosis. Which of the following is the most likely etiology for this finding?

(A) hereditary disorder of squamous epithelium

(B) hormonal imbalance

(C) human papillomavirus

(D) normal intermenstrual reaction

(E) protozoan infection or infestation

24. The sulfonylurea class of drugs is used to treat Type II diabetes function by which of the following mechanisms?

(A) activating the PPAR-gamma class of factors leading to increased hepatic glucose metabolism

(B) binding to and blocking pancreatic K⁺ channels leading to increased insulin secretion

(C) interfering with carbohydrate digestion, thus reducing glucose intake

(D) restricting hepatic glucose output, thereby reducing the hyperglycemia

(E) stimulating pancreatic glucose metabolism leading to increased insulin secretion
Questions 25 through 28

A 35-year-old single woman complains of fatigue, insomnia, and depression.

25. If the patient had recent weight gain and has been feeling cold much of the time, which of the following tests would be most useful?

(A) blood thiamine level
(B) dexamethasone suppression test
(C) Rorschach test
(D) serum calcium level
(E) thyroid function test

26. If the patient seems very sluggish in movement and speech, and takes an inordinate amount of time to answer a question, the patient is suffering from which of the following?

(A) hysteria
(B) pseudobulbar palsy
(C) psychomotor agitation
(D) psychomotor retardation
(E) restless leg syndrome

27. If the patient says that she intends to kill herself by taking an overdose and adamantly refuses hospitalization, which of the following choices would you make?

(A) call the family and have the patient stay with the family
(B) hospitalize her under emergency certificate
(C) prescribe fluoxetine 20 mg in the morning with a return visit within 1 month
(D) prescribe fluoxetine 40 mg in the morning with a return visit in 1 week
(E) provide crisis counseling

28. If further history reveals that she had attempted suicide several times in the past, which of the following statements would be most useful?

(A) The patient is not a serious suicide risk.
(B) The patient probably has antisocial personality disorder.
(C) The patient should be evaluated for a psychotic disorder.
(D) The risk of successful suicide is decreased.
(E) The risk of successful suicide is increased.

29. A drug was administered to a patient with an arrhythmia. In the laboratory this drug had been observed to increase action potential duration. The ECG recorded before and after drug administration to the patient is shown in Figure 8-4. Which of the following drugs was administered?

![Figure 8-4](https://via.placeholder.com/150)

29. A drug was administered to a patient with an arrhythmia. In the laboratory this drug had been observed to increase action potential duration. The ECG recorded before and after drug administration to the patient is shown in Figure 8-4. Which of the following drugs was administered?

(A) adenosine
(B) ibutilide
(C) lidocaine
(D) quinidine
(E) verapamil

30. Glutamate dehydrogenase is an extremely important enzyme involved in nitrogen homeostasis. This enzyme catalyzes a reversible reaction (Figure 8-5) that either incorporates or liberates the ammonium ion. When catalyzing the reaction in the direction of ammonium ion liberation, the enzyme is allosterically activated by which of the following?

![Figure 8-5](https://via.placeholder.com/150)
31. Which of the following statements is correct regarding the oncogenes of DNA tumor viruses?

(A) They are expressed late in the viral multiplication cycle.
(B) They are normally expressed at low levels during embryogenesis.
(C) They are virtually identical to cellular proto-oncogenes.
(D) Their expressed proteins combine with normal cell proteins and alter function.
(E) They slow the proliferation rate of infected cells.

32. What predictably results in a temporary increase in the number of circulating reticulocytes?

(A) allergic reaction to ragweed pollen
(B) bacterial infection
(C) moving from sea level to a high altitude
(D) vaccination against measles
(E) viral infection

33. A 20-year-old woman complains of increasing muscle weakness. She tires during simple tasks, her eyelids droop, and she has fallen repeatedly. A blood test reveals acetylcholine receptor antibodies in her blood, and she is diagnosed with myasthenia gravis (MG). Application of which drug would most likely ameliorate her symptoms?

(A) like curare that blocks acetylcholine receptors
(B) like hemicholinium that blocks choline reuptake
(C) like pyridostigmine that blocks acetylcholine esterase
(D) that acts presynaptically to block acetylcholine release
(E) that blocks presynaptic calcium channels

34. A 53-year-old man who presented to a gastroenterologist with the chief complaint of a 9-month history of progressively worsening epigastric pain and feelings of early satiety was found on endoscopy to have a stomach area of thickened rugal folding with a central ulceration. Biopsy revealed the presence of a monomorphous population of large, poorly differentiated cells in the lamina propria and the submucosa, with an accompanying eosinophilic infiltrate and significant destruction of gastric glands. Histochemical staining for mucin was negative. Based on these findings, what is the most likely diagnosis?

(A) gastric adenocarcinoma
(B) malignant lymphoma
(C) menetrier disease
(D) peptic ulcer disease
(E) type A chronic gastritis

35. A 57-year-old female patient has suffered a large cerebral infarction in the left hemisphere. The patient has significant difficulty of speech and displays severe impairment of repetition and comprehension. An angiogram reveals an occlusion in which of the following vessels?

(A) anterior cerebral artery
(B) lenticulostriate artery
(C) middle cerebral artery
(D) posterior cerebral artery
(E) posterior choroidal artery
36. A 5-year-old girl undergoing chemotherapy develops a rash on her scalp, face, and trunk. A physical examination reveals skin lesions consisting of papules, vesicles, and pustules all present at the same time. A diagnosis of disseminated varicella-zoster infection is rendered. Which of the following is the most likely reason for this viral infection?

(A) deficiency in the third component of complement
(B) hypogammaglobulinemia
(C) outgrowth of virus from varicella-zoster immunization
(D) synergism between varicella-zoster and chemotherapy
(E) T-cell deficiency

37. Which of the following is an effective pharmacologic antagonist of sedation by an overdose of diazepam?

(A) EDTA (ethylenediaminetetra-acetic acid)
(B) flumazenil
(C) fomepizole
(D) naltrexone
(E) physostigmine

38. An 8-year-old boy has PMNs with a genetic deficiency in nicotinamide adenine dinucleotide phosphate (NADPH) oxidase production, resulting in chronic granulomatous disease. Which of the following bacteria will most often be the likely infectious agent?

(A) *Staphylococcus aureus*
(B) *S. agalactiae*
(C) *S. mitis*
(D) *S. pneumoniae*
(E) *S. pyogenes*

39. Which of the following statements best describes the anticlotting action of clopidogrel?

(A) activation of antithrombin III
(B) direct conversion of plasminogen to plasmin
(C) inhibition of factor Xa
(D) inhibition of thromboxane synthesis
(E) irreversible blockade of platelet ADP receptors

40. A 25-year-old woman complains that whenever she is in the sun for more than a few minutes she develops an erythematous rash on the sun-exposed skin by the next day. This is accompanied by joint pain and a feeling of fatigue. Laboratory tests reveal a Coombs-positive anemia and urinary sediment containing red and white cells and some casts. To help you reach a diagnosis, which of the following would you order next?

(A) differential count on synovial fluid
(B) renal biopsy
(C) serum test for antinuclear antibodies
(D) skin biopsy
(E) urine test for porphyrins

41. A 5-year-old girl with heart palpitations is diagnosed with atrial septal defect. Her right heart is hypertrophied, with a fixed split of the second heart sound, a pulmonic diastolic murmur and a systolic murmur. Figure 8-6 shows the right ventricular pressures during a single heart beat. At what point is the fixed split of the second heart sound heard?

(A) A
(B) B
(C) C
(D) D
(E) E

42. A 4-year-old boy receives a wasp sting on his left forearm and very quickly the area becomes
red and swollen. These changes are the result of a complex sequence of events some of which are listed below. If these events were placed in the correct temporal sequence, which one would be listed fourth?

(A) emigration of leucocytes  
(B) increased vascular permeability  
(C) release of chemical mediators  
(D) slowing of blood flow  
(E) vasodilation of arterioles

43. Retrograde transport from the end of the axon to the perikaryon plays an important role in the interaction between neurons and nerve growth factors. Which of the following molecules is responsible for retrograde transport in neurons?

(A) desmin  
(B) dynein  
(C) kinesin  
(D) myosin  
(E) neurofilaments

44. Neuroimaging revealed extensive necrosis in the substantia nigra of a patient. Which of the following symptoms is most likely expected in this patient?

(A) athetosis  
(B) chorea  
(C) “cogwheel” rigidity  
(D) hyperkinesias  
(E) intention tremors

45. A 40-year-old writer is to be treated for major depression. Which of the following drugs is the most selective inhibitor of the serotonin (5-HT) reuptake transporter (SERT) in nerve endings?

(A) amitriptylline  
(B) bupropion  
(C) citalopram  
(D) desipramine  
(E) maprotiline

46. A 36-year-old woman had a mass removed from her left ovary and a section of the lesion is shown in Figure 8-7. Based upon the microscopic features shown here, what is the most likely diagnosis?

FIG. 8-7 (Also see color insert.)

(A) dermoid cyst  
(B) dysgerminoma  
(C) granulosa cell tumor  
(D) mucinous cystadenocarcinoma  
(E) serous cystadenocarcinoma

47. A young man in his mid-twenties presented with mucosal lesions in his mouth. Based on his CD4 cell count and other signs during the past few months, he was diagnosed as having AIDS. Which of the following is the most likely etiology of the oral lesions?

(A) actinomyces  
(B) candida  
(C) cryptococcus  
(D) microsporum  
(E) nocardia

48. After a severe head trauma, a 25-year-old female patient has a taste deficit in the posterior one-third of the tongue. Where is the location of the neuronal cell bodies for the special visceral afferent (taste) fibers for the posterior one-third of the tongue?

(A) geniculate ganglion  
(B) inferior ganglion of ninth cranial (glossopharyngeal) nerve  
(C) submandibular ganglion  
(D) superior ganglion of ninth cranial (glossopharyngeal) nerve  
(E) trigeminal ganglion
49. A patient is referred for treatment of severely elevated cholesterol and triglyceride levels. Which of the following drugs is most likely to raise triglycerides while lowering LDL?

(A) colestipol
(B) ezetimibe
(C) gemfibrozil
(D) niacin
(E) rosvastatin

50. A 39-year-old man who has had ulcerative colitis for many years now presents with pruritis and jaundice. Laboratory tests reveal increased levels of total bilirubin and alkaline phosphatase. Endoscopic retrograde cholangiopancreatography (ERCP) shows a characteristic beading of the bile ducts. A liver biopsy shows a lymphocytic infiltrate, some bile duct proliferation with periductal fibrosis, and some destruction. Which of the following is the most likely diagnosis?

(A) ascending cholangitis
(B) choledochal cysts
(C) polycystic liver disease
(D) primary biliary cirrhosis
(E) primary sclerosing cholangitis
1. (C) The nucleotide analog, 5-azacytidine (5-azaC), is incorporated into replicating DNA when DNA polymerase would normally use deoxycytidine as the substrate. The incorporation of a nitrogen instead of carbon at position 5 of the nucleobase prevents subsequent methylation of 5-azaC in the DNA, when it is inserted into positions where the template strand of DNA contains CpG methylation sites. Thus, the incorporation of 5-azaC prevents conservation of methylation status in newly synthesized DNA, that is, results in hypomethylation, not hypermethylation (choice B). The nucleotide analog does not act as or reduce mutagenesis (choices A and D). Since 5-azaC is freely incorporated into DNA during replication, it does not interfere with replication (choice E).

2. (C) Viral diagnosis services are now done in many local medical center clinical laboratories due to improvements in test procedures and laboratory scientist expertise. CMV is a herpesvirus that is widespread in the population, usually in a latent infection format. It is also readily transmitted person-to-person, by close contact with virus-bearing material being required. When immune capacity is decreased (naturally or with immunosuppression), CMV often reemerges from latency and is capable of being very opportunistic. Isolation on human fibroblasts in the laboratory is desired to initiate gancyclovir treatment. When specimens need to be sent to outside laboratories for viral isolation/identification studies, it is important to have them protected from heat and/or drying. Choice C is the recommended condition for protecting viral viability during transportation. Most laboratories have excellent success in isolating and identifying CMV if the sample is kept at a temperature of −70°C and dry ice is utilized. The other choices (A, B, D, and E) would not be appropriate treatment or processing for such a specimen.

3. (C) This patient is exhibiting the typical findings of disseminated intravascular coagulation. This is initiated by the release of tissue factor or thromboplastic substance (either exogenous, e.g., amniotic fluid, or endogenous, e.g., tissue damage as in this case) into the circulation. This activated the coagulation cascade, resulting in the formation of multiple thrombi that can block the microcirculation and produce ischemia and necrosis in vulnerable tissues. As thrombus formation continues, platelets and clotting factors can be exhausted, allowing hemorrhage to occur. The ischemic changes and hemorrhage are both apparent in this patient. The other choices listed here, antithrombin deficiency (choice A), air emboli (choice B), and tissue hypoxemia (choice E) do not produce this combination of signs and symptoms. Infection (choice D), particularly gram-negative organisms, can produce disseminated intravascular coagulation via endothelial damage. Given the history and timing of this case, trauma leading to the release of tissue factor is more likely. However, endothelial injury may also initiate disseminated intravascular coagulation by the release of tissue factor.

4. (D) The apparent volume of distribution is a primary pharmacokinetic parameter and is calculated from the formula \( V_d = \frac{Amt}{C} \), where \( V_d \) is the apparent volume of distribution, \( Amt \) is the amount of drug present in the body, and \( C \) is the plasma (or blood) concentration. We know the amount of drug administered in this example (100 mg). Because the drug is subject to elimination immediately after administration, we must use the concentration at time 0 for our calculations. The curvature seen in the early data points results from slow distribution of the drug from blood into the tissue compartments that comprise the volume of distribution. Therefore, we cannot use these data points directly. However, the linear portion of
the data can be extrapolated back to time 0 to determine the plasma concentration that would have been obtained if distribution had been instantaneous. The administered amount (100 mg) divided by the extrapolated plasma concentration (1 mcg/mL or 1 mg/L) yields an apparent $V_d$ of 100 L.

5. (E) The septum secundum is a crescent-shaped wedge of tissue that incompletely partitions the developing atria, leaving a defect called the foramen ovale near the floor of the right atrium. The muscular interventricular septum (choice A) arises from the inferior part of the bulboventricular sulcus to incompletely partition the developing ventricles. The defect in the interventricular septum is closed by growth of the endocardial cushions creating the membranous interventricular septum. The ostium primum (choice B) is the opening between the right and left sides of the developing atrium that is gradually closed by the developing septum primum. The ostium secundum (choice C) is formed by the resorption of the superior part of the septum primum before it completely partitions the ventricles. The septum primum (choice D) is the first partition of the atria and would result in complete partitioning except for the timely development of the ostium secundum.

6. (C) Parainfluenza viruses are widespread throughout the population and can cause respiratory illnesses in all ages. They are major pathogens of infants and young children. In immunocompetent hosts, the viruses appear to grow only in the respiratory epithelial cells. More extensive infections (especially with types 1 and 2) may involve the larynx and upper trachea, resulting in croup (laryngotracheobronchitis). Croup is characterized by respiratory obstruction due to swelling of the larynx. This results in a resonant barking cough, difficult and suffocative breathing, and laryngeal spasm, resulting often in hypoxia. The most common complication of parainfluenza virus infection is otitis media. Nasal washes are good specimens for viral isolation. Bacteria (*H. influenzae*—choice A and *S. pneumoniae*—choice E) would be isolated using specific media in just a few days, not 2 weeks. Influenza virus (choice B) also attacks the upper respiratory tract, primarily a risk for the elderly, the very young, and patients with chronic illnesses. Symptoms would include high fever, muscular aches, malaise, and anorexia, but not the characteristic barking cough of croup. Clinical symptoms are similar in children and adults with influenza. RSV (choice D) primarily infects infants and children under the age of one. Bronchiolitis is the distinct clinical syndrome associated with this virus.

7. (D) Insulin action leads to the regulated expression of a number of genes encoding metabolic enzymes. Some of these regulatory events are positive and some negative on gene expression. PEP carboxykinase expression is reduced in response to insulin action. Additionally, expression of fructose 1,6-bisphosphatase and glucose 6-phosphatase is reduced as a result of insulin action. Conversely, insulin action leads to increased expression of acetyl CoA carboxylase (choice A), hepatic glucokinase (choice B), lipoprotein lipase (choice C), and pyruvate kinase (choice E).

8. (C) Presenting symptoms of lead poisoning are fairly nonspecific and include colicky abdominal pain, headache, irritability, constipation, and often times a line of precipitated lead sulphide along the gingival margins. These patients have a characteristic microcytic, hypochromic anemia with basophilic stippling of the RBCs. Fatty change of the liver with necrosis (choice A) can be seen in many situations, including carbon tetrachloride poisoning. Interstitial nephritis with lymphocytic infiltration (choice B) is seen in a number of situations and is a common adverse response to a number of antibiotics and other drugs. A common cause of pulmonary edema with hyperemia (choice D) is increased hydrostatic pressure that accompanies left heart failure. It also occurs with inflammation in response to injury and infection.

9. (C) Extrapolating the linear portion of the data, the concentration at time 0 is 1 mg/mL. By definition, the half-life is the time interval for 50% reduction in concentration for single-dose drug disappearance. The plasma concentration of
0.5 mg/mL is reached after approximately 8 hours. The half-life predicts the time course of approach to the final concentration for any situation in which first-order kinetics apply. Single-dose disappearance kinetics can be thought of as the approach to a final concentration of zero.

10. (B) In congenital coarctation of the aorta, the thoracic aorta is usually obstructed just past the origin of the left subclavian artery. If the constriction reduces the diameter of the aorta by more than 50%, then the patient develops symptoms such as decreased tolerance to exercise and greater fatigability. Because the radial artery arises from branches proximal to the coarctation and the posterior tibial artery from branches distal to the coarctation, simultaneous palpation of their pulses typically reveals posterior tibial pulses to be delayed and of lesser volume than the radial pulses. Choices A, C, D, and E are all incorrect.

11. (E) Viral myocarditis is often preceded by a few days or weeks of an upper respiratory infection or acute fever, although in some cases there may be no preceding symptoms. Patients often complain of continuous soreness in the chest and dyspnea and may also report leg swelling and palpitations. The myocarditis presents a spectrum of clinical possibilities. On the one hand it may resolve uneventfully and on the other it may present with signs of heart failure that becomes fatal. The typical microscopic findings are as described, but endomyocardial biopsy is not that sensitive as the inflammatory reaction may be patchy and thus missed on biopsy. This patient does not have the usual risk factors (intravenous drug abuse or preexisting valve abnormalities) or new onset murmurs associated with acute infective endocarditis (choice A) and this condition does not cause the microscopic findings reported here, making this an unlikely cause. Acute rheumatic fever (choice B) is principally a disease of childhood. The usual symptoms are polyarthritis, pancarditis, skin lesions (erythema marginatum) and nodules, and chorea. These are the major Jones criteria, two of which are needed to diagnose rheumatic fever. Alternatively, one major and two minor (arthralgia, fever, previous rheumatic fever, increased erythrocyte sedimentation rate or C-reactive protein, and prolonged PR interval on ECG) Jones criteria may be used. This patient does not meet these criteria. Hypertrophic cardiomyopathy (choice C) would not show the inflammatory changes seen microscopically in this patient but will reveal myocyte disarray in many cases. Myocardial infarction (choice D) would show an area of coagulative necrosis with a PMN infiltrate (depending upon the time postinfarction). In addition, this patient did not demonstrate the characteristic chest pain or ECG changes typical of infarction.

12. (E) Erythromycin inhibits protein synthesis in susceptible bacteria by binding to a site on the 50S ribosomal subunit. Minor mutations, such as methylation of the binding site, can render the organism resistant to the antibiotic. Expression of beta-lactamase activity (choice D) is a mechanism of resistance to penicillins and cephalosporins. Altered forms of dihydrofolate reductase occur in resistance to trimethoprim. Changes in the bacterial cell wall porins (choice B) are mechanisms for resistance to drugs used for gram-negative infections. Alteration of transpeptidases (choice C) is a mechanism of resistance to antibiotics that interfere with cell wall peptidoglycan synthesis such as beta lactams.

13. (C) The acute onset of painful enlargement of the thyroid accompanied by a fever following a recent upper respiratory viral infection is typical for granulomatous (or subacute or DeQuervain) thyroiditis. Microscopically, one sees a granulomatous response with phagocytosis of colloid that was released from damaged follicles. The process usually resolves within a few months without clinical consequences. Cells with clear (Orphan Annie eye) nuclei arranged in papillary structures are seen in papillary thyroid cancer. Dense fibrosis replacing thyroid and extending into surrounding structures (choice B) describes Riedel thyroiditis. Lymphocytic infiltration and lymphoid follicles with germinal centers (choice D) is found in Hashimoto thyroiditis. Polygonal
cells arranged in nests and sheets with stromal amyloid (choice E) is a description of medullary thyroid carcinoma which may occur as part of the multiple endocrine neoplasia type 2.

14. (B) Glucagon-like peptide-1 is derived from the product of the proglucagon gene. This gene encodes a preproprotein that is differentially cleaved dependent on the tissue in which it is synthesized. In the gut prohormone convertase one-third action leads to release of several peptides including GLP-1. On nutrient ingestion, GLP-1 is secreted from intestinal enteroendocrine L cells. Bioactive GLP-1 consists of two forms: GLP-1(7-37) and GLP-1(7-36) amide, where the latter form constitutes the majority (80%) of the circulating hormone. The primary physiologic responses to GLP-1 are glucose-dependent insulin secretion, inhibition of glucagon secretion, and inhibition of gastric acid secretion and gastric emptying. In addition, GLP-1 activity results in increased expression of the glucose transporter-2 (GLUT-2) and glucokinase genes in pancreatic cells. The action of GLP-1 at the level of insulin and glucagon secretion results in significant reduction in circulating levels of glucose following nutrient intake. The glucose-lowering activity of GLP-1 is highly transient as the half-life of this hormone in the circulation is less than 2 minutes. GLP-1 does not have a direct effect on the release of fatty acids from adipose tissue (choice A). However, it should be noted that since glucagon action on adipose cells leads to fatty acid release, a decrease in glucagon secretion will lead to secondary effects on adipose cell lipid release. GLP-1 does not affect the intestinal transport of sugars (choice C), the degradation of hepatic glycogen (choice D), nor the presentation of GLUT-4 in skeletal muscle (choice E).

15. (D) Gastrin infusion stimulates gastric acid secretion. Thus, initially, before peptide X was given, there was high gastric acid concentration. Secretin must have been peptide X because it is known to inhibit gastric acid secretion and to stimulate pancreatic bicarbonate production. Peptide X could not have been angiotensin II (choice A), which has several functions (e.g., stimulation of aldosterone secretion), none of which is inhibition of gastric acid secretion or stimulation of pancreatic bicarbonate secretion. Nor could it have been cholecystokinin (choice B), which mainly stimulates pancreatic enzyme secretion and gallbladder contraction. It also could not have been motilin (choice C), which has mainly to do with regulation of motility patterns. Somatostatin (choice E) has many inhibitory effects, in particular it is known to inhibit gastric acid secretion but it does not stimulate pancreatic bicarbonate production.

16. (E) SA node cells serve as the normal cardiac pacemaker. SA node cells spontaneously depolarize and this depolarization depends on potassium current, calcium current, and a current termed $I_p$. Diltiazem, a calcium channel blocker, will block SA nodal calcium current thereby slowing the rate of pacemaker depolarization thus slowing heart rate. Since pacemaker depolarization depends on calcium current, inhibiting that current would not increase heart rate (choice B). Calcium current in the SA node cell depolarizes the membrane, thus a drug that inhibits calcium current would hyperpolarize the cell (choice A). The action potential of SA node cells depends on calcium influx through voltage-gated calcium channels. Blocking calcium channels in the SA node would decrease the amplitude of this action potential (choices C and D).

17. (C) The image in Figure 8-3 shows a fairly typical pleomorphic adenoma with a biphasic pattern of epithelial cells and chondromyxoid matrix with numerous ducts and ductules. Chronic sialoadenitis (choice A) should be marked by the presence of inflammatory cells which are not seen. The microscopic appearance of a mucocele (choice B) is that of a cyst-like space filled with mucinous material. Recurrent laryngeal carcinomas (choice D) are almost always squamous cell carcinomas so one would expect to see malignant squamous cells in the image, which is clearly not the case. Warthin tumors (choice E) have the distinctive appearance of a double layer of eosinophilic, oncocytic epithelial cells on a lymphoid stroma.
18. (B) The deoxygenated subunits of the hemoglobin tetramer exist in the T ("tense") conformational state. As erythrocytes enter the capillaries of the lung alveoli, the partial pressure of \(O_2\) has increased sufficiently to allow binding to hemoglobin. When one mole of \(O_2\) binds, it causes a shift in the overall conformation of the other subunits to a more R ("relaxed") conformational state. This change in conformation leads to higher affinity of the remaining monomers for \(O_2\). Each deoxygenated monomer has a progressively increased affinity for \(O_2\) as more oxygen binds. This cooperative binding is observed as a sigmoidal saturation curve when plotting the partial pressure of oxygen versus moles of \(O_2\) bind. Binding of oxygen does impact the secondary structure of hemoglobin but only to a minor degree, and, this has no impact on its affinity for \(CO_2\) (choice A). As indicated, oxygen binds cooperatively to hemoglobin, not with equal affinity to each deoxy subunit (choice C). Oxygen binding shifts the position of the heme group, but not sufficiently to place it on the exterior of any hemoglobin subunit (choices D and E).

19. (B) \(CO\) and \(O_2\) compete for a common binding site. Both bind to the heme group of hemoglobin. \(CO\) competes allosterically with \(O_2\) and does not bind to the heme group. \(CO\) thus does not directly compete with \(CO\) (choice A). \(CO\) is particularly toxic because it binds to hemoglobin with about 250 times higher affinity than does \(O_2\) and can displace \(O_2\) thereby decreasing the blood’s \(O_2\)-carrying capacity (choice C). Despite its high affinity for hemoglobin, \(CO\) does slowly dissociate since, like \(O_2\), \(CO\) forms a reversible bond with hemoglobin (choice D). \(CO\) is a diffusion-limited gas since it normally does not equilibrate when exposed to pulmonary capillary blood. It is thus not perfusion-limited (choice E). Because it is diffusion-limited, \(CO\) is used in a clinical setting to measure the lung diffusion capacity.

20. (D) 21-beta hydroxylase deficiency is the most common enzyme defect in the adrenal gland. In one form of the disorder, called the "salt-wasting" form, aldosterone synthesis is impaired. This is due to the fact that progesterone cannot be converted to 11-deoxycorticosterone, an intermediate on the adrenal mineralocorticoid pathway toward aldosterone (see Figure 8-8). The lack of aldosterone leads to a lack of sodium reabsorption by the distal renal tubules and hence to low serum sodium concentrations, not high ones (choice B). If untreated, hyponatremic dehydration, hyperkalemia, and metabolic acidosis develop. By the second or third week of life, continuous dehydration, worsened by vomiting, leads to circulatory collapse, termed salt wasting crisis. The lack of 21-beta-hydroxylase also leads to a decrease of cortisol synthesis. This is due to the fact that 17-alpha-hydroxyprogesterone cannot be converted to 11-deoxycortisol, the precursor of cortisol (see Figure 8-8). By feedback regulation, low serum cortisol concentration results in increased production of ACTH. Increased ACTH leads to adrenal gland hyperstimulation and increased production of adrenal androgens, which results in precocious puberty, not delayed puberty as stated in choice A. In the moderate form of classical 21-beta-hydroxylase deficiency, virilization before puberty is the most prevalent symptom. Increased ACTH production requires increased production of the ACTH precursor POMC. POMC not only generates ACTH, but also alpha-MSH (melanocyte-stimulating hormone), which
causes hyperpigmentation, not hypopigmentation (choice C). Fast growth, promoted by the excess of sex steroids, is accompanied by early closure of the epiphyseal plate resulting in a short stature, not a tall stature (choice E).

21. (A) The transplanted kidney is usually placed in the iliac fossa in the greater pelvis for better support, and its renal artery and vein are connected to the external iliac artery and vein. This procedure thus requires only short lengths of the renal vessels from the transplanted kidney. The inferior vena cava (choice B) would require longer lengths of renal vessels from the transplanted kidney. The internal iliac artery and vein (choice C) are located deep in the lesser pelvis and it is inconvenient to try to connect them to the renal vessels. The same is true of the lumbar artery and vein (choice D), which are located deep in the posterior abdominal wall. The nonfunctioning kidney is usually left in place in the patient and thus, the vessels of the transplanted kidney are not attached to the renal artery and vein (choice E).

22. (A) Atenolol is a powerful beta-adrenoceptor-blocking agent and may cause AV blockade in patients with preexisting conduction disease. It is an effective prophylactic in recurrent angina but would not be used in this patient. Atorvastatin (choice B) is an effective lipid-lowering drug and has no direct effect on angina. However, clinicians now consider lipid-lowering of prime importance in patients with severe angina who also have high cholesterol. Clonidine (choice C) is useful in hypertension, but is not indicated for angina in the absence of elevated blood pressure. Isosorbide mononitrate (choice D) is a longer-acting oral nitrate preparation for prophylaxis of angina and would probably be the drug of choice in this patient. Nifedipine (choice E) in its slow-release forms might be considered for this patient. Because it causes marked vasodilation, it causes sympathetic discharge. This sympathetic effect tends to maintain normal AV conduction.

23. (C) A significant proportion of low-grade squamous intraepithelial lesions result from human papillomavirus infection. Viral subtypes 16 and 18 are more likely to progress to high-grade dysplasias. Koilocytosis is the usual morphologic marker of viral infection. It is unlikely that these changes would result from a hereditary disorder (choice A), hormonal imbalances (choice B), normal intermenstrual reactions (choice D), or a protozoan infection (choice E).

24. (B) There are several classes of drugs that are currently in use for the treatment of the hyperglycemia associated with Type II diabetes. The sulfonylurea drugs function by binding to and inhibiting the pancreatic ATP-dependent K⁺ channel that is responsible for glucose-mediated insulin secretion. The normal pancreatic response to increased blood glucosa is an increased uptake by beta cells with concomitant oxidation. The increase in glucosa oxidation leads to an elevation in the ATP/ADP ratio. This in turn leads to an inhibition of the ATP-sensitive K⁺ channel. The net result is a depolarization of the cell leading to Ca²⁺ influx and insulin secretion. The sulfonylureas have been used in the United States for nearly 50 years. The first-generation sulfonylureas (tolbutamide, acetohexamide, chlorpropamide, and tolazamide) are not routinely prescribed any longer in the United States. The second-generation sulfonylureas include glipizide (Glucotrol), glimepiride (Amaryl), and glyburide (DiaBeta, Micronase, Glynase). Because all of these drugs can induce pronounced hypoglycemia, treatment is initiated with the lowest possible dose and carefully monitored until the dose is found that results in a free plasma glucose concentration of 110–140mg/dL. The thiazolidinedione drugs, for example, pioglitazone (Actos) and rosiglitazone (Avandia), work by activating the PPAR-gamma class of transcriptional cofactors (choice A). The alpha-glucosidase inhibitors, for example, acarbose (Precose), interfere with carbohydrate digestion (choice C). The biguanides, for example, metformin (Glucophage), act, in part, by suppressing hepatic glucose output (choice D). Although the sulfonylureas increase insulin secretion from the pancreas, they do not stimulate an increase in pancreatic glucose metabolism (choice E).
25. (E) Hypothyroidism is often characterized by confusion, anxiety, and depression combined with fatigue, insomnia, and weight gain (myxedema). A dexamethasone suppression test (choice B) may be positive in major depression as well as in Cushing syndrome, but is of questionable clinical value in this case. Increased serum calcium level (choice D) may be associated with depressive symptoms, but is of questionable value in this case. Beriberi (choice A) may also cause weight gain and depression, but is unlikely to cause cold sensitivity. Psychological tests such as Rorschach (choice C) are also unlikely to be of much help.

26. (D) Psychomotor retardation refers to decreased motoric and speech response which often occurs in depression. Increased activity (psychomotor agitation) (choice C) may also be seen in depression. Emotional lability may be seen in hysteria and pseudobulbar palsy (choices A and B), but there is no history to support these diagnoses. Restless leg syndrome (choice E) involves motoric activity not connected with depressive syndrome with agitation.

27. (B) A patient who has suicidal intentions and agitated depression is a very high-risk patient, and hospitalization is indicated even against the patient’s wishes. Family, even if available, may not be able to provide safe-enough environment for the patient (choice A). Choice C is inappropriate as an acutely depressed, even if not currently suicidal, should be followed up at least within a week or two as they may become suicidal. Choice D may be appropriate in a non-suicidal depressed patient. Crisis counseling (choice E) might be appropriate during or after hospitalization.

28. (E) Past suicidal attempts increase the risk of suicide. Therefore, coupled with agitated depression, the patient’s suicidal intent should be taken very seriously. Choices A and D are therefore incorrect. Suicide attempts are common in psychosis (choice C), but there is no evidence of it at present. Antisocial personality (choice B) is not usually associated with suicide attempt.

29. (B) The ECG shows prolongation of the QT interval, the interval that reflects the ventricular repolarization time (i.e., the duration of the ventricular action potential). Ibutilide is a group III antiarrhythmic drug that prolongs action potential duration and the QT interval by blocking the delayed rectifier potassium channel (IK). Adenosine (choice A), is a member of the miscellaneous group of antiarrhythmic agents and does not prolong ventricular action potential duration. Its major effect is to block AV conduction. Lidocaine (choice C) is a highly selective group IB agent that has little effect on the ECG. Quinidine (choice D), a group IA sodium channel blocker, prolongs the QRS duration as well as the QT interval. Verapamil (choice E), a group IV calcium channel blocker, prolongs PR interval and has little effect on the QT interval.

30. (A) Glutamate dehydrogenase uses both nicotinamide nucleotide cofactors; NAD⁺ in the direction of nitrogen liberation and NADPH for nitrogen incorporation. The reaction catalyzing the liberation of ammonia and alpha-ketoglutarate (α-KG) from glutamate is a key anapleurotic process linking amino acid metabolism with TCA cycle activity. This reaction allows glutamate to play an important role in energy metabolism. Glutamate dehydrogenase provides an oxidizable carbon source used for the production of energy as well as a reduced electron carrier, NADH. In the forward reaction, as shown in Figure 8-5, glutamate dehydrogenase is important in converting free ammonia and alpha-KG to glutamate, forming 1 of the 20 amino acids required for protein synthesis. As expected for a branch point enzyme with an important link to energy metabolism, glutamate dehydrogenase is regulated by the cell energy charge. ATP (choice B) and GTP (choice E) are positive allosteric effectors of the formation of glutamate, whereas ADP and GDP are positive allosteric effectors of the nitrogen-liberating reaction. Thus, when the level of ATP is high, conversion of glutamate to alpha-KG and other TCA cycle intermediates is limited; when the cellular energy charge is low, glutamate is converted to ammonia and oxidizable
TCA cycle intermediates. Citrate (choice C) and glutamine (choice D) do not allosterically affect glutamate dehydrogenase.

31. (A) Oncogene is the general term given to genes that cause cancer. Normal versions of these transforming genes are present in normal cells and have been called proto-oncogenes. The discovery of cellular oncogenes came from studies with acutely transforming retroviruses. Normal cells contained highly related, but not identical, copies of various retrovirus-transforming genes and probably occurred by accidental transduction. A number of mechanisms may activate a benign proto-oncogene, producing products that may be oncogenic. Fundamental differences exist between the oncogenes of DNA and RNA tumor viruses. DNA tumor virus genes encode functions for viral replication and do not have similar homologs in cells. The DNA virus-transforming gene products complex with normal cell proteins and alter their function. DNA viruses, including polyomaviruses, papillomaviruses, adenoviruses, and herpesviruses all have identified oncogenes. Since DNA viral oncogenes encode functions for viral replication, they are expressed early in the viral multiplication cycle, not late (choice B). They are also specific for DNA virus replication and not expressed at low levels (choice C) during embryogenesis. DNA virus oncogenes are not identical to cellular oncogenes (choice D). Retrovirus-transforming genes are similar to cellular oncogenes. Transformed cells are often recognized by the more rapid and uncontrolled growth when compared to non-transformed cells. Therefore, DNA oncogene function does not lead to slowing of the proliferation rate of infected cells (choice E).

32. (C) Movement of an individual to a higher altitude (with decreased partial pressure of oxygen) requires greater oxygen-carrying capacity of blood and is thus a stimulus for an increased rate of erythrocyte production. The mechanism underlying this response entails increased production, by the kidney, of the hormone erythropoietin. This is reflected by an increased percentage of circulating erythrocytes that are newly developed (reticulocytes). Exposure to allergens (choice A), infectious agents (choices B and E), or vaccines (choice D) elicit responses involving distinct populations of leukocytes.

33. (C) The pathology of MG results from destruction of postsynaptic acetylcholine receptors with alteration of the normal morphology of the postsynaptic membrane. The acetylcholine receptor is a ligand-gated ion channel that, when activated depolarizes the postsynaptic cell and, in skeletal muscle, generates an end plate potential (EPP). Due to destruction of the acetylcholine receptors, normal presynaptic release of acetylcholine may not be sufficient to create a large enough EPP to bring the fiber to threshold to fire an action potential. Any manipulation that increases the amount or duration of action of acetylcholine in the synaptic cleft can activate additional receptors, thereby increasing the size of the EPP. Since acetylcholine esterase hydrolyzes acetylcholine in the synaptic cleft, a drug like pyridostigmine, that inhibits the esterase, can mitigate the effects of MG by increasing levels of acetylcholine (choice C is correct). Choices A, B, D, and E all decrease release, production, or efficacy of acetylcholine as a transmitter at the neuromuscular junction and would only worsen symptoms in MG.

34. (B) The description of a monomorphous population of poorly differentiated cells immediately suggests the diagnosis of a malignancy. Infiltration of these cells in the lamina propria and submucosa, accompanied by an eosinophilic infiltrate and destruction of gastric glands describes the histological appearance of a high-grade B-cell lymphoma; clinical findings associated with this disease include early satiety, peptic ulcer disease-like complaints, and gastric outlet obstruction. Gastric adenocarcinoma (choice A) would be expected to be mucin-positive, and thus is ruled out by the negative histochemical staining. Menetrier disease (choice C), peptic ulcer disease (choice D), and type A gastritis (choice E) are not neoplastic diseases and are therefore eliminated from consideration.

35. (C) This patient displays global aphasia, resulting from infarction of the cortical speech
centers. The middle cerebral artery supplies the majority of the lateral aspect of the cerebral hemisphere, including all the cortical speech centers. The anterior (choice A) and posterior (choice D) cerebral arteries supply the medial and inferior aspect of the cerebral hemisphere. The lenticulostriate (choice B) and the posterior choroidal (choice E) arteries supply subcortical structures.

36. (E) An undesirable side effect of chemotherapy used to treat malignancies is the destruction of T cells, which play a key role in the development of immunity against viral infections. This is especially true for viral diseases in which the etiological agent remains dormant in the body. Varicella-zoster is an excellent example of such a virus. Thus, flareups of varicella-zoster infections are well known occurrences in cancer patients who receive chemotherapy. The varicella-zoster virus is a single entity. It is a medium-sized (100–200 nm) double-stranded DNA virus of the herpesvirus group, with only one serological type. Primary infection with the varicella-zoster virus causes chicken pox. Immunity develops, but the virus remains latent in the body. Immunosuppression by chemotherapy reactivates the varicella-zoster virus and causes shingles (choices C and D). Deficiency in the third component of complement is associated with enhanced susceptibility to pyogenic extracellular bacterial, but not viruses (choice A). Hypogammaglobulinemia has not been shown to cause disseminated varicella-zoster infection (choice B).

37. (B) Flumazenil binds to the BZ receptor and selectively inhibits the actions of benzodiazepines. EDTA (choice A) is a chelating agent (a chemical antagonist) used in heavy metal poisoning. Fomepizole (choice C) inhibits alcohol dehydrogenase and reduces the toxicity of methanol and glycerol ingestion. Naltrexone (choice D) is a pharmacologic antagonist of mu-opioids. Physostigmine (choice E) inhibits acetylcholinesterase and because it enters the CNS readily, can be used to reduce the central toxicity of atropine poisoning.

38. (A) Chronic granulomatous disease patients cannot generate hydrogen peroxide metabolically because of their genetic defect in NADPH oxidase. Thus, they are repeatedly infected with catalase-positive microorganisms such as staphylococci. In contrast to this, these patients are rarely infected with catalase-negative bacteria such as streptococci (choices B, C, D, and E). This occurs because catalase-negative bacteria accumulate hydrogen peroxide, activating the defective myeloperoxidase-hydrogen peroxide-halide system of the host neutrophils.

39. (E) Clopidogrel and ticlopidine irreversibly bind to the ADP receptors of platelets and inhibit aggregation. Activation of antithrombin III (choice A) is the major mechanism of action of heparin. Direct activation of plasminogen to plasmin (choice B) is the mechanism of action of tissue plasminogen activators such as alteplase and tenecteplase. Inhibition of thromboxane synthesis (choice D) is the mechanism of antiplatelet action of aspirin. Inhibition of factor Xa (choice C) is the mechanism of action of regular heparin and low-molecular-weight heparins.

40. (C) The history and laboratory results strongly suggest systemic lupus erythematosus (SLE). The test for antinuclear antibodies is positive in nearly every patient with SLE, but is also positive in other autoimmune diseases. In active cases, a more specific test is the demonstration of anti–double-stranded DNA antibodies, which is virtually diagnostic. A differential count on synovial fluid (choice A) is not diagnostic, even though the majority of patients with SLE have joint involvement. A renal biopsy (choice B) may at some time be necessary to assess renal status, but it would not be done at this time as a diagnostic procedure. A majority of patients with SLE have skin changes, but because these are not specific, a skin biopsy (choice D) is not diagnostic. Patients with porphyria also have skin lesions that are exacerbated by sun exposure. However, they do not have the other findings of this patient, so a urine test for porphyrins (choice E) is not appropriate.

41. (D) The second heart sound occurs with the closing of the outlet valves of the right and left ventricles: the aortic and pulmonic valves, as
the ventricle pressure is decreasing from the peak systolic pressure. Increased right ventricular pressure will delay the closing of the pulmonary valve component of the second heart sound so that a splitting of the valve closing sounds occurs. Choice A represents the time of atrial contraction, which if it is heard, would be associated with the fourth heart sound. Choice B represents the closing of the atroventricular (A-V) valves of the right and left heart and is heard as the first heart sound. Choice C represents the opening of the outlet valves of the heart and is not normally heard. Choice E represents the opening of the A-V valves of the right and left heart and is not normally heard.

42. (D) This child’s wasp sting will stimulate an acute inflammatory response which consists of two principal components, a vascular reaction and a cellular reaction. The vascular changes occur first as a result of chemical mediators (choice C, step 1) that are released in response to the provoking insult. Although several different mediators are involved, vasodilation of arterioles (choice E, step 2) is chiefly induced by histamine, prostaglandins, and nitric oxide. Vasodilation is rapidly followed by increased vascular permeability of postcapillary venules (choice B, step 3), principally regulated by histamine, bradykinin, and leukotrienes. Subsequent extravasation of fluid into the interstitial space leads to an increase in blood viscosity, and hence, subsequent slowing of blood flow (stasis). The cellular response of acute inflammation is then initiated as leukocytes marginate to the vessel wall and progress through a sequence of events that leads to their emigration (choice E, step 5) into the interstitium and eventual source of the injury.

43. (B) Dynein has an ATP-binding head interacting with the microtubule and a tail binding to receptor sites on transport vesicles. Retrograde movement along the microtubule results from continuous hydrolysis of ATP. Desmin (choice A) is a component of the Z disk of sarcomere in skeletal muscle. Kinesin (choice C) is responsible for anterograde transport along the axons of neurons. Myosin (choice D) associates with actin in muscle to form contractile structures. Neurofilaments (choice E) are cytoskeletal components of neuronal dendrites and axons. They are not involved in axonal transport.

44. (C) The symptoms related to degeneration of the substantia nigra are best known from Parkinson’s disease, which is characterized by progressive rigidity and slowness of movement (bradykinesia), as well as difficulty initiating movements. On examination, passive movement of the limbs is met with constant resistance. Superimposed tremors give it a “cog wheel”-like quality. Athetosis (choice A)—writhing involuntary movements of the proximal extremities—and chorea (choice B)—brief purposeless movements of the distal extremities—are examples of hyperkinesias due to dopaminergic overactivity in the basal ganglia. Hyperkinesia (choice D) is an excess of movement often due to disorders of the basal ganglia. Degeneration of substantia nigra and Parkinson’s disease is characterized by poverty of movement and a mask-like facial expression. Intention tremors (choice E) are characteristic of cerebellar lesions.

45. (C) Citalopram is a selective serotonin reuptake inhibitor (SSRI) and is by far the most selective of the agents listed. Amitriptylline (choice A) is a first generation tricyclic antidepressant with only slightly more effect on serotonin reuptake than on norepinephrine reuptake. Bupropion (choice B) is an unusual antidepressant with a poorly understood mechanism. It has little or no effect on serotonin reuptake. Desipramine (choice D) is another first-generation tricyclic with much greater effect on norepinephrine than on serotonin reuptake. Maprotiline (choice E) is a newer antidepressant but, like desipramine, it has much greater effect on norepinephrine reuptake.

46. (A) Figure 8-7 shows an area of cartilage adjacent to the salivary gland. The only ovarian tumor that features a random mixture of mature tissues is a mature cystic teratoma or dermoid cyst. Tissues derived from all three germ layers
are found in these tumors with skin, hair, and sebaceous glands being the most common components. Dysgerminoma (choice B) is the ovarian counterpart of the testicular seminoma, demonstrating nests of round clear cells separated by fibrous septae-containing lymphocytes. Granulosa cell tumor (choice C) is an estrogen-secreting tumor that has a somewhat variable cellular composition with the presence of the characteristic Call-Exner bodies. Mucinous cystadenocarcinoma (choice D) is composed of variably differentiated mucinous columnar cells. Serous cystadenocarcinoma (choice E) is the most common malignant ovarian tumor and is usually composed of complex papillary structures of variable differentiation.

47. **B** While healthy, immunocompetent people are usually resistant to fungal infections, patients with immunocompromised host defenses (AIDS patients) are susceptible to them. As members of the normal microbial flora, candida and related yeasts are endogenous opportunists. In patients with AIDS, the susceptibility and incidence of opportunistic mycoses are inversely correlated to the CD4 lymphocyte count. *Actinomyces* (choice A) are a large group of gram-positive bacilli. Cervicofacial actinomycosis presents as a swollen, erythematous process in the jaw area, while thoracic disease resembles a subacute pulmonary infection where lung tissue is destroyed. Peritoneal actinomycosis may follow a ruptured appendix. *Cryptococcus* (choice C) is a yeast with a capsule which is widespread in nature and often found in large numbers in dried pigeon feces. Cryptococcosis is usually associated with immunosuppression, but can also occur in healthy normal hosts. The major clinical manifestation is chronic meningitis, which is ultimately fatal if untreated. *Microsporum* (choice D) species are cutaneous fungi that infect only skin, hair, and/or nails. *Nocardia* (choice E) are gram-positive opportunistic bacteria found in soil and water and are usually found as abscesses.

48. **D** The unipolar neuronal perikarya in the superior ganglion of cranial nerve IX provide special visceral afferent (taste) fibers for the posterior one-third of the tongue and project centrally to the gustatory nucleus in the medulla oblongata. The geniculate ganglion (choice A) provides taste fibers for the anterior two-thirds of the tongue and also projects to the gustatory nucleus. Fibers of the geniculate ganglion are carried by the VIIth cranial (facial) nerve. The inferior ganglion of the IXth cranial nerve (choice B) provides visceral afferent fibers for the soft palate, posterior one-third of the tongue, tonsils, fauces, pharynx, auditory tube, and tympanic cavity. It carries information from the carotid sinus and body. The submandibular ganglion (choice C) contains postganglionic parasympathetic neurons, which receive their preganglionic parasympathetic innervation from fibers of the chorda tympani. The submandibular ganglion provides parasympathetic innervation for the submandibular and sublingual gland. The trigeminal ganglion (choice E) provides general sensory afferent (touch, pain, and temperature) fibers for the entire tongue.

49. **A** Resins such as colestipol and cholestyramine tend to increase triglycerides while lowering cholesterol, so they would be unsuitable for this patient. Ezetimibe (choice B) reduces cholesterol levels by inhibiting transport across the intestinal epithelium. Gemfibrozil (choice C), a fibrate, acts peripherally to increase lipoprotein lipase activity and reduce VLDL levels. Niacin (choice D) acts in the liver to reduce VLDL secretion and also reduces triglyceride levels. Both niacin and fibrates are useful in hypertriglyceridemia. Rosuvastatin (choice E) inhibits HMG-CoA reductase and reduces cholesterol synthesis in the liver. It also lowers triglycerides.

50. **E** Primary sclerosing cholangitis is a chronic progressive periductal fibrosing biliary tract disease primarily affecting middle-aged men. It is associated with ulcerative colitis in about 70% of patients. Radiographic procedures are essential to show the diagnostic beading of the intrahepatic or extrahepatic bile ducts caused by the periductal fibrosis alternating with areas of ectasia. Ascending cholangitis (choice A) is
caused by bacteria entering the biliary tract via the sphincter of Oddi, usually as a result of obstruction to bile flow. Choledochal cysts (choice B) are congenital dilations of the common bile duct. Polycystic liver disease (choice C) is an autosomal dominant condition in which multiple fluid-filled cysts appear throughout the liver. They appear in association with adult polycystic renal disease. Primary biliary cirrhosis (choice D) is a chronic progressive cholestatic disease primarily affecting middle-aged women. There is a strong association with autoimmune disorders and anti-mitochondrial antibodies are usually present.


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CHAPTER 9

Practice Test 2
Questions

1. A 32-year-old woman was in good health with no medical complaints before undergoing surgery for a left foot fracture. During the operation, a 2-cm translucent, lobulated mass with a small area of calcification was also removed. Histology demonstrated nodules of well-circumscribed cartilage with a hyaline matrix and irregularly scattered chondrocytes with an area of ossification at the nodular periphery. Based on this information, which of the following is the most likely diagnosis?

   (A) chondroma
   (B) chondrosarcoma
   (C) osteochondroma
   (D) osteoid osteoma
   (E) osteosarcoma

2. Which of the following agents has negative inotropic effects in the normal heart and may exacerbate acute heart failure, but has been shown to be beneficial in chronic heart failure?

   (A) captopril
   (B) dobutamine
   (C) metoprolol
   (D) nesiritide
   (E) spironolactone

3. A 9-year-old boy had a brain tumor removed 2 years ago. It was located in the vermis of the cerebellum and was growing into the fourth ventricle. He has now developed signs and symptoms of spinal cord compression. The tumor that was removed was most likely which of the following?

   (A) craniopharyngioma
   (B) glioblastoma multiforme
   (C) medulloblastoma
   (D) meningioma
   (E) oligodendroglioma

4. The Randall hypothesis was proposed to explain the acquisition of insulin resistance associated with central adiposity. Which of the following statements best reflects the basis of the Randall hypothesis?

   (A) An increase in adipocyte volume due to increased lipid storage causes adipocytes to lose their responsiveness to insulin.
   (B) Increased circulating free fatty acids in obese individuals impair the ability of insulin to stimulate skeletal muscle cells glucose uptake.
   (C) Long-term hyperlipidemia leads to permanent elevation in pancreatic insulin secretion that ultimately causes down-regulation of insulin receptors.
   (D) The high level of circulating free fatty acids stimulates the liver to shut off gluconeogenesis that then impairs pancreatic sensing of the need for insulin release.
   (E) The hyperglycemia prevalent in obese individuals activates glucagon release from the pancreas leading to increased adipocyte lipolysis.
5. If a patient has an amnestic syndrome due to thiamine deficiency, the lesions are most likely to be in which of the following structures?
   (A) cerebellum  
   (B) frontal lobe  
   (C) limbic system  
   (D) occipital lobe  
   (E) parietal lobe

6. Arrow 5 in Figure 9-1 points to which of the following structures in the organ of Corti?

   (A) inner hair cells  
   (B) inner tunnel  
   (C) outer hair cells  
   (D) outer phalangeal cells  
   (E) tectorial membrane

7. A 14-year-old student has a history of multiple microbial infections which do not respond to tobramycin therapy. Which of the following represents the most common mode by which bacteria become resistant to streptomycin or other aminoglycosides?
   (A) acetylation of hydroxyl groups  
   (B) decaboxylation of aminoglycosides  
   (C) dephosphorylation of aminoglycosides  
   (D) removal of adenyl groups  
   (E) removal of amino groups of aminoglycosides

8. Autopsy findings from a 54-year-old woman who died secondary to end-stage kidney failure revealed shrunken, asymmetrical kidneys with extensive corticomedullary scars and dilated, blunted calyces. Microscopically, patchy atrophic tubules were seen interspersed with dilated, hypertrophic tubules containing acellular casts. Extensive glomerular and interstitial fibrosis and chronic tubulointerstitial inflammation were present. Based on these findings, what was the most likely underlying cause of this patient’s kidney failure?
   (A) acute tubular necrosis  
   (B) analgesic nephropathy  
   (C) chronic pyelonephritis  
   (D) diabetic glomerulosclerosis  
   (E) focal segmental glomerulosclerosis

9. Which of the following statements about the treatment of Parkinson’s disease is most correct?
   (A) Anticholinergic agents such as biperiden should not be used together with dopamine agonists.  
   (B) Bromocriptine can be effective but often causes prolactinemia.  
   (C) Concurrent use of an atypical antipsychotic agent such as clozapine will prevent the beneficial effects of levodopa.  
   (D) Ropinirole is an effective D₂ agonist that is used alone as well as with levodopa in Parkinson’s disease.  
   (E) Tolcapone and entacapone are effective via inhibition of MAO in the extrapyramidal system.

10. There is strong evidence for the existence of an internal biological clock. Disturbance of this clock causes irregularities in circadian rhythms and sleep disorders. Which of the following statements are true regarding circadian rhythms of a rested person in ambient temperature?
   (A) after darkness, melatonin production falls  
   (B) children below the age of 3 do not show circadian rhythms  
   (C) the core temperature at 5 a.m. is higher than at 5 p.m.
11. The technique referred to as RNA interference (RNAi) involves the targeted destruction of mRNAs leading to reduced levels of bioactive protein. Using RNAi could be expected to have a pharmacological benefit in which of the following disorders?

(A) Huntington’s disease
(B) PKU
(C) retinoblastoma
(D) Tay-Sachs disease
(E) von Hippel-Lindau syndrome

12. A farmer develops a fever that rises and falls on a daily basis. Additional signs and symptoms include chills, headache, enlarged lymph nodes, and great fatigue. A culture of blood reveals a small gram-negative rod after a 3-week incubation period. This bacterium is most likely to be which of the following?

(A) Brucella melitensis
(B) Burkholderia mallei
(C) Enterobacter aerogenes
(D) Vibrio parahaemolyticus
(E) Yersinia pseudotuberculosis

13. A patient with severe hepatic cirrhosis has developed marked peripheral pitting edema and ascites (fluid in the peritoneal cavity). Which of the following drugs is most likely to cause an effective diuresis in this patient?

(A) captopril
(B) digoxin
(C) hydrochlorothiazide
(D) spironolactone
(E) triamterene

14. The vertebral artery can be observed in the floor of the suboccipital triangle, as it lies on the posterior arch of the C1 (atlas) vertebra. The suboccipital triangle is formed by muscles responsible for producing movements of the atlanto-occipital joints. Which of the following innervates the muscles of the suboccipital triangle?

(A) anterior ramus of C1 nerve
(B) dorsal ramus of C1 nerve
(C) greater occipital nerve
(D) lesser occipital nerve
(E) third occipital nerve

15. A 50-year-old company mid-level executive worried constantly about work and noticed an increase in severe “heart-burn” symptoms that finally brought him to his physician. Which of the following represents the most useful and rapid diagnostic test to verify the presence of H. pylori?

(A) carbohydrate utilization tests
(B) culture of gastric contents on blood agar containing metronidazole and bismuth salts
(C) determination of IgE
(D) Gram stain of the gastric contents
(E) in vivo or in vitro tests for urease

16. A 56-year-old woman is to be treated for severe chronic rheumatoid arthritis. She is already receiving maximum doses of naproxen. Which of the following agents would be most appropriate for providing additional chronic anti-inflammatory activity?

(A) celecoxib
(B) dexamethasone
(C) infliximab
(D) methotrexate
(E) tacrolimus
17. Which of the following changes occurs as blood passes through pulmonary capillaries?
(A) The oxygen/hemoglobin dissociation curve shifts to the right.
(B) The pH of the blood becomes more acidic.
(C) There is a net movement of bicarbonate ions from plasma to erythrocytes.
(D) There is a net movement of $\text{Cl}^-$ from plasma to erythrocytes.
(E) There is net movement of $\text{CO}_2$ from alveolar air to blood.

18. Activation of which of the following enzymes, involved in the regulation of cholesterol bio-
genesis, occurs in response to an altered ATP/ADP ratio?
(A) AMP-activated kinase (AMPK)
(B) HMG-CoA reductase phosphatase
(C) protein phosphatase 2C
(D) protein phosphatase inhibitor-1
(E) protein kinase A (PKA)

19. A patient who is dehydrated because of severe sweating and inadequate water intake would be expected to exhibit which one of the following?
(A) decreased plasma ADH
(B) decreased plasma serum albumin concentration
(C) hyperosmotic urine
(D) low plasma sodium concentration
(E) positive free-water clearance

20. The Food and Drug Administration of the US government regulates the purity, dosage, and medical claims of which one of the following products?
(A) echinacea
(B) gingko
(C) iron sulfate
(D) kava
(E) St. John’s wort

21. In olfaction, the odoriferous substances are dissolved in a serous fluid containing the odorant-binding protein and protective substances such as IgA and lysozyme. Which of the following components of the olfactory epithelium is responsible for the secretion of this serous fluid?
(A) basal cells
(B) cells of olfactory gland of Bowman
(C) immature olfactory cells
(D) olfactory neurons
(E) supporting cells

22. A 23-year-old man has been complaining of intermittent diarrhea, fever, and abdominal pain for several months. A radiograph of the small bowel reveals several separate areas of lumenal narrowing. A photomicrograph of this patient’s ileal biopsy is displayed in Figure 9-2. What is the most likely diagnosis?

(A) abetalipoproteinemia
(B) adenocarcinoma
(C) carcinoid tumor
(D) Crohn’s disease
(E) ulcerative colitis

23. Which of the following is true concerning tobacco?
(A) It is the most common type of drug dependency in the United States.
(B) Nicotine is associated with psychological dependence but no physical withdrawal symptoms.
(C) Physical complications of chronic tobacco use usually begin to appear in 40 pack-years.
(D) The relapse rate of most smoking cessation programs is 30%.
(E) Tobacco dependence usually begins in childhood.

24. A 27-year-old woman complains of an extremely painful lesion at the distal end of her left middle finger. Examination reveals a reddish-blue, exquisitely tender nodule that measures 0.5 cm x 0.5 cm. This most likely represents which of the following?
(A) basal cell carcinoma
(B) capillary lymphangioma
(C) glomus tumor
(D) hemangioendothelioma
(E) nevus flammeus

25. The parents of a 6-month-old are alarmed at the apparent regression of their child’s psychomotor skills. The infant has had difficulty in feeding accompanied by recurrent vomiting. Examination reveals a protruberant abdomen with clear hepatosplenomegaly. Extremities are thin and emaciation is apparent. Ophthalmologic examination reveals cherry-red maculae. Histochemical examination of the monocytic fraction of the plasma demonstrates the presence of lipid-laden foam cells engorged with sphingomyelin. These findings are indicative of which of the following disorders?
(A) fucosidosis
(B) Gaucher disease
(C) GM₂ activator deficiency
(D) Niemann-Pick disease (NPD) type I A
(E) Tay-Sachs disease

26. A 15-year-old female patient has developed a malignant tumor at the base of the cranium which extends to the nasopharynx. Although the tumor is slow growing, it has infiltrated the bone and is impossible to remove. The tumor is classified as a chordoma and arises from which of the following structures?
(A) anulus fibrosus
(B) myotome
(C) notochord
(D) nucleus pulposus
(E) sclerotome

27. Using laboratory micropuncture technique, samples of renal tubular fluid are collected from the end portions of the proximal tubule. Compared to the blood plasma entering the glomerulus, which of the following has the lowest tubular fluid/plasma concentration ratio?
(A) chloride
(B) bicarbonate
(C) glucose
(D) potassium
(E) sodium

28. Constipation is a predictable consequence for which of the following?
(A) a balanced fiber diet
(B) a decreased activity of the external anal sphincter
(C) patients with Zollinger-Ellison syndrome
(D) stopping the chronic use of laxatives
(E) when taking antibiotics

29. A young woman sought help from her physician for a vaginal discharge that was frothy yellow. The mucosal surfaces were inflamed and tender. Laboratory tests discovered a protozoan etiology. Which of the following protozoa is known only in the trophozoite stage?
(A) Balantidium coli
(B) Entamoeba histolytica
(C) Giardia lamblia
(D) Toxoplasma gondii
(E) Trichomonas vaginalis
30. Three hours following a lengthy, complicated surgery secondary to extensive crush injuries, a 34-year-old man is found to have confusion, acute dyspnea, scattered petechial hemorrhages, and profuse bleeding from the surgical site. What is the most likely pathogenesis behind these clinical findings?
(A) acute idiopathic thrombocytopenic purpura
(B) disseminated intravascular coagulation
(C) hemolytic uremic syndrome
(D) hypovolemic shock
(E) rhabdomyolysis

31. Which of the following drugs stimulates the secretion of insulin from intact beta cells in the pancreas?
(A) alendronate
(B) metformin
(C) miglitol
(D) pioglitazone
(E) repaglinide

32. Regulation of glycogen metabolism is tightly controlled at the level of the activity of glycogen phosphorylase. This enzyme is most active when it is phosphorylated. Which of the following is known to act as a negative effector only of the most active form of glycogen phosphorylase?
(A) AMP
(B) cAMP
(C) Ca^{2+}
(D) glucose-6-phosphate
(E) protein kinase A (PKA)

33. A 77-year-old man dies from complications 14 days following a myocardial infarction. On autopsy, histological section of the periphery of infarcted myocardium is most likely to demonstrate which of the following?
(A) coagulative necrosis with prominent neutrophilic infiltration
(B) dense, acellular collagenous scar tissue
(C) extensive phagocytosis of dead tissue by macrophages
(D) fibrovascular granulation tissue
(E) nuclear pyknosis with increased eosinophilia

34. Which of the following is associated with the use of benzodiazepines?
(A) addictive effects
(B) agitation in the elderly
(C) muscle relaxant effects
(D) non-impairment of conditioned avoidance learning

35. Which of the following statements concerning the apex as opposed to the base of the upright human lung is correct?
(A) alveoli are less compliant at the apex than at the base
(B) blood perfusion is higher at the apex than at the base
(C) on average, alveoli at the apex are smaller than alveoli at the base
(D) the ventilation/perfusion ratio is lower at the apex than at the base
(E) ventilation is higher at the apex than at the base

36. The structure indicated by arrow 4 in Figure 9-3 represents which of the following?
(A) left atrium
(B) left ventricle

FIG. 9-3
(C) right atrium
(D) right ventricle

37. A 31-year-old woman with no significant medical history presents for a routine physical examination. Vital signs include blood pressure 118/78 mm Hg, pulse 70 per minute, respiratory rate 16 per minute, and temperature 98.8°F. Physical examination reveals a soft late systolic murmur and midsystolic click on cardiac auscultation. The remaining examination is unremarkable, and ECG and laboratory results are all within normal limits. Which of the following is the most likely explanation for the abnormal cardiac finding?

(A) congenital bicuspid valve leading to aortic stenosis
(B) congenital collagen defect leading to tricuspid prolapse
(C) infective aortic endocarditis leading to aortic regurgitation
(D) myxomatous valvular degeneration leading to mitral prolapse
(E) previous subclinical episode of rheumatic fever leading to mitral stenosis
(F) progressive pulmonary hypertension leading to tricuspid regurgitation

38. Which of the following is a serious adverse effect that may occur with a single dose of one aspirin tablet?

(A) bronchoconstriction
(B) cardiac arrhythmia
(C) hemolytic anemia
(D) hepatotoxicity
(E) nephrotoxicity

39. Which of the following factors is present only in the intrinsic pathway of blood coagulation?

(A) factor I (fibrinogen)
(B) factor II (prothrombin)
(C) factor V
(D) factor VIII
(E) factor X

40. A 68-year-old male with diabetes mellitus ate a meal that included raw oysters. Within a few days he died of septicemia and shock. Which of the following organisms is the most likely cause?

(A) Campylobacter jejuni
(B) Helicobacter pylori
(C) Providencia rettgeri
(D) Vibrio cholerae
(E) Vibrio vulnificus

41. For the past 6 months, a 67-year-old woman has been aware of a small, flesh-colored papule on her lower eyelid which more recently became ulcerated. A photograph of this papule’s microscopic appearance is shown in Figure 9-4. What is the appropriate diagnosis?

(A) basal cell carcinoma
(B) Bowen disease
(C) epidermal cyst
(D) molluscum contagiosum
(E) verruca vulgaris

42. Which of the following statements concerning typical neuroleptic antipsychotic drugs is true?

(A) combined use with anticholinergic agents is contraindicated
(B) most are dopamine receptor blockers
(C) most are effective against negative symptoms of schizophrenia
(D) most decrease serum prolactin levels
(E) most of them are non-sedating
43. Which of the following substances are blood-borne proteins synthesized in the liver?
   (A) cholesterol
   (B) fibrinogen
   (C) growth hormone (GH)
   (D) insulin
   (E) renin

44. A 20-year-old male with extreme fatigue, sore throat, and enlarged lymph nodes is diagnosed as having infectious mononucleosis. Which of the following is characteristic for the virus that causes this disease?
   (A) It activates T cells to transform them into atypical B lymphocytes.
   (B) It causes infected cells to resemble “owl eyes.”
   (C) It induces production of heterophile antibodies.
   (D) It is a single-stranded DNA-containing virus.
   (E) It routinely infects T lymphocytes.

45. A 10-year-old child is evaluated in seizure clinic for therapy of absence seizures. Which of the following drugs would be most useful in this patient’s condition with the lowest risk of hepatic toxicity?
   (A) ethosuximide
   (B) gabapentin
   (C) lithium
   (D) phenytoin
   (E) valproic acid

46. A 48-year-old woman moved to a new area and is being seen for a routine physical examination as a new patient in a general medicine clinic. Her present medical history is significant for a 30-lbs weight excess and an 8-year history of noninsulin-dependent diabetes mellitus, which she reports has been fairly well controlled with oral agents and a strict diet regimen. However, she is now anxious about her condition and admits to recently developing poor and irregular eating habits, and occasionally missing a medication dosage due to the high stress level surrounding her recent move. The most accurate estimation of this patient’s recent glucose control would be which of the following?
   (A) fasting insulin and C peptide levels
   (B) glucose tolerance test
   (C) glycated hemoglobin level
   (D) random serum glucose
   (E) urine ketone body level

47. The curves in Figure 9-5 illustrate the volume of a red blood cell after addition (at the arrows) of either compound “X” or compound “Y” to the bathing medium. Which of the following statements best characterizes these compounds?
   (A) Compound “X” comes to equilibrium, “Y” does not.
   (B) Compound “X” is actively transported, “Y” is not.
   (C) The permeability of compound “Y” across the red cell membrane exceeds the permeability of water across the red cell membrane.
   (D) The red blood cell membrane is impermeant to both compounds.
   (E) The red blood cell membrane is more permeable to compound “Y” than to “X.”

48. A female fetus is spontaneously aborted at the 13th week of pregnancy. Autopsy reveals that the fetus has a horseshoe-shaped kidney due to fusion of the inferior poles of the kidneys. The kidney normally arises from which of the following embryonic structures?
   (A) allantois
   (B) mesonephroi
49. Verapamil is beneficial in the treatment of angina because it does which of the following?
(A) dilates veins
(B) decreases cardiac contractility
(C) increases oxygen extraction by the myocardium
(D) reduces diastolic fiber tension
(E) slows atrioventricular conduction

50. During a recent visit to an infertility specialist, a 35-year-old woman reports an inability to get pregnant over the past 2 years. During this time she also reports having irregular menses, menorrhagia, occasional suprapubic pain and dysuria, and occasional dyspareunia and painful defecation. A diagnostic laparoscopy reveals thickened adnexa, abdominal adhesions, two hemorrhagic cysts on the right ovary, and one ruptured hemorrhagic cyst on the left ovary. Microscopically, fibrotic patches of tissue found on the rectum and urinary tract reveal hemosiderin-laden glandular and stromal tissue. These collective findings most likely suggest a diagnosis of which of the following?
(A) endometriosis
(B) luteal phase dysfunction
(C) ovarian carcinoma
(D) pelvic inflammatory disease
(E) polycystic ovary disease
1. (A) Chondromas are small, slow-growing tumors that are, as the name suggests, composed of benign hyaline cartilage that are referred to as endochondromas when they arise in the medullary cavity. They may on occasion elicit pain or cause a pathological fracture, but are usually asymptomatic and may be incidental findings as in this case. These tumors are usually located in the metaphyseal region of tubular bones, particularly in the small bones of the hands and feet. The nodules of cartilage with peripheral ossification provide the typical histological findings. Chondrosarcomas (choice B) are tumors of malignant chondrocytes that affect men more than women and usually occur after the age of 40. Typically they originate in the central skeleton (pelvis, shoulder, ribs) and are rare in the peripheral skeleton. Osteochondromas (choice C) are the most common benign tumors of bone and develop as pedunculated, cartilage-capped bony lesions. They arise at the metaphysis near the growth plate of bones of endochondral origin in children and adolescents. Osteoid osteomas (choice D) occur in adolescents and young adults. They are very painful tumors due to the production of excess prostaglandin E but respond dramatically to aspirin therapy. The microscopic appearance is that of random, interconnecting trabeculae of woven bone. Osteosarcomas (choice E) are the most common primary malignant tumors of bone. About 75% appear in adolescents and the remainder occur in association with Paget disease or previous radiation. Microscopically one sees highly pleomorphic cells in haphazard osteoid or bone formation.

2. (C) Metoprolol, a beta-blocking drug, has typical negative inotropic and chronotropic effects on the normal heart and can exacerbate acute heart failure by further reducing cardiac output. However, it has documented value in slowing progression of chronic heart failure, perhaps by reducing apoptosis of myocytes. Captopril (choice A) also has beneficial effects in chronic failure but has no negative inotropic effects on the heart. Dobutamine (choice B), a beta-1-agonist drug, is useful in acute failure but has no benefit in chronic failure. Nesiritide (choice D), a vasoactive peptide, has natriuretic and vasodilator actions that make it possibly useful in acute failure but because it must be given parenterally, it is of no value in chronic failure. Spironolactone (choice E) is of proven value in chronic failure but has no inotropic actions on the heart.

3. (C) Medulloblastoma is principally a childhood tumor that originates in the cerebellum—most commonly in the midline cerebellar vermis in the posterior fossa. It is a fast-growing, aggressive tumor that is well known for its ability to spread via the CSF to involve the spinal cord. Craniopharyngioma (choice A) is a suprasellar tumor occurring mostly in children. It is derived from remnants of Rathke pouch. It can expand to involve such adjacent structures as the pituitary, causing hypopituitarism and in particular diabetes insipidus, the optic chiasm to cause visual deficits, or the third ventricle to produce hydrocephalus. However, it is not malignant and cannot spread to the spinal cord. Glioblastoma multiforme (choice B) is the most malignant and most common of the glial neoplasms. It originates in the cerebral hemispheres in older individuals—most commonly the fourth to sixth decades. Patients do not usually live more than 18 months after diagnosis. Meningioma (choice D) is a tumor that arises from the arachnoid villi. It can grow down to displace the underlying cortex and can also erode into the overlying bone. It occurs most commonly in middle age and does not spread to other locations. Oligodendroglioma (choice E) is a slowly growing tumor of middle-aged adults that arises in the cerebral hemispheres.
4. (B) The Randall hypothesis states that elevations in circulating free fatty acids (FFAs) interfere with insulin action in liver and skeletal muscle (refer to Figure 3-10). Increased FFA uptake and metabolism by the liver results in an increased production of acetyl CoA. All of the acetyl CoA cannot be oxidized completely in the TCA cycle. The elevated acetyl CoA levels result in inhibition of pyruvate dehydrogenase resulting in increased citrate transport to the cytosol. Increased cytosolic citrate inhibits 6-phosphofructokinase-1 (PFK1) resulting in reduced glucose oxidation and an increase in glucose-6-phosphate levels. Increases in glucose-6-phosphate lead to inhibition of hepatic hexokinase resulting in reduced glucose utilization. In addition, the elevated plasma FFAs impair insulin receptor tyrosine phosphorylation of IRS1, resulting in defects in insulin-mediated signaling events in target cells, primarily skeletal muscle. Loss of insulin signaling in skeletal muscle prevents glucose transporter (GLUT4) mobilization to the cell surface with a resultant block to glucose uptake. The increased FFAs stimulate hepatic gluconeogenesis, thus adipocytes indirectly control hepatic glucose output. The overall consequences of a high-fat diet are a progressive impairment in hepatic glucose homeostasis, impairment of insulin-mediated glucose uptake by skeletal muscle, and pancreatic β-cell decompensation (refer to Figure 3-10). The latter leads to reduced insulin secretion and, thus, further impairment of the role of insulin in regulation of blood glucose. Increased adipocyte volume and number, in obese individuals, does not impair their responsiveness to insulin (choice A). Long-term hyperlipidemia leads to pancreatic beta-cell decompensation and reduced insulin output not an increase (choice C). Elevations in circulating FFAs lead to increased hepatic gluconeogenesis, not reduced (choice D). Glucagon is released from pancreatic alpha cells in response to reduced blood glucose not in response to hyperglycemia (choice E).

6. (C) Arrow 5 points to the outer hair cells. The inner hair cells (choice A) are indicated by arrow 4. Arrow 2 points to the inner tunnel (choice B) and the outer phalangeal cells (choice D) by arrow 3. The tectorial membrane (choice E) is marked by arrow 1.

7. (A) Resistance can be based on a deficiency of the ribosomal receptor (chromosomal mutant), enzymatic destruction of the drug (plasmid-mediated), or a lack of permeability to the drug molecule and lack of active transport into the cell. The most common mode by which bacteria become resistant to streptomycin, amikacin, tobramycin, and other aminoglycosides is enzymatic acetylation, adenylation, or phosphorylation of the hydroxyl and amino groups of aminoglycosides. Thus, choices B, C, D, and E are incorrect. Anaerobic bacteria are often resistant to aminoglycosides because transport through the cell membrane is an energy-requiring process that is oxygen-dependent.

8. (C) Chronic pyelonephritis results in irregular scarring that can involve one or both kidneys. (If the disease has resulted from vesicoureteral reflux, the scarring will tend to be at the poles.) Sectioning of the kidney will reveal dilated, blunted calyces. Microscopically, one can see both atrophic tubules and hypertrophic, dilated tubules containing casts (“thyroidization”). Variable chronic interstitial fibrosis and chronic tubulointerstitial inflammation are present. Glomeruli may be fibroed or may be spared. Microscopically, acute tubular necrosis would show patchy necrosis affecting the proximal more than the distal tubules with sparing of the glomeruli and would not demonstrate fibrosis or chronic inflammatory cells. Analgesic nephropathy (choice B) produces papillary necrosis leading to cortical tubulointerstitial nephritis. The gross external appearance of the kidney is usually normal (i.e., no scarring) but when sectioned, the necrosis of the papillae is apparent. The significant changes of diabetic glomerulosclerosis (choice D) are microscopic and, of course, involve the glomeruli. Basement membrane thickening is a constant finding with mesangial changes that usually take the form of nodular glomerulosclerosis or diffuse mesangial

5. (C) Amnestic syndrome is associated with lesions in the limbic system, including the hippocampus, fornix, and mammillary bodies. Therefore, choices A, B, D, and E are incorrect.
sclerosis. Focal (affecting only some of the glomeruli) segmental (affecting only part of a glomerulus) glomerulosclerosis (choice E) occurs in grossly normal kidneys. Initially this disease process involves the juxtamedullary glomeruli and thus may be missed on biopsy. Many of these cases represent children with nephrotic syndrome who do not respond to corticosteroid therapy and are thus distinguished from the children with nil disease.

9. (D) Ropinirole and pramipexole are effective dopamine receptor agonists that can be used alone or in combination with other antiparkinson drugs. Anticholinergic agents (choice A) are often used together with levodopa and other dopamine agonists. Bromocriptine (choice B) is sometimes used to treat prolactinemia as it inhibits pituitary release of the hormone, just as dopamine does. Levodopa may exacerbate mental illness in susceptible patients and antipsychotic drugs may be necessary. The older, D₂-blocking antipsychotics such as phenothiazines are contraindicated since they block the antiparkinson effects of levodopa. However, newer antipsychotics such as clozapine (choice C), which do not depend on D₂ blockade for their action, can be used effectively. Tolcapone and entacapone (choice E) are COMT inhibitors, not MAO inhibitors. Tolcapone acts in the periphery and the CNS, entacapone acts primarily in the periphery.

10. (D) A rhythmic change in the hypothalamic thermoregulatory set point affects the threshold for sweating in a way that it is higher in the afternoon than in the morning. The same is true for the core temperature of a resting person. It is slightly higher at 5 p.m. than at 5 a.m., the reverse of choice C. The hormone melatonin is involved in modulating physiological rhythms. Its production in the pineal gland is unique in that it is synthesized and secreted predominantly at night (choice A), with peak levels occurring in the wee hours of the morning. The blood level then falls during the day. While melatonin secretion is high during night-time, it is not produced during casual darkness during the day. Similarly, while it is secreted while sleeping, sleep is not a prerequisite for its production and it is not produced during daytime sleep. Circadian rhythms such as sleep-wake cycles are more prominent and more regular in children compared to adults (choice B). Circadian cycles are present even without visual signal input. However, the cycles tend to drift and become disturbed in people who are totally blind, which often makes them sleepy during the day and awake at night. Giving melatonin at bedtime has been helpful in many cases (choice E).

11. (A) RNAi involves a mechanism of RNA-directed regulation of gene expression principally at the level of the mRNA product of the targeted gene. Interference can involve mRNA degradation or a block to translation or both. The RNAi pathway is initiated by the enzyme dicer, which cleaves double-stranded RNA (dsRNA) to short double-stranded fragments of 20–25 base pairs. One of the two strands of each fragment, known as the guide strand, is then incorporated into the RNA-induced silencing complex (RISC) and base-pairs with complementary sequences. When the guide strands base pairs with a messenger RNA (mRNA) molecule, it induces degradation of the mRNA by argonaute, the catalytic component of the RISC complex. The short RNA fragments are known as small interfering RNA (siRNA) when they derive from exogenous sources and microRNA (miRNA) when they are produced from RNA-coding genes in the cell’s own genome. Since RNAi reduces the level of the target mRNA, the encoded protein is consequently reduced. Therefore, the RNAi technique can prove useful in treating diseases where expression of a mutant or aberrant protein is the cause of the symptoms such as in Huntington’s disease. Diseases such as PKU (choice B), retinoblastoma (choice C), Tay-Sachs (choice D), and von Hippel-Lindau syndrome (choice E) are all the result of reduced or lost expression of a protein necessary for normal activity, not the expression of a mutant protein and therefore, would not be amenable targets for RNAi-mediated therapies.

12. (A) The brucellae (choice A) are obligate parasites of animals and humans and are
characteristically located intracellularly. *B. melitensis* typically infects goats. The disease in humans (brucellosis, undulant fever) is characterized by an acute bacteremic phase, followed by a chronic stage that may last several years. They are small, gram-negative rods that form small colonies on enriched medium. The typical fever rises in the afternoon and falls during the night, accompanied by drenching sweat.

*B. mallei* (choice B) used to be classified as pseudomonas and causes glanders, a horse disease that may be transmitted to humans. It causes pneumonia when inhaled. *E. aerogenes* (choice C) is a gram-negative rod found free-living in nature and in intestinal tracts. It is primarily seen in urinary tract infections and sepsis. *V. parahemolyticus* (choice D) is a halophilic, curved gram-negative rod that causes acute gastroenteritis after ingestion of infected seafood. *Y. pseudotuberculosis* (choice E) is acid-fast, not gram-negative.

14. (B) The dorsal ramus of the C1 nerve provides motor innervation to all the muscles of the suboccipital triangle. The anterior ramus of the C1 nerve (choice A) runs anteriorly and joins with the hypoglossal (twelfth) cranial nerve. It will leave this cranial nerve and join with the anterior rami of C2 and C3 nerves to form the ansa cervicalis in the neck. The greater occipital (choice C), lesser occipital (choice D), and third occipital (choice E) nerves are all sensory nerves of the back of the scalp.

15. (E) *H. pylori* is a small, spiral microbe that produces large amounts of urease. Thus, tests for urease activity have been employed as rapid and useful diagnostic assays. Patients with gastritis caused by *H. pylori* do not show elevation in their IgE levels. *H. pylori* does not have any unusual carbohydrate utilization patterns which can be used for the diagnosis of gastritis (choice A). Culture of gastric contents on blood agar containing metronidazole and bismuth salts (choice B) will result in the inhibition of growth of *H. pylori*, which is susceptible to metronidazole and bismuth salts. Patients with parasitic infections have high IgE levels in their serum (choice C). Gram stains do not provide any reliable information for the diagnosis of gastritis caused by *H. pylori*, because there are many microbes that resemble *H. pylori* (choice D).

16. (D) Methotrexate has been shown to be a disease-modifying antirheumatic drug (DMARD) and, therefore, is appropriate therapy for rheumatoid arthritis that is not responding adequately to nonsteroidal anti-inflammatory drugs (NSAIDs). Low doses of methotrexate are adequate to reduce the immunologic process that underlies the disease, so toxicity is low. Celecoxib (choice A) is an NSAID like naproxen and would not have additional effect. Infliximab (choice C) is an expensive
parenteral monoclonal antibody with much more severe adverse effects than methotrexate in the doses used. Tacrolimus (choice E) is an inhibitor of calcineurin, an intracellular mediator of T-cell function that is important in transplant rejection reactions.

17. (C) The central concept addressed here concerns the fact that blood picks up CO₂, generated by tissue metabolism, as it passes along systemic capillaries. This CO₂ is eliminated in the lungs. Thus, as blood passes through the pulmonary capillaries, there is a net movement of CO₂ from the blood to alveolar air (choice E is incorrect). Most of the CO₂ in blood is carried as bicarbonate. As CO₂ is eliminated, protons combine with bicarbonate, catalyzed by the enzyme carbonic anhydrase present in the erythrocyte, to generate more CO₂ for elimination. Blood loses protons, becoming less acidic as CO₂ is blown off in the lungs (choice B is incorrect). Increased alkalinity causes the dissociation curve to shift to the left (choice A is incorrect). Inside the erythrocyte, bicarbonate levels decrease as they combine with protons to generate more CO₂ for elimination. A carrier protein, present in the red cell membrane, transports bicarbonate ions from plasma to the erythrocyte to provide bicarbonate to sustain the CO₂-generating reaction (choice C is correct). The carrier is a counter transport protein which exchanges bicarbonate for chloride. In pulmonary capillaries, erythrocytes lose chloride in exchange for bicarbonate (choice D is incorrect).

18. (A) Regulation of HMG-CoA reductase (HMGR) is controlled primarily by a short-term regulatory cascade that results in phosphorylation of the enzyme. This complex regulatory pathway is shown in Figure 3-15. Once phosphorylated HMGR is much less active and thus, cholesterol biosynthesis will be reduced. In order to return to a more active state, the phosphorylated sites on HMGR must be dephosphorylated. All of the enzyme choices listed are involved in regulation of HMGR activity, however, only AMP-activated kinase (AMPK) activity is affected by alteration in the ATP/ADP ratio in cells. When ATP levels fall, AMP levels will rise and AMPK becomes fully activated. Phosphorylation of HMGR by AMPK results in reduced cholesterol synthesis which results in reduced ATP consumption.

19. (C) Antidiuretic hormone (ADH) is regulated by changes in extracellular fluid osmolality. Increased osmolality triggers ADH release which acts on the kidney to increase water reabsorption (negative free water clearance), rather than excretion into the urine. Thus choice C is correct because a dehydrated person with increased ADH secretion will be actively reabsorbing water from the tubular fluid, thus making hyperosmotic urine. The net result is a return of extracellular fluid osmolality to normal. Choice A is incorrect because a dehydrated person will have an increased extracellular osmolality, which should increase, not decrease plasma ADH. Choice B is incorrect because dehydration should increase, not decrease plasma serum albumin concentration. Choice D is incorrect because a dehydrated patient will have an increased, not a decreased plasma sodium concentration. Choice E is incorrect because the action of elevated ADH in a dehydrated patient will be to increase renal water reabsorption (negative free water clearance) instead of reducing renal water reabsorption (positive free water clearance).

20. (C) Iron sulfate is controlled by the FDA as an over-the-counter drug in the United States. The other agents listed are claimed to be food supplements or herbal preparations and, for political reasons, have escaped oversight by the regulatory body. While iron has well-defined clinical indications, effects, and toxicities, the information regarding herbal preparations is very incomplete and such controlled trials as have been carried out have been negative or inconclusive.

21. (B) The cells of the olfactory gland of Bowman secrete the serous fluid containing the odorant-binding protein. The basal cells (choice A) undergo mitosis to give rise to the immature olfactory cells (choice C), which eventually become the mature olfactory neurons (choice D). The olfactory neurons have modified cilia which trap the odorant brought to them by the
22. (D) Figure 9-2 displays granulomatous inflammation characterized by multinucleate giant cell formation, lymphocytes, plasma cells, and monocytes. Of the listed choices, only Crohn's disease characteristically invokes a granulomatous inflammatory response. Abetalipoproteinemia (choice A) is a genetic disorder. Malabsorption without granulomatous inflammation is the typical clinical picture. A biopsy of ileal adenocarcinoma (choice B) would demonstrate malignant gland-forming epithelium without granulomatous inflammation. Carcinoid tumor (choice C) should display islands or ribbons of cohesive neoplastic epithelial cells. Granulomatous inflammation is not evident. Ulcerative colitis (choice E) is a type of idiopathic inflammatory bowel disease that extends proximally from the rectum in a continuous distribution; granulomatous inflammation is not present.

23. (A) Tobacco dependence is the most common and most difficult-to-control drug dependence in the United States. Choice B is incorrect because nicotine is an extremely addicting substance, and sudden cessation of its use results in both physical and psychological withdrawal symptoms. Choice C grossly underestimates the harmfulness of tobacco because physical complications of chronic tobacco use begin to appear in 20 pack-years. Choice D is incorrect because the relapse rate of smoking cessation programs is 60–70%. Choice E is incorrect as tobacco dependence usually begins in adolescence.

24. (C) A glomus tumor is a benign, extremely painful, vascular tumor that most commonly arises under the fingernails. It originates from the glomus body which is a specialized arteriovenous anastomosis involved in temperature regulation. None of the other lesions listed below produce the extreme pain characteristic of a glomus tumor. Basal cell carcinoma (choice A) appears as a pearl-like papule on sun-exposed skin that tends to develop central necrosis as it enlarges. Capillary lymphangioma (choice B) is a benign subcutaneous tumor of lymphatics that is usually found around the head and neck and in the axilla. Hemangioendothelioma (choice D) refers to any one of a group of vascular neoplasms some of which, especially in children, tend to be benign and some that can metastasize. Nevus flammeus (choice E), commonly known as a "port-wine stain," is a congenital vascular malformation that is usually found on the head or neck.

25. (D) NPD comprises two distinct but related types of lipid storage disorder, type I and type II. In addition, both types comprise two subtypes. Type I A (NPA) and type I B (NPB) both result from a defect in acid sphingomyelinase. The type II variants of NPD lead to accumulations of abnormal LDL-cholesterol. NPA is a disorder that leads to infantile mortality. NPB is variable in phenotype and is diagnosed by the presence of hepatosplenomegaly in childhood and progressive pulmonary infiltration. Pathologic characteristics of the type I NPDs are the accumulation of histiocytic cells that result from sphingomyelin deposition in cells of the monocyte-macrophage system. Fucosidosis (choice A) results from a deficiency of the lysosomal enzyme alpha-fucosidase. This defect results in the accumulation and excretion of a variety of glycolipids, glycoproteins, and oligosaccharides containing fucose moieties. The more severe phenotype is associated with dystosis multiplex, neurologic and psychomotor retardation, and coarse facial features. A characteristic finding in fucosidosis patients is an increase in NaCl in sweat. Gaucher disease (choice B) results from defects in beta-glucosidase leading to accumulation of glucosylceramide and three types have been delineated. Common symptoms include hepatosplenomegaly and bone lesions with occasional involvement of the lungs or other organs. The GM₂ activator, GM₂A, is a component of the active beta-hexosaminidase complex. The complex consists of two isoforms, Hex A with a structure of alpha-beta, and Hex B with a structure of beta-beta. The beta-hexosaminidase complex hydrolyzes GM₂ gangliosides in combination with the GM₂A protein. A deficiency in GM₂A (choice C) or
HEXA leads to variants of GM₂ gangliosidosis. Deficiency in HEXA is more commonly recognized as Tay-Sachs disease (choice E). The GM₂ gangliosidoses range from infantile-onset, rapidly progressing neurodegenerative diseases ending in death by age 4.

26. (C) The notochord is a mesenchymal cellular rod which defines the primordial axis of the embryo and forms the basis for development of the axial skeleton. Normally, it degenerates and disappears during the formation of the bones at the base of the skull and the vertebrae. However, its remnants may persist after birth and result in a chordoma. These tumors are difficult to treat and the prognosis for the patient is poor (5 years or less). The anulus fibrosus (choice A) is the ring of fibrocartilage of the intervertebral disc in the adult. The myotome (choice B) in the embryo will give rise to the axial musculature. The nucleus pulposus (choice D) forms from the notochord and becomes the gelatinous center of the intervertebral disk. The sclerotome (choice E) gives rise to the vertebrae.

27. (C) The tubular fluid/plasma concentration ratio for glucose is zero, since the proximal tubule normally reabsorbs all the filtered glucose. By contrast, the concentration of sodium (choice E) and potassium (choice D) are unchanged at the end of the proximal tubule because equal amounts of filtered water and sodium and potassium are reabsorbed in this tubule segment, hence the tubular fluid/plasma concentration ratios are 1.0. The tubular fluid/plasma concentration ratio is 0.6 for bicarbonate (choice B), showing that bicarbonate is reabsorbed to a greater extent than the tubular water. By comparison, chloride reabsorption lags behind the other ions, having a tubular fluid/plasma concentration ratio of 1:3 (choice A).

28. (D) When laxatives are taken for a long time, the colon begins to rely on them to bring on bowel movements. Additionally, laxatives can damage nerve cells in the colon and interfere with the colon’s natural ability to contract. Thus, when after chronic use of laxatives the medication is stopped, constipation might even be a greater problem than at the beginning of the treatment. The most common cause of constipation is a diet low in fiber and high in fats. People who eat a diet balanced in fibers are less likely to become constipated (choice A). The external anal sphincter is a muscle under voluntary conscious control. If not constricted in the presence of fecal material it leads to incontinence (choice B). Zollinger-Ellison syndrome (choice C) typically causes diarrhea. The disease is due to a tumor-related overproduction of gastrin, which results in increased secretion of stomach acid. This abnormally acidifies the small intestinal juice leading to malabsorption. The nonabsorbed food binds water which causes diarrhea. A common side effect of taking antibiotic medicine is diarrhea (choice E). Antibiotics do not discriminate between pathological microorganisms and “good” microorganisms of the natural GI flora. As a result antibiotics can upset the normal balance of bacteria in the intestine leading to undigested food and diarrhea.

29. (E) T. vaginalis (choice E) is the most common form of trichomoniasis in humans. T. vaginalis is pear-shaped with a short undulating membrane and flagella. Cysts have not been found. Infected tissues are usually tender and inflamed and covered by a frothy yellow or cream-colored discharge in women. B. coli (choice A) is a large (60 × 45 μm) ciliated trophozoite. They are mostly involved in harmless intestinal infections, causing diarrhea. E. histolytica (choice B) is a common parasite in the large intestine of humans which has three stages of development: active amoeba, inactive cyst, and the intermediate precyst. G. lamblia (choice C) is a flagellate found in the duodenum and jejenum of humans that exists as trophozoites and infective cysts. T. gondii (choice D) is a coccidian protozoan the final host of which is the cat. Transmission to humans is via the oocyst stage.

30. (B) The pathogenesis of this constellation of clinical findings is due to disseminated intravascular coagulation (DIC), most likely occurring secondary to the combination of this patient’s crush injuries and subsequent surgery. DIC occurs via two main mechanisms—as a result of diffuse endothelial damage, as in
cases of infectious disease, such as gram-negative sepsis (e.g., meningococcemia; also, rickettsial, fungal infections), or by release of tissue factor (a procoagulant factor synthesized by the endothelium) or other thromboplastic substances, into the bloodstream (e.g., amniotic fluid embolism; fat embolism, snake venom; acute promyelocytic leukemia; mucinous carcinomas, etc.); burns can initiate DIC via either mechanism. In massive trauma, burns, or extensive surgery, traumatized tissue is believed to release tissue thromboplastins into the circulation which then trigger DIC. Release of thrombogenic stimuli into the circulation activates the coagulation cascade, via either the extrinsic or intrinsic pathway, resulting in the formation of small thrombi and emboli throughout the microcirculation. Widespread thrombotic diathesis results in the consumption of coagulation factors, fibrinogen, and platelets, which secondarily leads to hemorrhage. Activation of the fibrinolytic system generates fibrin degradation products, which also possess anticoagulant properties and thus help to exacerbate the bleeding tendency. Deposition of fibrin within the microvasculature may also lead to a microangiopathic hemolytic anemia, resulting from fragmentation of RBCs as they squeeze through the thrombi. A patient with DIC may present with a range of signs and symptoms, from diffuse ischemia, thrombosis, and microinfarctions in the thrombotic phase, to skin, mucosal, and internal bleeding in the hemorrhagic phase. Clinical manifestations are numerous, but may include dyspnea, severe respiratory distress, neurological signs including convulsions and coma, cerebral hemorrhage, acute renal failure, and circulatory failure. None of the other choices offered fit this clinical scenario.

Acute idiopathic thrombocytopenic purpura (choice A) is typically seen in young children following a history of a viral infection and is caused by immune complexes that bind to platelets and induce a transient thrombocytopenia; most patients recover in 4–6 weeks, and 90% recover within 6 months. Presenting symptoms are typically limited to purpura or petechiae. Hemolytic uremic syndrome (choice C) also occurs in children, and onset is again often associated with a preceding viral illness; an immune-complex mediated cause has been proposed. In this disorder, thrombi deposition is localized to the kidney. Patients present with thrombocytopenia, microangiopathic hemolytic anemia, hypertension, and varying degrees of renal failure. While severe hypoxia may potentially be associated with hypovolemic shock (choice D) and therefore account for this patient’s confusion and acute dyspnea, it cannot explain his petechial hemorrhages or profuse bleeding. Likewise, rhabdomyolysis (choice E), the destruction of skeletal muscle with accompanying release of myoglobin into the circulation, may certainly have occurred in this case secondary to the patient’s crush injuries; however, it is associated with myoglobinuria and acute renal failure, and not with the constellation of signs and symptoms given here.

31. (E) Repaglinide stimulates insulin secretion, so it requires that intact pancreatic beta cells be present, as in Type II diabetes. Alendronate (choice A) is a bisphosphonate and acts on calcium metabolism in bone; it has no relevance to glucose metabolism. Metformin (choice B) is a very important antidiabetic drug. Its mechanism of action is not completely understood, but it does not require the presence of intact beta cells. Postulated mechanisms include decreased glucagon secretion, increased glucose uptake by peripheral tissues, and reduced glucose absorption from the gut. Miglitol (choice C) acts by inhibiting alpha-glucosidase in the gut, an enzyme necessary for conversion of complex starches to sugar. Pioglitazone (choice D) activates the peroxisome proliferator-activated receptor-gamma, which results in increased expression of proteins involved in carbohydrate and lipid metabolism.

32. (D) Glycogen homeostasis is controlled by regulating the rate of glycogen synthesis and breakdown. Release of glucose from stored glycogen is the role of glycogen phosphorylase (generally just called phosphorylase). The rate of glucose liberation from glycogen by phosphorylase is controlled primarily by short-term phosphorylation and dephosphorylation events. When phosphorylase is phosphorylated by
glycogen synthase-phosphorylase kinase (generally just called phosphorylase kinase), it is more active in releasing glucose. This phosphorylation occurs in hepatocytes when stimulation by glucagon leads to increased activity of PKA which in turn phosphorylates, and activates, phosphorylase kinase (Figure 9-6). Active phosphorylase liberates glucose-1-phosphate from glycogen, which is converted to glucose-6-phosphate. The glucose-6-phosphate is either oxidized in the glycolytic pathway or the phosphate is removed by glucose 6-phosphatase and the free glucose flows into the blood. When glucose-6-phosphate levels rise in hepatocytes, due to reduced utilization, it acts as an allosteric inhibitor of the phosphorylated and active form of phosphorylase. AMP (choice A) is a positive allosteric effector for the dephosphorylated and less active form of phosphorylase. Cyclic-AMP (choice B), Ca²⁺ (choice C), and PKA (choice E) have no allosteric effects on phosphorylase.

33. (D) It is initially important to note that healing of any kind will depend on a variety of factors, such as lesion size, nutritional status, circulation, and presence of underlying systemic disease (e.g., diabetes mellitus). Because larger myocardial infarctions heal more slowly in their center than smaller ones, characterizing the morphological evolution following a myocardial infarction (MI) has been best described through observation of changes at the infarct periphery. By light microscopy, the initial histological changes occurring within the first 24 hours following an MI include nuclear pyknosis, myocardial hypereosinophilia (choice E), and early coagulative necrosis. Between days 1–3, coagulative necrosis progresses and an acute inflammatory response consisting of interstitial neutrophilic infiltration ensues (choice A). Neutrophilic liquefaction of dead tissue occurs during this time and is followed by increasing infiltration of macrophages (~4–7 days), which progressively phagocytose the necrotic tissue (choice C). Generally beginning day 7–10 post-MI, and continuing for 3–4 weeks, the necrotic area becomes gradually replaced by granulation tissue, in which fibroblasts and angioblasts proliferate and deposition of collagen increases. After roughly 1 month, fibroblasts and new
blood vessels recede, and the collagenous scar becomes progressively acellular and more dense (choice B). Maturation and remodeling of the scar continue indefinitely.

34. (B) Benzodiazepines are antianxiety agents. They are also muscle relaxants and anticonvulsants as well as sedatives. Because of the sedative action, an elderly patient may develop paradoxical agitation due to the disinhibition of higher cortical function.

35. (A) Alveoli are less compliant at the apex of the upright human lung than at the base. This is due to the fact that, because of the weight of the overlying lung tissue, on average, alveoli at the apex are larger than alveoli at the base (choice C is incorrect). Larger alveoli are less compliant than small alveoli. Because alveoli at the apex are less compliant, the apex of the lung is less well ventilated than the base (choice E is incorrect). Due to the effects of gravity, alveoli at the apex are less well perfused with blood than are alveoli at the base (choice B is incorrect). As indicated above, both ventilation and perfusion increase as we move from the apex to the base of the lung. Since the change in perfusion is most pronounced, the ratio of ventilation/perfusion is highest at the apex and lowest at the base (choice D is incorrect).

36. (B) Arrow 4 points to the left ventricle. In the chest, the heart points to the left side of the body. For this reason, the right side of the heart always lies anteriorly and the left side lies more posteriorly. The larger chamber on the left side of the heart is then the left ventricle and the smaller chamber, the left atrium (arrow 2). In this scan, the interventricular wall can be seen as the dark line separating the right ventricle (arrow 3) from the left ventricle (arrow 4). The right atrium is indicated by arrow 1.

37. (D) A late systolic murmur with a midsystolic click is the typical auscultatory finding in mitral valve prolapse. This condition is the most frequently occurring valvular lesion and results from a myxomatous change in the mitral valve that, in the vast majority of affected individuals (mostly women), remains asymptomatic. Aortic stenosis (choice A) produces a “crescendo-decrescendo” systolic murmur following an ejection click. The signs and symptoms of tricuspid prolapse (choice B) are similar to those of mitral valve prolapse but tricuspid prolapse is a very unusual finding; it may occur in association with Ebstein anomaly. Aortic regurgitation (choice C) typically produces a high-pitched blowing decrescendo diastolic murmur. Mitral stenosis (choice E) produces an opening snap followed by a late diastolic murmur. Tricuspid regurgitation (choice E) produces a holosystolic murmur and is most commonly due to right ventricular dilation in right heart failure.

38. (A) Some individuals exhibit an intolerance to aspirin even at low doses. This is manifested by a range of symptoms from rhinitis to acute bronchoconstriction, angioedema, and shock. These are effects of leukotrienes. The reaction probably arises from excessive inhibition of cyclooxygenase and shunting of arachidonic acid into the 5-lipoxygenase pathway. For reasons that are not understood, aspirin intolerance is associated with the presence of nasal polyps. Cardiac arrhythmias (choice B) are not associated with the use of aspirin and low-dose aspirin therapy is recommended for most individuals at risk for cardiovascular events. Hemolytic anemia (choice C) does not occur with aspirin, but mild hemolysis may occur in individuals with a deficiency of glucose-6-phosphate dehydrogenase activity. Hepatotoxicity (choice D) is rarely associated with aspirin therapy and usually occurs with plasma concentrations maintained at 150 μg/mL or greater. Elevation of liver enzyme activity in the plasma is the usual sign of hepatotoxicity. Nephrotoxicity (choice E) is rarely seen with aspirin used alone, but may occur with chronic high-dose therapy and more so with newer NSAIDs.

39. (D) Clotting factors that are unique to the intrinsic pathway include factors VIII, IX, XI, and XII. The activation of factor X (choice E) represents the point of convergence of the intrinsic and extrinsic pathways. Factors required for clotting that are activated subsequent to activation of factor X are all part of the common pathway. Activated factor X proteolytically cleaves prothrombin (choice B).
to thrombin, which in turn cleaves fibrinogen (choice A) to fibrin. Factor V (choice C) stimulates the activation of factor X, and fibrin-stabilizing factor (factor XIII) stabilizes the clot by cross-linking fibrin. The defect in hemophilia A is a deficiency in factor VIII, or the antihemophilic factor. This factor acts at the last step of the intrinsic pathway. Factor VIII, which is activated by minute amounts of thrombin, acts in concert with activated factor IX, a proteolytic enzyme, to activate factor X (see Figure 9-7).

40. (E) *V. vulnificus* can cause severe wound infections, bacteremia, and gastroenteritis. It is a free-living bacteria found in the estuary coastal United States. It is particularly apt to be found in oysters, especially in the warm months. Wounds are more serious in immunocompromised individuals and susceptibility to gastroenteritis may be greater also. The organism can be cultured and treated with tetracycline. *C. jejuni* (choice A) is a curved gram-negative rod and is acquired by the oral route (food, drink, contaminated animal products). Seafood, including oysters, is usually not seen as an infection source. *H. pylori* (choice B) is a spiral-shaped gram-negative rod associated with duodenal (peptic) ulcer disease and is a strong producer of urease. Most likely, person-to-person transmission is involved. *P. rettgeri* (choice C) is a member of the normal intestinal flora and most often is seen in urinary tract infections. *V. cholerae* (choice D) causes cholera in humans only. Transmission is human-to-human by fecal contamination of water sources.

41. (A) Figure 9-4 displays the histology of a basal cell carcinoma. These tumors are slow growing, appear as flesh- to pearl-colored cutaneous nodules, and arise principally on sun-exposed areas. The histological pattern is one of infiltrating small dermal clusters of basophilic cells with peripheral basal orientation (palisading). Bowen disease (choice B) is another term for cutaneous intraepidermal squamous cell carcinoma. An epidermal cyst (choice C) is a benign dermal collection of central keratotic debris with a peripheral cyst wall formed by benign, mature, stratified squamous epithelium. Molluscum contagiosa (choice D) is a viral disorder and molluscum bodies are the critical histological finding. *Verruca vulgaris* (choice E) is a cutaneous viral disorder with prominent papillomatosis.

42. (B) All typical antipsychotic drugs, such as haloperidol, are dopamine receptor antagonists and increase serum prolactin levels. They are likely to be effective for the positive symptoms, such as hallucinations, delusions, loosening of association, and catatonia. Unlike the atypical antipsychotics (e.g., risperidone, olanzapine), they are not effective in treating the negative symptoms (such as flat affect, paucity of thought) of schizophrenia. For the pseudoparkinsonian side effect of typical antipsychotics, anticholinergic agents such as benztropine may be used. They tend to be sedating.

43. (B) Fibrinogen is a protein produced by the liver. Its function is to help stop bleeding by promoting the formation of blood clots. Cholesterol (choice A) is partly synthesized in the liver, it is however a lipid, not a protein. GH (choice C) is made by cells in the anterior pituitary gland. However, much of GH’s action is mediated by insulin-like growth factor-1 (IGF-1), a protein secreted from the liver in response to stimulation by GH. Insulin (choice D) is made in cells of the endocrine pancreas and acts on the liver, but is not produced there. Renin (choice E) is made by cells of the juxtaglomerular
apparatus in the kidney. However, its action is to cleave circulating angiotensinogen, which is made by the liver.

44. (C) Epstein-Barr virus (EBV) is a herpesvirus which is very widespread in the human population. It is the causative agent of acute infectious mononucleosis and the probable cause of lymphomas and other lymphoproliferative disorders in immunocompromised individuals. EBV is very immunogenic, giving rise to antibodies against VCA and EBNA antigens. The diagnostic value of these appears to be limited. EBV infection also gives rise to heterophile antibodies, transient antibodies to sheep RBCs, which can be used in specific screening tests to show presumptive infection of EBV. EBV cannot be isolated and identified routinely in the diagnostic laboratory. Cytomegalovirus (CMV) will grow in fibroblast cells and causes a typical nuclear inclusion (CPE) called “owl eyes” (choice B). EBV preferentially grows in fibroblasts and B lymphocytes, not T lymphocytes (choice A and E). Herpesviruses all have double-stranded DNA, not single stranded (choice D).

45. (A) Ethosuximide is an older antiseizure drug that is very useful in absence but not tonic-clonic seizures. It is usually safe, having sedation as its major adverse effect. Gabapentin (choice B) is useful in some cases of partial seizures but not absence seizures. It does, however, appear to have significant usefulness against neuropathic pain and postherpetic neuralgia. Lithium (choice C) is the usual drug of choice in bipolar disorder (valproic acid and carbamazepine are also used), but is of no value in epilepsy. Phenytoin (choice D) is a drug of choice (with carbamazepine) in partial (tonic-clonic) seizures but has no demonstrated efficacy in absence seizures. Valproic acid (choice E) has unusual versatility. It is effective in both absence and tonic-clonic seizures and in the management of bipolar disorder as well. Unfortunately, it carries significant risk of hepatotoxicity.

46. (C) When present in high concentration, glucose can react nonenzymatically with protein amino groups to form an unstable intermediate, or Schiff base, which subsequently undergoes an internal rearrangement to form a stable glycated protein. The glycation of the amino acids valine and lysine on the beta chain of hemoglobin A results in the formation of hemoglobin A1c (HbA1c), or glycated hemoglobin. One hypothesis for the pathogenesis of diabetic microvascular disease is that prolonged glucose elevation leads to the glycation of basement membrane proteins in the same manner. Because red blood cells circulate for an average of 90–120 days, assaying HbA1c provides an index of a diabetic patient’s glucose control over the preceding 3–4 months. Although normal values vary between laboratories, on an average nondiabetic subjects have HbA1c levels roughly between 4% and 6%. Fasting levels of insulin and C peptide (choice A) (C peptide is an amino acid component of the insulin precursor proinsulin) are not used in the evaluation of glycemic control. A glucose tolerance test (choice B) is used in the diagnosis of diabetes mellitus by measuring glucose levels during a 2-hour period following the ingestion of 75 g of oral glucose. A random serum glucose value (choice D) is of little value in estimating glucose control because it represents only the blood glucose level at any single point in time and is influenced by dietary conditions. A urine ketone body level (to test for ketonuria) (choice E) is obtained in conjunction with urine glucose (to test for glycosuria), serum glucose, and serum ketone levels in the diagnosis of diabetic ketoacidosis. Insufficient insulin results in mobilization of free fatty acids from adipose tissue, which are then oxidized in the liver through the stimulatory effects of glucagon and eventually converted into ketone bodies. Ketone bodies are moderately strong acids and lead to the onset of diabetic ketoacidosis.

47. (E) Addition of either compound to the bathing media increases the osmolarity of the solution. Water will rapidly flow out of the red cell to equalize osmotic pressures inside and outside the cell. This accounts for the rapid initial fall in cell volume, which is seen in both cases. In both cases, volume increases as the compounds diffuse into the cell down their concentration gradients, with water following to maintain isotonicity. The higher the permeability of a solute,
the more rapidly it enters the cell, and the more rapidly volume returns toward its original level (choice E is correct). Since volume returns to its original level, both compounds have reached equilibrium (choice A). Nothing in the question indicates whether or not either compound is actively transported (choice B). If either compound were impermeable to the red cell membrane, the volume would decrease and not recover. Since volume does recover back to its initial level in both cases, both compound “X” and compound “Y” can cross the red cell membrane (both compounds must have significant permeability across the red cell membrane) (choice D). If the permeability of “Y” exceeded that of water, then the initial rapid fall in volume would not occur (choice C).

48. (C) The metanephroi develops from the metanephric diverticulum, which gives rise to all the renal structures from the collecting tubules to the ureter, and from the metanephric mass of intermediate mesoderm, which gives rise to the nephrons. The allantois (choice A) remains in the adult as a vestigial structure: the urachus, extending from the umbilicus to the top of the bladder. The mesonephroi (choice B) serve as temporary kidneys but they soon degenerate and are not found in the adult. The pronephroi (choice D) are nonfunctional, vestigial kidneys which also degenerate during development. The urogenital sinus (choice E) gives rise to the bladder, urethra, and the external genitalia.

49. (B) Verapamil decreases oxygen demand of the heart by reducing contractility and afterload. It has a slow onset of action, so it is used for prophylaxis rather than treatment of acute attacks. Venodilation (choice A) is the major mechanism of action of the nitrates. None of the useful antianginal drugs increases oxygen extraction (choice C), which is nearly maximum in the normal and the atherosclerotic heart. Reduction of diastolic fiber tension (choice D) occurs with venodilators such as nitrates but negative inotropic drugs such as calcium channel blockers and beta blockers increase diastolic tension. While calcium blockers can slow atrioventricular conduction (choice E), this effect is not relevant to the action in angina.

50. (A) Endometriosis is the presence of endometrial tissue in a site other than the lining of the endometrial cavity. It most commonly occurs in the ovaries, wall of a fallopian tube, parametrial soft tissue, and serosa of the intestine but can also occur at many other locations. This condition may be asymptomatic but is an important cause of infertility, dysmenorrhea, and pelvic pain. Repeated episodes of hemorrhage result in fibrosis, which can lead to peritoneal adhesions or intestinal obstruction. Involvement of the fallopian tubes can block the lumen and lead to infertility and an increased risk of ectopic pregnancy. Luteal phase dysfunction (choice B) is also a cause of infertility. Even though ovulation may occur, insufficient progesterone is produced to prepare the endometrial lining for implantation. This is not associated with the other findings of the case described. Ovarian carcinoma (choice C) may be divided into three main types: primary epithelial tumors, germ cell tumors, and sex cord–stromal tumors. Most of these tumors remain clinically silent until quite advanced; although the prognosis varies depending on the type and stage of the tumor, it is generally not good. The presentation of the case does not match that of ovarian carcinoma. Pelvic inflammatory disease (choice D) is a common disorder in women in which there is infection of the fallopian tubes and ovaries as well as surrounding tissues. The most common causative agent is Neisseria gonorrhoeae, but several other organisms, including Chlamydia, have been implicated. Pelvic inflammatory disease is a cause of dyspareunia and sterility (as well as many other conditions), but the case does not indicate an infectious process and the hemorrhagic cysts are classic for endometriosis. Polycystic ovary disease (choice E) is characterized by bilaterally enlarged ovaries, numerous cystic follicles, and absence of corpora lutea (indicating failure of ovulation). In the presence of amenorrhea, this is referred to as the Stein–Leventhal syndrome. These patients have persistent anovulation, obesity, and hirsutism. This is one of the more common causes of infertility, but the other aspects of the case are not explained by polycystic ovary disease.
1. In persons suffering from severe anaphylactic shock from a bee sting, the drug of choice for restoring circulation and relieving angioedema is which of the following?
   (A) dopamine  
   (B) epinephrine  
   (C) isoproterenol  
   (D) norepinephrine  
   (E) phenylephrine

2. A 37-year-old woman visits her primary care physician after developing jaundice and scleral icterus. She is diagnosed with paroxysmal nocturnal hemoglobinuria. Which of the following metabolites would you expect to be increased in her urine?
   (A) bile  
   (B) conjugated bilirubin  
   (C) stercobilin  
   (D) unconjugated bilirubin  
   (E) urobilinogen

3. The total serum calcium level of a 50-year-old man was determined as 2 mmoles/L (normal 2.2–2.55 mmoles/L). The man is asymptomatic and at the time, the results from other blood tests were not available. Which of the following may cause the hypocalcemia?
   (A) acute dehydration  
   (B) chronic kidney insufficiency  
   (C) excess parathyroid hormone

4. Irrigation of the seated patient’s right ear with warm water should produce which of the following?
   (A) fast conjugate horizontal eye movement to the left  
   (B) no horizontal eye movements  
   (C) slow conjugate horizontal eye movement to the left  
   (D) slow conjugate horizontal eye movement to the right  
   (E) slow horizontal movement of right eye and fast movement of left eye

5. A 32-year-old woman dies after having a chronic illness since she was 14. An autopsy was performed and one of the many pathological findings related to her illness included vegetations on both atrioventricular valves. Of the following, which is most likely to be the chronic disease from which she suffered?
   (A) acute rheumatic fever  
   (B) carcinoid syndrome  
   (C) chronic rheumatic heart disease  
   (D) infective endocarditis  
   (E) mucinous adenocarcinoma  
   (F) systemic lupus erythematosus
6. A deficiency in which of the following factors of hemostasis, whose symptoms generally do not appear prior to age 15, would manifest with recurrent deep vein thrombosis, pulmonary embolism, and cerebral vein thrombosis?

(A) antithrombin III
(B) factor VIII
(C) fibrinogen
(D) protein C
(E) von Willebrand factor

7. Which of the following has been shown to reduce the incidence of congenital neurological anomalies, for example, spina bifida, when given during pregnancy?

(A) erythropoietin (epoetin alfa)
(B) folic acid
(C) intrinsic factor
(D) thiamine
(E) vitamin B₁₂

8. Current serological diagnostic tests for influenza antibodies include HA-inhibition and ELISA. Earlier diagnostic antibody tests made use of the fact that HA and NA antibodies bind complement. In an influenza virus complement-fixation procedure, the indicator system consists of complement, sheep RBCs, plus which of the following?

(A) antibody to influenza virus
(B) antibody to sheep RBCs
(C) ⁵¹Cr-labeled sheep RBCs
(D) fluorescent-tagged virus
(E) neuraminidase

9. A 64-year-old African American female is referred to a nephrologist following an initial diagnosis of renal failure. Which of the following changes could be a direct consequence of renal failure?

(A) diminished progression of atherosclerosis
(B) hypotension
(C) increased insulin requirements in patients with diabetes mellitus
(D) polycythemia
(E) secondary hyperparathyroidism

10. Which one of the following drugs is the most efficacious for the treatment of severe cystic acne?

(A) bacitracin
(B) griseofulvin
(C) isotretinoin
(D) mupirocin
(E) triamcinolone acetonide

11. Neonatal urea cycle defects are usually misdiagnosed because of a failure to assess which of the following?

(A) level of ammonia in the blood
(B) level of argininosuccinate in the blood
(C) level of citrulline in the blood
(D) level of orotic acid in the urine
(E) odor of acetone on the breath

12. A 57-year-old homeless man is brought to County Hospital following massive hematemesis. Attempts to stabilize him are unsuccessful and he dies the same day. A section of his liver taken at autopsy is shown in Figure 10-1. Of the following, what is the most likely diagnosis?

(A) α₁-antiprotease deficiency
(B) hemochromatosis
(C) primary biliary cirrhosis
(D) primary sclerosing cholangitis
(E) viral hepatitis

FIG. 10-1 (Also see color insert.)
13. Graft-versus-host disease (GVHD) can appear in acute, hyperacute, and chronic forms of disease, and prevention of GVHD is essential in patient management. A GVHD reaction may occur as a consequence of which of the following?

(A) because the graft has histocompatibility antigens not found in the recipient
(B) because the graft is contaminated with gram-negative microorganisms
(C) only when tumor tissues are grafted
(D) when a histocompatible graft is irradiated before engraftment
(E) when immunocompetent lymphoid cells are present in the graft and the recipient is immunosuppressed

14. A violin player is devastated since she cannot feel the high-frequency vibration of the violin strings as well as she used to. Which of the following mechanoreceptors is mainly responsible for sensation of fast vibration when touching an object?

(A) free nerve endings
(B) Golgi tendon organ
(C) hair follicle
(D) Meissner corpuscle
(E) Pacinian corpuscle

15. Ondansetron is effective in reducing chemotherapy-induced vomiting by acting on which of the following?

(A) acetylcholine muscarinic receptors
(B) dopamine D₂ receptors
(C) glucocorticoid receptors
(D) histamine H₁ receptors
(E) 5-HT₃-gated ion channels

16. Insulin receptor activation results in an increase in the flux of glucose into glycogen in skeletal muscle. A defect in which of the following proteins involved in glycogen homeostasis would be expected to result in the greatest deficit in insulin-mediated glycogenesis in these cells?

(A) glucose-6 phosphatase
(B) glycogen synthase-phosphorylase kinase
(C) glycogen phosphorylase
(D) protein phosphatase inhibitor-1 (PPI-1)
(E) protein targeting glycogen (PTG)

17. A recently recognized disease is associated with an unusually high concentration of serum component X. A screening test has identified a number of patients with positive results who potentially have this disease. Which of the letters in Figure 10-2 represents the most appropriate decision limit for a subsequent confirmatory test that is to be performed on these patients’ serum samples?

(A) A
(B) B
(C) C
(D) D
(E) E

18. Beta-thalassemias are genetic disorders in the synthesis of the beta-globin chains in hemoglobin. Affected individuals usually begin to exhibit some degree of anemia at about 6 months of age. Therapy for severe anemia involves multiple transfusions. What is the most serious complication of transfusion therapy?

(A) cardiac arrhythmias
(B) copper overload
(C) globin overload
(D) increased blood viscosity
(E) iron overload
19. The vestibular system monitors the position and movements of the head. This information is coordinated in the brainstem with inputs from the visual system and the spinal cord to produce the vestibulo-ocular reflex, stabilizing the retinal images. Which of the following tracts connect the vestibular system with the brainstem nuclei innervating the extraocular muscles?

(A) central tegmental tract  
(B) lateral vestibulospinal tract  
(C) medial lemniscus  
(D) medial longitudinal fasciculus (MLF)  
(E) medial vestibulospinal tract

20. Which of the following drugs acts by inhibiting viral protease, thus preventing final protein editing?

(A) acyclovir  
(B) amprenavir  
(C) didanosine  
(D) enfuvirtide  
(E) zidovudine

21. Most blood vessels dilate under hypoxic conditions. In which arterial region does hypoxia cause vasoconstriction?

(A) coronary arteries  
(B) GI arteries  
(C) pulmonary arteries  
(D) renal arteries  
(E) skeletal muscle arteries

22. Neuronal cell bodies innervating the chromaffin cells of the suprarenal (adrenal) gland may be found in which of the following locations?

(A) celiac ganglia  
(B) dorsal motor nucleus of the vagus  
(C) lateral horn of the thoracic spinal cord  
(D) nucleus ambiguus  
(E) nucleus of the solitary tract

23. A 42-year-old woman presents with an acute onset of fever, jaundice, tender liver enlargement, and ascites. Liver biopsy reveals histological features of scattered foci of hepatocytes undergoing swelling and necrosis, with neutrophilic infiltration around the affected cells, and sinusoidal and perivenular fibrosis. This is most suggestive of which of the following?

(A) acetaminophen overdose  
(B) acute fatty liver of pregnancy  
(C) alcoholic hepatitis  
(D) Budd–Chiari syndrome  
(E) pyogenic liver abscess

24. A 20-year-old medical student in the last trimester of pregnancy presents with dysuria and lower abdominal pain. This is her first pregnancy, and it has, thus far, proceeded normally. A dipstick test of her slightly pink urine reveals the presence of protein, but no glucose. Her urine is sent for culture and grows >100,000 gram-negative rods. Given this brief history, which of the following is the most likely organism?

(A) Enterobacter aerogenes  
(B) Escherichia coli  
(C) Klebsiella pneumoniae  
(D) Proteus mirabilis  
(E) Pseudomonas aeruginosa

Questions 25 through 27

A 28-year-old woman is brought to the hospital because she had not come out of her room for 3 days, missing work. She would eat only when a tray was brought in.

25. If the patient was observed in her room alone talking loudly and gesticulating, this is probably an example of which of the following?

(A) delusion  
(B) hallucination  
(C) obsessive compulsive behavior  
(D) panic behavior  
(E) schizophrenia
26. When the patient arrives, she is observed walking very slowly, and when you try to speak with her, she responds very slowly after a long latency. This may be an example of which of the following?

(A) autistic thinking  
(B) circumstantiality  
(C) folie à deux  
(D) psychomotor retardation  
(E) thought blocking

27. While you are trying to understand her, she suddenly stops talking, staring into space. She probably has which of the following?

(A) ambivalence  
(B) delusion  
(C) illusion  
(D) negativism  
(E) thought blocking

28. Treating patients for enterococcal endocarditis is problematic because phagocytic cells provide little help in clearing the infection on the heart valve so that killing of an organism within the vegetation is very much dependent on antimicrobial activity. Vancomycin is a therapeutic option. Which of the following statements least likely describes vancomycin?

(A) High-level resistance to vancomycin is usually transferable.  
(B) Resistance to vancomycin can result from chromosomal encoded genes that can alter the peptidoglycan subunit.  
(C) Resistance to vancomycin can result from plasmid encoded genes that can alter the peptidoglycan subunit.  
(D) Vancomycin inhibits peptidoglycan synthesis by forming complexes with the acyl-D-alanyl-D-alanine end of the lipid-linked disaccharide precursor molecule.  
(E) Vancomycin inhibits transpeptidases that are involved in crosslinking of linear peptidoglycan strands.

29. A 20-year-old male patient displays bitemporal hemianopia. A magnetic resonance scan reveals a developing tumor severely compressing the visual pathway. Where is the most likely location of the compression?

(A) left optic nerve  
(B) left optic tract  
(C) optic chiasma  
(D) right optic nerve  
(E) right optic tract

30. A 62-year-old woman with chronic hepatitis B infection and a 3-year history of cirrhosis presents with jaundice, increasing ascites, left upper quadrant pain, and malaise. Liver biopsy is performed after an abdominal CT scan reveals the presence of an 18 cm mass in the left lobe. Histology demonstrates abnormally thickened hepatic cords composed of moderately well-differentiated hepatocytes with an increased nuclear to cytoplasmic ratio and prominent nucleoli; many cells contain bile and eosinophilic material within the cytoplasm. Which of the following oncogenic mechanisms is most likely responsible for the initial hit underlying the changes in the patient’s liver?

(A) failure of immune surveillance  
(B) hepatic conversion of procarcinogen to a carcinogenic metabolite  
(C) loss of p53 tumor suppressor gene  
(D) spontaneous chromosomal point mutation  
(E) viral DNA insertion into the host genome

31. Which of the following statements best describes the mechanism of action of rifampin?

(A) binds to 30S ribosomal proteins  
(B) inhibits dihydrofolate reductase  
(C) inhibits dihydropteroate synthase  
(D) inhibits DNA-dependent RNA polymerase  
(E) inhibits synthesis of mycolic acids
32. A 66-year-old woman presents to her neurologist with a 4-week history of increasing right leg weakness. An MRI with contrast medium reveals an irregular left cerebral mass with cystic areas and surrounding tissue edema. A stereotactic biopsy is performed and sections demonstrate a neoplasm with increased cellularity, nuclear pleomorphism, vascular proliferation, and areas of necrosis surrounded by dense rims of pleomorphic cells. Based on this clinical and morphological information, which of the following is the most likely diagnosis?

(A) ependymoma  
(B) glioblastoma multiforme  
(C) metastatic sarcoma  
(D) oligodendroglioma  
(E) pilocytic astrocytoma  
(F) primary lymphoma

33. A medical student has been immunized with hepatitis B virus (HBV) recombinant vaccine before he could interact in any way with his prospective patients. The curve in Figure 10-3 represents the production of protective antibodies to the viral component present in the recombinant vaccine. This viral component is most likely which of the following?

(A) nucleocapsid proteins of HBV  
(B) RNA genome of HBV  
(C) viral core antigen (HBcAg)  
(D) viral e antigen (HBeAg)  
(E) viral surface antigen (HBsAg)

![FIG. 10-3](image)

34. Which of the following refers to peptide hormones the actions of which are exerted on cells adjacent to their site of synthesis but not on the cell of synthesis?

(A) autocrine  
(B) chemokine  
(C) exocrine  
(D) paracrine

35. A 45-year-old male with prostatic cancer was placed in a hyperlordotic supine position for a radical prostatectomy. An epidural catheter was introduced at the L 1-2 interspace without problem. The operation lasted 7 1/2 hours under general anesthesia combined with epidural anesthesia. Upon recovery from anesthesia, the patient complained of severe lower back pain in addition to the pain at the incisional site. After the residual analgesic effects had fully disappeared, he experienced muscular weakness in the left thigh, could not extend the leg, and thus could not walk. It took him 7 weeks to walk without the support of a brace after surgery. The primary cause of the presented symptoms was related to the hyperlordotic supine surgical position, which put excessive pressure on the intervertebral discs and compressed the intervertebral foramina. Which of the following is the nerve responsible for the innervation of muscles extending the leg?

(A) femoral nerve  
(B) inferior gluteal nerve  
(C) obturator nerve  
(D) pudendal nerve  
(E) sciatic nerve
36. The section of tissue shown in Figure 10-4 was taken from a surgical specimen removed from a 74-year-old woman. This lesion most likely represents which of the following?

(A) adenoma  
(B) adenocarcinoma  
(C) choristoma  
(D) hamartoma  
(E) papilloma  
(F) squamous cell carcinoma

37. In treating an elderly male patient with long-standing hypertension and mild congestive heart failure, which of the following agents would be most likely to slow the progression of heart failure?

(A) digoxin  
(B) dobutamine  
(C) hydrochlorothiazide  
(D) spironolactone  
(E) theophylline

38. A patient with a history of unexplained polydipsia is admitted for evaluation of possible diabetes insipidus. After several hours of fluid deprivation, the following measurements are made: plasma osmolarity: 300 mosm/L, urine osmolarity: 150 mosm/L, urine solute output: 900 mosm/d. What is the solute clearance in this patient?

(A) 1.5 L/d  
(B) 2.0 L/d  
(C) 3.0 L/d  
(D) 6.0 L/d  
(E) unable to be calculated unless plasma volume is also known

39. A 3-month-old infant experienced several severe seizures and was brought to the doctor for testing. The test results showed hyperphenylalaninemia and the doctor diagnosed phenylketonuria (PKU) as the likely disease causing the seizures. The infant was placed on a low-phenylalanine diet but developed progressive neurological symptoms and died 6 months later. A defect in which of the following enzymes would best explain the observations and outcomes in this case?

(A) dihydropteridine reductase  
(B) nitric oxide synthase  
(C) phenylalanine hydroxylase (PAH)  
(D) tryptophan hydroxylase  
(E) tyrosine hydroxylase

40. Lymphatics of the prostate gland drain primarily into which of the following?

(A) external iliac nodes  
(B) inferior mesenteric nodes  
(C) internal iliac nodes  
(D) superficial inguinal nodes  
(E) superior mesenteric nodes

41. A 72-year-old man is brought to the ER by his wife after 3 days of persistent malaise, anorexia, and diarrhea. An arterial blood gas reveals the presence of an acid-based disorder. Given this clinical scenario, which of the following pairs of $P_{CO_2}$ and $HCO_3^-$ values would you most expect this patient’s arterial blood gas to reveal?

(A) $P_{CO_2} = 27$ mm Hg; $HCO_3^- = 19$ mmol/L  
(B) $P_{CO_2} = 33$ mm Hg; $HCO_3^- = 21$ mmol/L  
(C) $P_{CO_2} = 40$ mm Hg; $HCO_3^- = 25$ mmol/L  
(D) $P_{CO_2} = 46$ mm Hg; $HCO_3^- = 29$ mmol/L  
(E) $P_{CO_2} = 53$ mm Hg; $HCO_3^- = 34$ mmol/L
42. The tracing in Figure 10-5 illustrates a portion of an EKG tracing which encompasses ventricular depolarization. How should these waves be designated?

(A) QR  
(B) QRS  
(C) QS  
(D) RS  
(E) RT

43. A 32-year-old man complains of a painful lesion on his upper back. Examination reveals a large, very tender, raised, erythematous lesion with purulent drainage through multiple sinuses. This lesion would be best characterized as which of the following conditions?

(A) abscess  
(B) carbuncle  
(C) granuloma  
(D) erysipelas  
(E) necrotizing fasciitis

44. A 2-week-old Asian American male is born with an isolated stenosis of the pulmonary valve. He has a murmur localized to the third intercostal space on the left side of the sternum. What additional findings are likely to be associated with this condition?

(A) Cardiac output will be normal because the left ventricle is unaffected.  
(B) Left ventricular end-diastolic pressure will be elevated.  
(C) Pulmonary capillary pressure will be elevated.  
(D) Pulmonary wedge pressure will be elevated.  
(E) Right ventricular end-diastolic volume will be elevated.

45. The Lineweaver-Burke derivation of Michaelis-Menton enzyme kinetic data allows one to linearly plot reaction velocity as a function of substrate concentration. These linear plots are especially useful when studying the effects of inhibitors on enzyme activity as they allow immediate determination of the type of inhibition. The plot shown in Figure 10-6 demonstrates a Lineweaver-Burke plot of which type of enzyme inhibition?

(A) competitive  
(B) irreversible  
(C) noncompetitive  
(D) uncompetitive

46. A 72-year-old woman was hospitalized following a myocardial infarction. On the seventh hospital day, she developed right-sided paralysis indicative of a left-sided cerebral lesion. If this lesion were to be examined microscopically, one would expect to see which of the following?

(A) amorphous, acellular area with surrounding giant cells and peripheral lymphocytes  
(B) intensely eosinophilic deposits within vessel walls with no inflammation  
(C) loss of tissue architecture with numerous lipid-laden macrophages  
(D) necrotic lipocytes with calcium deposits and a neutrophilic infiltrate  
(E) preservation of neural structures with increased eosinophilia and absence of nuclei
47. Arsenic is used to fabricate semiconductors in the electronics industry. Which of the following drugs is the best current initial treatment for chronic arsenic poisoning?
   (A) calcium disodium edetate
   (B) deferoxamine
   (C) dimercaprol
   (D) folic acid
   (E) trientine

48. Although the major metabolic effect of insulin is to promote fuel storage following meals, this hormone also has growth factor activity. One of the growth-promoting responses to insulin action is an increase in the rate of translation. Which of the following proteins of translation is a target of insulin-mediated action, the consequence of which is a reduced level of phosphorylation and thus increased activity?
   (A) 4EBP
   (B) eEF-2
   (C) eIF-2
   (D) eIF-2B
   (E) eRF

49. A fungus was isolated from a patient. The photomicrograph in Figure 10-7 displays the organism that may cause which of the following?

   (A) aspergillosis
   (B) phycomycosis
   (C) tinea barbae
   (D) tinea corporis
   (E) tinea pedis

50. Concerning human immunodeficiency virus (HIV) infection, which of the following statements is correct?
   (A) Most women acquire HIV infection through IV drugs.
   (B) The number of infected men is growing at a higher rate than infected women.
   (C) The percentage of heterosexual men with HIV is decreasing.
   (D) The percentage of total cases among gay and bisexual men has declined in the United States.
   (E) The sex ratio between infected males and females is about the same.
1. **(B)** Epinephrine is the drug of choice in the treatment of anaphylaxis because it provides a pressor response through alpha-1-adrenoceptor actions, cardiac stimulation through beta-1-adrenoceptor actions, and bronchodilation and prevention of mast cell release of histamine and leukotrienes through actions on beta-2 adrenoceptors. The actions of dopamine (choice A) on the cardiovascular system are complex; dopamine exerts effects on renal, mesenteric, and myocardial vascular D₁ receptors (vasodilation), cardiac beta-1-receptors (positive inotropic effect), and vascular alpha-1-receptors (vasoconstriction), depending on the dopamine concentration. Dopamine may also cause release of norepinephrine from sympathetic nerve terminals, but it does not inhibit mast cell release of mediators of shock nor does it cause bronchodilation. Dopamine is useful in hypovolemic and cardiogenic shock in maintaining renal perfusion. Isoproterenol (choice C) inhibits mast cell release of mediators and provides cardiac stimulation and bronchodilation, but does not provide needed pressor activity. Norepinephrine (choice D) provides pressor activity to treat hypotension, but does not inhibit mast cell release of mediators of shock and does not dilate the bronchi. Phenylephrine (choice E), like norepinephrine, provides pressor activity, but not cardiac stimulation or inhibition of mast cell function.

2. **(E)** Paroxysmal nocturnal hemoglobinuria is a hemolytic anemia in which an acquired cell membrane defect increases red blood cell susceptibility to lysis by endogenous complement. Intravascular hemolysis overwhelms hepatic enzyme conjugation capability and leads to an increase in unconjugated bilirubin (water insoluble) in serum. The liver enzyme glucuronyl transferase converts unconjugated bilirubin into conjugated bilirubin (now water soluble), which is then excreted by hepatocytes into the bile. After secretion of bile into the intestine, ileal and colonic bacteria convert conjugated bilirubin into urobilinogen. A fraction of urobilinogen is oxidized to stercobilin (choice C) and directly excreted in feces (and hence, would not be a urinary metabolite). The remaining urobilinogen is reabsorbed from the intestine and reenters the portal circulation where a portion is taken up by the liver and reexcreted into bile, while the rest bypasses the liver and is excreted by the kidney. Therefore, in hemolytic anemias, increased liver excretion of conjugated bilirubin will lead to an increase in urinary urobilinogen levels. Note that this is in contrast to biliary tract obstruction in which failure of conjugated bilirubin to enter the intestine would lead to decreased levels of both fecal and urinary urobilinogen. In biliary tract obstruction, conjugated bilirubin will accumulate proximal to the point of obstruction and will reflux back into the circulation, leading to an increase in urinary conjugated bilirubin (choice B), a process that does not occur in hemolytic anemia. Unconjugated bilirubin (choice D) is not water soluble and therefore would not be found in urine.

3. **(B)** Total plasma calcium is homeostatically regulated within a narrow range between 2.2 and 2.55 mmoles/L (8.8–10.4 mg/dL). Consequently, the man’s calcium level is just beneath normal levels, and without any symptoms related to hypocalcemia, laboratory values should be confirmed. Nevertheless, chronic kidney insufficiency could be considered. Adequate kidney functioning is necessary to create the active form of vitamin D, called 1,25-dihydroxycholecalciferol. It is one of the substances that regulate plasma calcium. Chronic kidney insufficiency could diminish vitamin D metabolism and lead to mild hypocalcemia. Acute dehydration (choice A) is caused by a rapid loss of fluids as a result of vomiting, diarrhea, hemorrhage, diuresis, or severe fever. None of these symptoms are
present. Although chronic and severe dehydration can lead to symptoms resulting from depletion of all kinds of minerals including calcium, acute dehydration generally first leads to symptoms related to sodium and potassium imbalances. The parathyroid glands are the primary sensors of plasma-free calcium. The glands release parathyroid hormone as the calcium concentration falls leading to an increase in free plasma calcium. Hence, excess parathyroid hormone (choice C) would cause hypercalcemia, not hypocalcemia. Total serum calcium levels are correlated with the amount of blood proteins, primarily albumin, so that low albumin, not high (choice D) could lead to low total calcium values. Physiologically, hyperalbuminemia can only occur with dehydration. This would make the patient’s free serum calcium levels lower than normal, in which case symptoms due to hypocalcemia would be likely. Plasma phosphate levels are not as well regulated as calcium levels. Nevertheless, they are often measured together with calcium to determine a substantial imbalance. Very high, not low serum phosphate levels (choice E), such as for instance seen in critically ill patients, can cause acute hypocalcemia since phosphate binds calcium avidly.

4. (C) With the patient seated and the head tilted anteriorly (chin on chest), irrigation of the right ear with warm water produces increased output from the right vestibular sensory apparatus, and this leads to activation of the left lateral rectus and right medial rectus muscles. These two muscles then produce slow (not fast, choices A and B) conjugate horizontal movement of the eyes to the left (not right, choices D and E), followed immediately by rapid conjugate movement to the right.

5. (F) Libman-Sacks endocarditis is a very characteristic finding associated with systemic lupus erythematosus. Multiple small vegetations are found on both surfaces of both the mitral and tricuspid valves. The vegetations do not embolize and do not usually interfere with valve function. Acute rheumatic fever (choice A) is associated with the formation of small vegetations principally on the mitral and aortic valves. These vegetations do not embolize, but can initiate the damage that eventually leads to chronic rheumatic heart disease (choice C). Carcinoid syndrome (choice B) is seen in patients who have a malignant carcinoid tumor of the intestine that metastasizes to the liver. Before the tumor metastasizes, any active tumor products that it releases have to pass through the liver where they are inactivated. However, once the tumor reaches the liver, these products can be released directly into the venous return, where they can reach the right heart causing endocardial fibrosis that involves the tricuspid and pulmonic valves. Infective endocarditis (choice D) is a destructive process that most often involves the mitral and aortic valves but, with intravenous drug abusers, can involve the right-sided valves. The infectious agent is usually bacterial but can also be fungal. Pieces of the destroyed valve readily break off and form septic emboli. Mucinous adenocarcinomas of the pancreas and other organs (choice E) can be associated with small, sterile, fibrinous vegetations on the mitral and aortic valves. This is also referred to as marantic endocarditis or noninfective endocarditis. These vegetations are loosely attached and can embolize.

6. (A) Antithrombin III is the most important since it can also inhibit the activities of factors IXa, Xa, XIa, and XIIa. The activity of antithrombin III is potentiated in the presence of heparin by the following means: heparin binds to a specific site on antithrombin III, producing an altered conformation of the protein, and the new conformation has a higher affinity for thrombin as well as its other substrates. This effect of heparin is the basis for its clinical use as an anticoagulant. The naturally occurring heparin activator of antithrombin III is present as heparan and heparan sulfate on the surface of vessel endothelial cells. It is this feature that controls the activation of the intrinsic coagulation cascade. Thrombin activity is also inhibited by alpha-1-macroglobulin, heparin cofactor II and alpha-1-antitrypsin. The characteristic features of antithrombin deficiency are deep vein and cerebral vein thrombosis and pulmonary embolism. The thromboembolic events associated with a deficiency in antithrombin are rarely seen in individuals younger than 15 years of age. The
reason for this is suggested to be the high levels of alpha-2-macroglobulin present in childhood. Deficiency in factor VIII (choice B) results in hemophilia A, which is characterized by easy bruising, prolonged bleeding from wounds, and joint and muscle hemorrhage. Fibrinogen deficiency (choice C) protein C (choice D) is an anticoagulant that, on activation by thrombin, cleaves the activated forms of factors V and VIII. A defect in protein C activity will result in venous thrombosis and pulmonary embolism. Deficiency in von Willebrand factor (choice E) causes mucocutaneous bleeding despite the presence of a normal platelet count.

7. (B) Folic acid supplementation has been strongly associated with prevention of spina bifida and related congenital abnormalities. The mechanism is not understood. Erythropoietin (choice A) is used in the anemia of renal failure and to increase erythropoiesis in collecting blood prior to surgery. It is not associated with congenital anomalies. Intrinsic factor (choice C) is a secreted glycoprotein involved in intestinal absorption of vitamin B12. The absence of intrinsic factor leads to B12 deficiency and pernicious anemia. Thiamine deficiency (choice D) may lead to neurologic problems, but is not associated with congenital anomalies. Alcoholism is the most common cause of thiamine deficiency in the United States. Vitamin B12 is important in erythropoiesis and neurological function in adults. Deficiency (choice E) results in pernicious anemia, peripheral neuropa thies, and behavioral alterations. It is not associated with birth defects.

8. (B) Complement-fixation procedures are performed in two stages. The test system consists of antigen and antibody (one of which is unknown) plus complement. The indicator system consists of sheep erythrocytes and hemolysin (an antisheep-RBC serum), which will sensitize the cells to the lytic action of complement. If complement is fixed in the test system, it is effectively bound (or consumed) in the antigen-antibody complexes there and is not free to participate in the lysis of the sensitized erythrocytes present in the indicator system. In an influenza virus complement-fixation test, the indicator system consists of complement, unlabeled sheep red blood cells, and antibody to sheep red blood cells (choice C). The indicator system does not need antibody to influenza virus (choice A), fluorescent-tagged virus (choice D), or neuraminidase (choice E).

9. (E) Vitamin D is a steroid hormone that plays a crucial role in calcium homeostasis. It has to be activated in a two-step process involving first the liver, then the kidney. In renal failure, the kidney’s ability to generate active vitamin D (1,25-dihydrocholecalciferol) is impaired or lost. Thus, serum calcium falls, serving as a stimulus to parathyroid hormone secretion, which in turn stimulates bone resorption. The latter response elevates serum phosphate that is not cleared by the kidney due to renal failure and therefore serves to bind calcium and lower the ionized calcium that triggers further PTH secretion, and so on. All of the other options are the opposite of what is generally observed in renal failure. Increased oxidative products not cleared by the kidneys results in accelerated atherosclerosis (choice A). Volume overload in renal failure tends to give hypertension, not hypotension (choice B). Insulin clearance occurs largely by the kidney; thus, an important tip-off of progression of renal failure is unexplained diminution in a patient’s insulin requirements (choice C). Loss of erythropoietin results in anemia, not polycythemia (choice D).

10. (C) Severe cystic acne is a disfiguring disease that affects mostly adolescents and young adults. Mild forms of acne may be successfully treated with special skin-cleansing agents and antibiotics, but cystic acne is refractory to these approaches. Isotretinoin, a vitamin A analog, has a poorly understood mechanism, but is remarkably efficacious. Unfortunately, it is extremely toxic to the fetus, so this drug is absolutely contraindicated in pregnancy and strictly regulated. Bacitracin (choice A) is a topical antibiotic used in minor skin infections. It is too toxic for systemic use. Griseofulvin (choice B) is a very slow-acting antifungal agent used mostly for infections of the nails. Mupirocin (choice D) is an antibiotic with activity against gram-positive dermatologic infections. It is used in impetigo and to reduce
nasal carriage of *S. aureus*. Triamcinolone acetonide (choice E) is an effective topical steroid used in a variety of inflammatory and pruritic skin conditions. It is not useful in cystic acne.

11. (A) Seemingly normal full-term infants suffering from urea cycle defects will usually become lethargic and need stimulation to feed within 24–72 h after birth. When presented in the emergency many will be comatose. One obvious outward clinical sign will be a bulging fontanel due to the ammonia-induced encephalopathy. If a correct diagnosis of hyperammonemia is not made in a timely manner, these infants will die. Elevated levels of various urea cycle intermediates are indicative of a particular defect in the pathway so that high argininosuccinate (choice B) is indicative of argininosuccinase deficiency, high citrulline (choice C) is indicative of argininosuccinate synthetase deficiency, and high orotic acid levels are indicative of ornithine transcarbamoylase deficiency. When excess fatty acids are oxidized, the acetyl-CoA that cannot be used in the TCA cycle is diverted into the production of the ketone bodies, acetoacetate, and beta-hydroxybutyrate. If the concentration of ketone bodies is high such that they are not used by nonhepatic tissues, much of the acetoacetate will spontaneously decarboxylate to acetone. Much of the acetone is then volatilized in the lungs. The odor of acetone on the breath is indicative of severe ketoacidosis that occurs in individuals with Type 1 (insulin-dependent) diabetes.

12. (B) Figure 10-1 shows a cirrhotic liver that is recognized by the islands of regeneration nodules surrounded by fibrosis. In this patient, the cirrhosis resulted in intrahepatic resistance to blood flow, which led to portal hypertension. One of the more serious consequences of this is the development of esophageal varices. It was rupture of these that led to the hematemesis and demise of the patient. Examination of the section reveals a golden-brown pigment throughout most of the tissue. Of the choices given, hemochromatosis is the only one that is due to the deposition of a pigment (hemosiderin). All of the others, alpha-1-antiprotease deficiency (choice A), primary biliary cirrhosis (choice C), primary sclerosing cholangitis (choice D), and viral hepatitis (choice E) are not associated with pigment deposition.

13. (E) The graft-versus-host reaction occurs when immunocompetent lymphoid cells are transferred to a histoincompatible recipient who is unable to reject them. The donor cells then mount an immune response against the foreign histocompatibility antigens of the recipient and attempt to reject them. This usually occurs in bone marrow transplantation performed as a therapeutic modality in patients with certain leukemias or other blood diseases, such as aplastic anemia. Contamination of the graft with gram-negative bacteria is not known to be the key factor for the graft-versus-host reaction. The basis of the graft-versus-host reaction has been explained in the previous paragraph (choice B). Graft-versus-host reactions can occur with any type of tissue grafting be that of neoplastic or non-neoplastic origin (choice C). A graft-versus-host reaction does not occur because the graft has histocompatibility antigens not found in the recipient, but because the reaction occurs when immunocompetent lymphoid cells are transferred to a histoincompatible recipient who is unable to reject the immunocompetent lymphoid cells (choice A). For the reasons stated above, a graft-versus-host reaction does not occur when a histocompatible graft is irradiated before engraftment (choice D).

14. (E) Pacinian corpuscles are pressure receptors mainly present in deep layers of the skin (see Figure 10-8). They are especially susceptible to vibrations and adapt rapidly to continuous pressure. Free nerve endings (choice A) are widely distributed throughout the body and are found as branches of unmyelinated or lightly myelinated fibers beneath the epithelium. They detect a variety of stimuli including pain, touch, pressure, and temperature. Golgi tendon organs (choice B) are encapsulated endings in the junction between muscle and tendon. They respond best to tension generated by active muscle contraction. Meissner corpuscles (choice D) are pressure receptors like Pacinian corpuscles. They are highly abundant in the palms and soles as well as on the fingertips and
lips. They adapt moderately fast and thus mediate the sensation of localized, slow vibrations. Since they can be located near the surface of the skin (see Figure 10-8), they are mainly responsible for detecting light touch. Mechatoreceptors are often found close to hair follicles (choice C) so that even if the skin is not touched directly, movement of the hair is detected.

15. (E) Ondansetron, an antagonist at 5-HT<sub>3</sub> receptors, is a very effective antiemetic in chemotherapy-induced and postsurgical vomiting. Muscarinic acetylcholine receptors (choice A) do not appear to be involved in chemotherapy-induced emesis, although scopolamine is effective in preventing vomiting due to motion sickness. Dopamine receptors (choice B) are involved in the action of the dopamine antagonist metoclopramide, another drug used to control chemotherapy-induced emesis. Glucocorticoid receptors (choice C) are important for the action of dexamethasone, another useful drug for chemotherapy-induced vomiting. Histamine H<sub>1</sub> receptors (choice D) are blocked by diphenhydramine, a drug that is useful in both chemotherapy- and motion sickness-induced vomiting.

16. (E) One of the many effects of insulin on cells is to increase glucose uptake and storage into glycogen. Glucose uptake (e.g., in skeletal muscle) is mediated by insulin-induced mobilization of glucose transporters (GLUT4) to the cell surface. The glucose is then incorporated into glycogen because of the effect of insulin on glycogen homeostatic enzymes. These effects are an increase in glycogen synthase and a decrease in glycogen phosphorylase activities. As shown in Figure 10-9, increased glycogen synthesis is affected by activation of phosphate removal from...
three key enzymes via the action of protein phosphatase-1 (PP1). These key enzymes are phosphorylase, phosphorylase kinase, and glycogen synthase. Dephosphorylation of the first two enzymes reduces their activity, while dephosphorylation of the latter increases its activity, leading to increased glucose storage. In order for this regulatory process to be carried out quickly and effectively, a subunit of PP1 “collects” all of the regulated enzymes into a multi-subunit complex. This subunit is called protein-targeting glycogen, PTG. Therefore, a defect in PTG function would reduce or eliminate the ability of insulin action to target glycogen homeostasis. Defects in none of the other enzymes (choices A–D) would lead to as great a deficit in insulin-mediated glycogen homeostasis as that resulting from PTG defects.

17. (D) An ideal confirmatory test would have no false negatives, that is, all positives are true positives. That criterion is achieved at point D (see Figure 10-2) where all individuals without disease are below the cutoff point, designating a specificity of 100% (all positives are true positives). Point B represents the cutoff point for an ideal exclusion test in which all individuals with disease are identified (i.e., 100% sensitivity indicating that all negatives are true negatives). The other points (A, C, E, and F) have no significance in these test interpretations.

18. (E) Iron is primarily absorbed from the diet, in the duodenum, as either organic or heme-bound forms. Inside the enterocyte the iron binds to cytoplasmic proteins, ferritin, and mobilferrin. Depending on total body iron stores, the iron is either transferred to the plasma, where it binds to plasma transferrin, or it remains in the enterocyte until it is lost with cell shedding. Once absorbed, iron is avidly retained by the body. An adult male excretes only about 0.03% of his total body stores per day (about 1 mg), while the loss in premenopausal women is still only about twice that amount. Blood normally contains 15 g hemoglobin per 100 ml. The concentration of hemoglobin in blood is thus about 2.3 mM. Since each molecule of hemoglobin contains four molecules of iron, the total blood iron concentration is almost 10 mM. A transfusion of 1 unit of packed red blood cells (about 500 mL) would thus add a total iron burden of about 250 mg. Given the body’s limited excretory capacity, multiple transfusions can elevate iron to toxic levels. The liver is particularly susceptible to damage. None of the other choices (A–D) should be associated with multiple transfusions.

19. (D) The MLF connects the vestibular nuclei rostrally to the oculomotor, trochlear, and abducens nuclei, which innervate the extraocular muscles. Lesion of the MLF results in impairments of the vestibulo-ocular reflex, as well coordination of eye movements. The central tegmental tract (choice A) carries information from the reticular formation to the diencephalon (thalamus and hypothalamus). The lateral vestibulospinal tract (choice B) projects from the lateral vestibular nucleus ipsilaterally to all levels of the spinal cord. The medial lemniscus (choice C) contains second order projections from the nuclei gracilis and cuneatus to the ventrobasal complex of the thalamus. The medial vestibulospinal tract (choice E) originates mostly from the medial vestibular nucleus, joins the MLF but runs caudally to cervical levels of the spinal cord.

20. (B) All of the drugs listed are antiviral agents. Amprenavir is a protease inhibitor and is often combined with other anti-HIV agents in highly active antiviral therapy (HAART) regimens. Inhibition of the protease prevents the final synthetic steps in virus multiplication. Acyclovir (choice A) is an antiherpes agent that blocks DNA synthesis. Didanosine (choice C) is a nucleoside reverse transcriptase inhibitor (NRTI) that blocks one of the initial steps in replication of the viral codon. Enfuvirtide (choice D) is one of the newest agents with activity against HIV. It appears to prevent fusion of the viral envelope with the cell membrane. Zidovudine (choice E) is an anti-HIV drug that blocks viral reverse transcriptase, the initial step in converting the host cell to virion production.

21. (C) Pulmonary arterioles are unique for their ability to constrict under conditions of hypoxia. This results in a local adjustment of perfusion
to ventilation. For example, if a bronchiole is obstructed, the lack of O₂ causes contraction of the pulmonary vascular smooth muscle in the corresponding area, shunting blood away from the hypoxic region to better-ventilated regions. Similarly, systemic hypoxia causes an increase in pulmonary artery resistance and increased workload for the right ventricle. Coronary (choice A), GI (choice B), renal (choice D), and skeletal muscle (choice E) arteries all dilate under hypoxic conditions, resulting in enhanced blood flow to their respective organs.

22. (C) The chromaffin cells of the suprarenal (adrenal) glands are derived from the neural crest and receive preganglionic sympathetic fibers directly from neurons located in the lateral horn of the thoracic spinal cord. Celiac ganglia (choice A) contain postganglionic sympathetic neurons; however, these do not project to the suprarenal glands. The dorsal motor nucleus of the vagus (choice B) provides preganglionic parasympathetic innervation for organs of the thorax and abdomen. The nucleus ambiguus (choice D) innervates skeletal muscles associated with the pharynx and larynx. The nucleus of the solitary tract (choice E) receives visceral afferent information.

23. (C) Alcoholic hepatitis (also called acute sclerosing hyaline necrosis of the liver) usually occurs acutely following an alcohol binge superimposed on steatosis (fatty liver) or cirrhosis. Variable degrees of liver cell necrosis are present with corresponding clusters of neutrophils and frequent accompaniment of pericellular and perivenular fibrosis. Intracellular Mallory bodies are common. Alcoholic hepatitis may range from asymptomatic to fulminant hepatic failure. Symptoms, which may persist for weeks or months, include upper abdominal pain, anorexia, fever, tender hepatomegaly, and jaundice. Severe disease may cause encephalopathy and death. Acetaminophen overdose (choice A) causes massive, dose-related centrilobular liver cell necrosis secondary to glutathione depletion. Toxicity begins with nausea, vomiting, diarrhea, abdominal pain, and sometimes shock, followed in a few days by jaundice. Liver injury occurs 24–48 h following ingestion. Acute fatty liver of pregnancy (choice B) occurs in late pregnancy and is characterized by increased microvesicular fat in the hepatocytes and fibrin deposits in the sinusoids. Budd–Chiari syndrome (choice D) refers to acute or chronic hepatic vein thromboses that may occur as a result of a number of predisposing thrombotic conditions (e.g., pregnancy, neoplasms, polycythemia vera). Liver changes are those of severe venous congestion including sinusoidal and centrilobular space of Disse erythrocytic infiltration. Chronic disease is associated with fibrosis and nodular regeneration. Clinical presentation includes hepatomegaly, portal hypertension, and very commonly ascites. Pyogenic liver abscesses (choice E) may be caused by many bacteria, most commonly E. coli, or by Entamoeba histolytica in regions where the parasite is endemic. Lesions are walled off focal collections of necrotic liver cells and accumulated neutrophils (pus). Clinical presentation is with upper right abdominal pain, high fever, and hepatomegaly.

24. (B) E. coli is the most common cause of urinary tract infection (UTI) and accounts for approximately 90% of first UTIs in young women. The symptoms include urinary frequency, dysuria, hematuria, and pyuria. Flank pain (thigh, hip, buttock areas) is associated with upper tract infection. Culture of >10⁵ cfu/mL is diagnostic of a urinary tract infection, even if patients are asymptomatic. All other organism choices (A, C, D, E) can also be opportunistic causes of UTIs, but their percentages of involvement is substantially less than E. coli etiology (80–90%) literature reports.

25. (B) Hallucination refers to perception without sensory input. The patient is having a conversation and gesticulating to someone who is not in the room. Delusion (choice A) refers to false belief (not perception) that is not amenable to reason. In obsessive-compulsive behavior (choice C), the patient recognizes the irrationality of the compulsion, but not engaging in it causes extreme anxiety. In panic states, the
patient experiences extreme anxiety, usually immobilizing or forcing him/her to escape from the situation. Schizophrenia (choice E) is a diagnosis in which hallucinations may occur, but there is insufficient data to make such a diagnosis in this case.

26. (D) Psychomotor retardation refers to slowness in both movement and cognitive activity, often seen in severe depression as well as psychosis. Circumstantiality (choice B) is an inability to get to the point without laborious elaborations. Folie à deux (choice C) is delusion shared by two people, thought blocking (choice E) is sudden absence of thought, and autistic thinking (choice A) is a more generic term denoting psychotic thinking.

27. (E) Thought blocking denotes the phenomenon in which the stream of thought simply stops, which is sometimes seen in schizophrenia. An illusion is a misperception of sensory stimulus (choice D). A delusion (choice B) is a belief not based on reality, ambivalence (choice A) is having strong opposing feelings at the same time, and negativism (choice E) is persistent negative response.

28. (E) Vancomycin is a glycopeptide antibiotic which is poorly absorbed from the intestine. It is very bacteriocidal for staphylococci, some clostridia and some bacilli. It inhibits early stages in cell wall peptidoglycan synthesis. Drug-resistant strains do not emerge rapidly, and vancomycin may be considered as a drug of last resort for resistant strains of microorganisms (staphylococci and enterococci). It is delivered by intravenous administration. High-level resistance to vancomycin (choice A) is not routinely seen. There are multiple vancomycin-resistance phenotypes, usually referred to as VanA, VanB, VanC, and VanE gene designations. This system of resistance genes is plasmid mediated rather than chromosomal (choice B). Van-resistance genes produce enzymes that produce an altered dipeptide rather than the normal peptide (D-ala-D-ala) which vancomycin can attach to (choice C). Vancomycin does form complexes with the D-ala-D-ala group of the pentapeptide chains of peptidoglycan precursors (choice D). Penicillins, not vancomycin, interfere with enzymes involved in crosslinking of linear peptidoglycan strands (choice E).

29. (C) Compression of the optic chiasm affects optic fibers carrying information from both temporal visual fields. This is usually due to a pituitary tumor. Severe compression of the left (choice A) or right (choice B) optic nerves results in blindness. Compression of the left (choice B) or right (choice E) optic tracts will be displayed as a right or left homonymous hemianopia, respectively, since each optic tract carries fibers containing information about the opposite visual fields.

30. (E) This woman’s history of chronic hepatitis B infection and cirrhosis greatly increase her risk for hepatocellular carcinoma. This diagnosis is confirmed by the microscopic description of the liver biopsy findings, which are classical for hepatocellular carcinoma. This tumor usually arises in a cirrhotic liver and, worldwide, hepatitis B infection is a major cause of cirrhosis. In such individuals, hepatitis virus DNA integration into host DNA can be demonstrated and is strongly suspected of having a role in the initiation of hepatocellular carcinoma. There are other factors that are also suspected of having a role, but given this woman’s medical history and the high prevalence of hepatocellular carcinoma in hepatitis B-positive populations, choice E is much more likely than the other proposed mechanisms (choices A through D).

31. (D) Rifampin is one of the two most important antitubercular drugs and acts by inhibiting RNA polymerase in mycobacteria. Isoniazid acts by inhibition of mycolic acid synthesis (choice E). Inhibition of dihydropteroate synthase (choice C) is the mechanism of action of antibacterial sulfonamides and may play a role in the action of dapsone, an important drug used in leprosy. Inhibition of the 30S ribosomal protein (choice A) is the mechanism of action ofaminoglycosides, including streptomycin, a second-line agent in tuberculosis therapy. Inhibition of dihydrofolate reductase (choice B) is the mechanism of trimethoprim, useful in some bacterial infections (but not tuberculosis).
32. **(B)** Astrocytomas are the most common primary intracranial neoplasms and the majority of these tumors arising in adults are high grade, supratentorial and, as suggested by the MRI, lack a clear margin of separation from the normal surrounding tissue. The microscopic features of vascular proliferation and necrosis classify this particular patient’s tumor as a grade 4 astrocytoma or glioblastoma multiforme. A rapid clinical onset is typical for these tumors. In adults, ependymomas (choice A) are more usually located in the spinal cord. Their microscopic appearance is somewhat variable but they often form pseudorosettes. Metastatic sarcoma (choice C) in the brain is unusual and its microscopic appearance would most likely be a spindle cell tumor. Oligodendrogliomas (choice D) usually have a prolonged clinical onset and microscopically are composed of sheets of cells with a “fried egg” appearance. Calcification and a capillary network commonly accompany these tumors. Pilocytic astrocytomas (choice E) are usually seen in children and young adults. Their usual location is cerebellar but they may be found in the cerebrum on occasion. Microscopically they demonstrate many hair-like glial processes. Primary lymphomas (choice F) are seen more typically in immunosuppressed individuals and are usually of B-cell origin; the general histology that characterizes lymphomas is not consistent with the description given in this case.

33. **(E)** The envelope of hepatitis B virus (HBV) contains an antigen known as HBsAg (hepatitis B surface antigen). This antigen is of germane importance because production of antibodies against HBsAg indicates immunity against hepatitis B virus, which resulted either from infection, or vaccination with HVsAg. Treatment of HBV with nonionic detergent removes the envelope and produces the viral core, which contains the hepatitis B core antigen (HVeAg). Neither the nucleocapsid proteins of HBV (choice A) nor the RNA genome of HBV (choice B) are protective. Antibodies to HVeAg are not protective (choice C). Treatment of the viral core with strong detergents results in the release of a soluble core antigen called hepatitis virus antigen e (HVeAg). Production of antibody against HVeAg (choice D) signals active disease, during which period the patient is infectious.

34. **(D)** Hormones that are synthesized in one cell, released into the surroundings to act on adjacent cells are referred to as paracrine hormones. Autocrine hormones (choice A) affect the same cells that produce them. Chemokines (choice B) are soluble factors secreted by certain immune system cells that stimulate the activity of other cells. Chemokines have chemotaxant properties and act as messengers between cells. Exocrine hormones (choice C) are synthesized by one cell, released to the circulation, and act on other distant cells.

35. **(A)** The femoral nerve innervates the quadriceps femoris, responsible for extension of the leg. The inferior gluteal nerve (choice B) innervates only the gluteus maximus muscle and has no muscular innervation in the thigh. The obturator nerve (choice C) innervates all the adductor muscles in the medial region of the thigh and plays no role in leg extension. The pudendal nerve (choice D) is motor to the perineal muscles, the external urethral sphincter, and the external anal sphincter. It has no motor role in the thigh. The sciatic nerve (choice E) innervates the hamstring muscles in the posterior aspect of the thigh and is responsible for leg flexion.

36. **(B)** The image shown in Figure 10-4 demonstrates a number of poorly formed glandular structures with a background of normal stroma and lymphocytic infiltration. Malignancy is indicated by glandular invasion and pleomorphic and hyperchromatic nuclei. Since this is a malignancy derived from glandular tissue, it is classified as an adenocarcinoma. Adenoma (choice A) and papilloma (choice E) are ruled out because they are benign lesions. Choristoma (choice C) refers to normal tissue in an atypical location. A hamartoma (choice D) is a mass of disorganized but otherwise normal tissue formed from tissues indigenous to the particular location. Squamous cell carcinoma (choice E)
would also demonstrate invasion, hypercellularity, and pleomorphism but instead of abortive gland formation, one would see sheets of polygonal cells with intercellular bridges forming keratin pearls.

37. (D) All of the drugs listed have been used in heart failure; hydrochlorothiazide and spironolactone are also used in hypertension. Of those listed, only spironolactone has been shown to reduce mortality in heart failure. The other aldosterone receptor antagonist, eplerenone, apparently has a similar beneficial effect. The cardiac glycosides such as digoxin (choice A) inhibit Na⁺/K⁺-ATPase, increase intracellular calcium concentration, and produce a therapeutic increase in cardiac contractility. As a result, digoxin can reduce the symptoms of failure, but it does not slow progression of the disease. Dobutamine (choice B) enhances contractility by activating beta-1 receptors and may also increase heart rate. It is used only for acute failure because it must be given parenterally; it does not slow progression of failure. Hydrochlorothiazide (choice C) is also of value in reducing the symptoms of mild heart failure by virtue of its ability to increase salt and water excretion, but there is little or no evidence that it can slow progression of chronic failure. Theophylline (choice E) was used in the past to treat acute pulmonary edema due to heart failure, but it is no longer considered a first-line agent due to its propensity to cause cardiac arrhythmias.

38. (C) Clearance is the amount of plasma that contained the solute excreted. Because, in this patient, the urine solute concentration is half the plasma concentration, the amount of plasma concentration (the amount of plasma that contained this solute) must be half the urine volume per day. Alternatively, you can calculate clearance from the usual equation: clearance = [urine flow] × [urine concentration]/[plasma concentration] = 6.0 L/d × 150 mosm/L/300 mosm/L = 3.0 L/d. Plasma volume (choice E) is not required for this calculation. Clearance is the fraction of plasma volume that contained the excreted amount of solutes (per day or minute).

39. (A) The pathway for conversion of phenylalanine (F) to tyrosine (Y), catalyzed by PAH, is shown in Figure 10-10. Conversion of F to Y is not only necessary for Y biogenesis but is also the first step in the catabolism of F. Classic PKU manifests with hyperphenylalaninemia, excretion of metabolites of transaminated phenylalanine (phenylpyruvate, phenylacetate, and phenyllactate) and severe mental retardation. PKU is the result of defects in PAH. However, as shown in Figure 10-10, PAH requires tetrahydrobiopterin (H₄B) as a cofactor, which is converted to dihydrobiopterin (H₂B) during the

![FIG. 10-10](image-url)
PAH reaction. Conversion of $H_2B$ back to $H_4B$ requires and additional enzyme, dihydropteridine reductase (DHPR). Defects in DHPR will result in reduced activity of any enzyme requiring $H_4B$ as a cofactor. Thus, defective DHPR will result in defective phenylalanine metabolism and lead to hyperphenylalaninemia with similar but distinct consequences to PKU. One distinction is that patients with DHPR defects do not respond to dietary restrictions in phenylalanine as effectively as do classic PKU patients. Although defects in PAH (choice C) result in hyperphenylalaninemia, treatment with phenylalanine restriction is quite effective at ameliorating symptoms. Defects in the other four enzymes (choices B, D, and E) would not yield the symptoms in the patient.

40. (C) Lymph drainage of the prostate gland is primarily to the internal iliac and sacral lymph nodes. External iliac nodes (choice A) receive lymphatic vessels from the bladder. The superior mesenteric (choice E) and inferior mesenteric (choice B) nodes drain lymphatic vessels from the digestive system. The superficial inguinal nodes (choice D) drain the external perineal region and the lower limb.

41. (B) Normal extracellular pH is approximately 7.40. Prolonged diarrhea will lead to metabolic acidosis principally due to the loss of bicarbonate in stool. Normal plasma concentrations for carbon dioxide and bicarbonate are approximately 40 mm Hg and 25 mmol/L (choice C), respectively. A decrease in pH stimulates respiration in an attempt to decrease carbon dioxide, the principal acid product of metabolism. Therefore, carbon dioxide levels should decrease, making a PCO2 of 46 mm Hg (choice D) and a PCO2 of 53 mm Hg (choice E) incorrect. For each decrement of 1 mmol/L of plasma bicarbonate, a decrease in carbon dioxide concentration of approximately 1.2 mm Hg is expected. In choice B, the correct answer, a bicarbonate concentration of 21 mmol/L correctly corresponds with a PCO2 of 33 mm Hg. A bicarbonate concentration of 19 mmol/L (6 mmol/L below normal) would then correspond to an approximate PCO2 of 33 mm Hg, not 27 mm Hg (choice A).

42. (D) We associate a QRS complex with ventricular depolarization. The Q designates a negative wave, the R designates a positive deflection, and a following negative wave is designated S. However, depending on the lead that is being used, or on the possible presence of some pathology, ventricular depolarization need not generate these three wave forms. A convention has been established to name the observed deflections associated with ventricular depolarization. By convention, the first positive deflection is designated R (whether or not it is preceded by a negative wave which would be termed Q). A negative deflection following a positive deflection is termed S. The above complex would thus be termed RS.

43. (B) Folliculitis refers to acute inflammation, most typically caused by *Staphylococcus aureus*, occurring in any hair follicle, but with predilection for moist, hairy areas such as the face, neck, axillae, and groin. Suppuration follows and leads to local abscess (choice A), or furuncle, formation (in lay terms, a “pimple”). A carbuncle is a more serious, spreading infection that may occur secondarily to folliculitis. Infection extends into deeper subcutaneous tissue and spreads laterally, typically where fascial planes favor spreading (e.g., face, back of the neck). Spreading of infection results in a large inflammatory mass with multiple areas of suppuration and drainage. Cutaneous granulomas (choice C) may be associated with a variety of diseases (e.g., sarcoidosis, brucellosis, leprosy, cat-scratch disease) and manifest as variable skin lesions; however, cutaneous granulomas are typically nodular, macular, or papular in appearance and while they may or may not demonstrate focal areas of necrosis, they would not have multiple areas of suppuration. Erysipelas (choice D) is a spreading dermal infection, typically associated with streptococci, which produces a raised, red, and painful skin lesion with a well-demarcated margin; suppurative skin lesions do not occur. Necrotizing fasciitis (choice E) is a very serious infection, often associated with group A streptococci, that involves the superficial and/or deep fascia of the extremities or trunk. It is marked by severe pain, and early in the course of disease minimal erythema may be the single
overlying skin finding; with disease progression skin changes may demonstrate more mottled erythema accompanied by edema.

44. (E) Blood flowing from the right ventricle to the lungs must pass through the pulmonary valve during cardiac contraction. Stenosis of this valve will impede flow, preventing normal emptying of the right ventricle. Hence the end-diastolic right ventricular volume will be elevated (choice E). Retarded flow into the pulmonary vasculature and the left ventricle will reduce the filling pressures at these sites (choices C and B). Subsequently blood flow out of the left ventricle will be reduced (choice A). Pulmonary wedge pressure is obtained by obstructing flow into a branch of the pulmonary artery by inflating a balloon at the tip of a flow-directed catheter introduced into the vena cava and passing through the right heart. The wedge pressure is a close estimate of left atrial pressure which in this case should be decreased (choice D).

45. (A) The double-reciprocal Lineweaver-Burk plot that accompanies the question illustrates a competitively inhibited enzyme. In competitive inhibition, the intercept on the y axis, which is equal to \( I/V_{\text{max}} \), does not change. This points out that at significantly high substrate concentration, the inhibition can be overcome. In non-competitive inhibition (choice C), the \( V_{\text{max}} \) and hence the y-axis intercept, does change. Noncompetitive inhibition cannot be overcome by increasing the substrate concentration. Irreversibly (choice B) and uncompetitively (choice D) inhibited enzymes cannot be treated by Michaelis-Menten kinetics.

46. (C) Following her myocardial infarction, this woman most likely developed a mural thrombus, part of which subsequently embolized to her brain where it resulted in ischemia and a cerebral infarct. Infarction of neural tissue produces liquefactive necrosis which appears microscopically as an area void of recognizable tissue structure and containing many macrophages (microglia) phagocytosing the dead, lipid-rich tissue. An amorphous, acellular area with surrounding giant cells and peripheral lymphocytes (choice A) describes the appearance of an area of caseous necrosis within a granuloma. Intensely eosinophilic deposits within vessel walls with no inflammation (choice B) are suggestive of the appearance of fibrinoid necrosis found in malignant hypertension. Necrotic lipocytes with calcium deposits and neutrophilic infiltrate (choice D) is the characteristic finding in pancreatic fat necrosis. Preservation of neural structures with increased eosinophilia and absence of nuclei (choice E) does not occur. It suggests a morphology that is consistent with coagulative necrosis, the type of necrosis characteristically seen in many solid organs secondary to prolonged ischemia, but which is not demonstrated in the brain.

47. (C) Dimercaprol, long known as British Anti-Lewisite (BAL), is currently the first-line agent for initial therapy of arsenic poisoning. Arsenic exists naturally in both inorganic and organic forms. Arsenate can substitute for phosphate in oxidative phosphorylation to form an unstable ATP analog that spontaneously hydrolyzes, thus uncoupling oxidative phosphorylation. Arsenic poisoning is treated with chelation therapy using first, dimercaprol (choice C), a parenteral agent. It may be followed by succimer (2,3-dimercaptosuccinic acid), or penicillamine, which can be given orally. Calcium disodium edetate (choice A) binds any available divalent or trivalent metal that has a greater affinity for EDTA than calcium. It is a drug of choice in lead poisoning. Deferoxamine (choice B) is an iron-chelating agent used in the treatment of toxicity from iron. This may arise from ingestion of iron supplements (as with children swallowing adult preparations), or diseases such as thalassemia. Folic acid (choice D) is a necessary dietary constituent that functions in synthesis of purines and pyrimidines. It is of no value as an antidote in metal poisoning. Trientine (choice E) is used to treat copper overload, which is most often associated with Wilson disease.

48. (D) All of the postreceptor responses initiated by insulin binding to its receptor are mediated as a consequence of the activation of several signal transduction pathways. With respect to insulin
effects on translation, these signaling cascades ultimately affect the activity of two kinases, mTOR (mammalian target of rapamycin) and GSK3 (glycogen synthase kinase 3). Activated mTOR phosphorylates the translation regulatory protein 4EBP (eIF-4E-binding protein). When 4EBP is phosphorylated it no longer binds to eIF-4E. When eIF-4E is not bound to 4EBP, it can interact with eIF-4G and interact with the cap structure of mRNAs which ultimately leads to increased rates of translation. Active mTOR also phosphorylates and activates p70S6K (70-kDa small ribosomal subunit protein 6). Active p70S6K phosphorylates many proteins but with respect to translation, the phosphorylation of S6 leads to increased ribosomal protein synthesis and as a consequence increased ribosome biogenesis and overall increased translation. GSK3 normally phosphorylates the translation initiation factor eIF-2B (Figure 10-11), which is responsible for the exchange of GDP for GTP bound to eIF-2. This nucleotide exchange reaction is essential to reactivate eIF-2 during each round of translation. When phosphorylated, eIF-2B is much slower at catalyzing the exchange. The effect of insulin in this cascade is to activate the kinase PKB, which in turn phosphorylates GSK3. When GSK3 is phosphorylated it can no longer phosphorylate eIF-2B, thus in response to insulin the nucleotide exchange action of eIF-2B is high leading to increased translation. Insulin-mediated phosphorylation/dephosphorylation events do not impact on the activities of eEF-2 (choice B), eIF-2 (choice C), or eRF (choice E) and as indicated above, phosphorylation of 4EBP (choice A) reduces, not increases its activity.

49. (A) The position of the conidiospores in strings arising from the columella is characteristic of the genus *Aspergillus*. The organism represented in the photo that accompanies the question is septate (note the divisions, or cross-walls) in the hypha. This observation rules out any of the phycomycetes (choice B), since these organisms are cyanobacteria. The dermatophytes that are the causative agents of the tinea infections (choices C, D, and E) usually have single conidiospores and are characterized by their macroconidial forms.

50. (D) Because of changes in sexual behaviors (practice of safe sex), the percentage of gay and bisexual men with HIV has gradually declined in the United States. Choice A is incorrect because more women are now being infected through heterosexual intercourse than IV substance abuse. Choice B is incorrect as the number of infected women is growing four times faster than the number of infected men. As for choice C, because there is a decrease in the percentage of infected gay and bisexual men, there is an increase in infected heterosexual men. Choice E is incorrect as the ratio of men to women who are infected with HIV is estimated to be 6:1.
1. A patient with multiple rib fractures following an automobile accident is brought to the emergency room. Which of the following arterial blood gas values would you expect in this patient, compared to normal?

<table>
<thead>
<tr>
<th>Normal</th>
<th>pH</th>
<th>Bicarbonate (mmol/L)</th>
<th>P CO2 (mm Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A)</td>
<td>7.25</td>
<td>26</td>
<td>60</td>
</tr>
<tr>
<td>(B)</td>
<td>7.35</td>
<td>18</td>
<td>33</td>
</tr>
<tr>
<td>(C)</td>
<td>7.45</td>
<td>31</td>
<td>60</td>
</tr>
<tr>
<td>(D)</td>
<td>7.50</td>
<td>22</td>
<td>30</td>
</tr>
</tbody>
</table>

2. Which of the following is considered an alkylating agent and has been shown to be effective in cancer chemotherapy?

(A) doxorubicin  
(B) cyclophosphamide  
(C) methotrexate  
(D) vinblastine  
(E) etoposide

3. The Philadelphia chromosome is the result of a translocation between chromosomes 9 and 22 leading to the generation of a chimeric tyrosine kinase gene, BCR-ABL. This chromosomal abnormality is associated with which of the following disorders?

(A) Burkitt lymphoma  
(B) chronic myeloid leukemia  
(C) Fanconi anemia  
(D) Li-Fraumeni syndrome (LFS)  
(E) von Hippel-Lindau syndrome (VHL)

4. Pinealocytes in the pineal gland secrete melatonin which induces sleepiness and inhibits gonadotropin and growth hormone secretion. The synthesis of melatonin is derived from which of the following?

(A) choline  
(B) glucose  
(C) glutamate  
(D) tryptophan  
(E) tyrosine

5. Which of the following cancers is most likely to cause depression?

(A) cervix  
(B) lung  
(C) pancreas  
(D) skin  
(E) stomach
6. A 77-year-old man suffers an extensive myocardial infarction and dies 8 days later. A section of the infarcted myocardium taken at autopsy is most likely to demonstrate which of the following microscopic changes?

(A) extensive infiltration of neutrophils with prominent areas of eosinophilia
(B) infiltration of macrophages and lymphocytes with extensive edema
(C) loss of myocardial cross-striations with nuclear pyknosis and few inflammatory cells
(D) mixed inflammatory infiltrate of neutrophils and macrophages with extensive necrosis
(E) pale, acellular area with abundant collagen and few fibroblasts
(F) scattered areas of necrosis with ingrowth of fibroblasts and capillaries

7. Which of the following drugs exerts an anticoagulant effect by directly binding to and activating antithrombin III?

(A) alteplase
(B) heparin
(C) hirudin
(D) ticlopidine
(E) warfarin

8. In the United States, children at day care centers have been observed to have a higher rate of infection with which of the following?

(A) Dientamoeba fragilis and Necator americanus
(B) Entamoeba histolytica and Isospora belli
(C) Giardia lamblia and Enterobius vermicularis
(D) G. lamblia and Trichinella spiralis
(E) Taenia saginata and Balantidium coli

9. A 40-year-old woman is admitted to county hospital complaining of shortness of breath over the past 18 months, ankle edema for 9 months, ascites for 3 months, and a marked increase in these symptoms for the past 2 weeks. Chest x-ray shows nodular lesions throughout both lung fields associated with some pleural thickening. Her condition deteriorates, and she dies 2 days later. Autopsy reveals that her disease process also involved other organs, including heart, spleen, and liver. The photomicrograph in Figure 11-1 demonstrates findings in the lungs that are similar to those of other organs. Which of the following is the most likely diagnosis?

(A) CREST syndrome
(B) metastatic lung carcinoma
(C) progressive systemic sclerosis
(D) sarcoidosis
(E) tuberculosis

10. An 8-month-old female has died due to cardiorespiratory failure. Physical findings that were apparent prior to her death included feeding difficulties, cardiomegaly, macroglossia, mild hepatomegaly, hypotonia, and a rapidly progressing muscle weakness. Autopsy findings demonstrated marked intralysosomal accumulation of glycogen of normal structure in cardiac and skeletal muscle. These physical and clinical findings are consistent with which of the following glycogen storage diseases?

(A) Anderson disease
(B) Forbe (or Cori) disease
(C) McArdle disease
(D) Pompe disease
(E) Tarui disease
11. A 34-year-old woman presents to the emergency room with a 103.5°F fever, right-sided weakness, confusion, petechial hemorrhages on her upper extremities, and tender nodules on her fingers. Cardiac examination reveals tachycardia and a loud systolic murmur at the apex. Urinalysis reveals moderate hematuria. Which of the following is the most likely diagnosis?

(A) acute rheumatic fever
(B) infective endocarditis
(C) rupture of an aortic aneurysm
(D) sepsis secondary to bacterial myocarditis
(E) systemic polyarteritis nodosa

12. Three family members developed double vision, swallowing difficulty, and speech difficulty 2 days after eating dinner together. Which microorganism listed below produces an exotoxin that is very specific in blocking transmission of cholinergic nerves?

(A) Bacillus anthracis
(B) Bacillus cereus
(C) Clostridium botulinum
(D) Clostridium difficile
(E) Clostridium tetani

13. The parents of a 5-month-old girl are concerned that the child does not seem to respond adequately to voices. A pure tone audiometry was performed and lead to the audiogram shown in Figure 11-2 (X: left ear, O: right ear). Which of the following is correct with respect to the child’s hearing?

(A) She cannot hear people talking to her.
(B) She has high-pitched hearing loss in left ear.
(C) She has high-pitched tinnitus in left ear.
(D) Her right ear hearing is normal.
(E) Her results are typical for presbycusis.

14. In a particular nerve cell, the resting membrane potential is −80 mV. The equilibrium potentials for Ca^{2+}, Na^{+}, Mg^{2+}, Cl^{−}, and K^{+} are, respectively, +120, +60, 0, −80, and −90 mV. Increase in the permeability to which of these ions could cause an inhibitory postsynaptic potential?

(A) Ca^{2+}
(B) Cl^{−}
(C) K^{+}
(D) Mg^{2+}
(E) Na^{+}

15. A 62-year-old woman is referred to a specialist for nephrolithiasis and a recent vertebral fracture. She has also reported frequent gastrointestinal upsets, weakness, and fatigue. Assuming normal renal function, which of the following sets of laboratory values for serum calcium, phosphate, and alkaline phosphatase, respectively, would most likely be associated with her condition?

(A) high, high, high
(B) high, high, low
(C) high, low, high
(D) low, high, low
(E) low, low, high
(F) low, low, low

16. A 66-year-old man suffering from COPD was diagnosed with nocardiosis which does not respond to trimethoprim. This is due to Nocardia asteroides that contains a new drug-insensitive enzyme. Which of the following represents this drug-insensitive enzyme?

(A) dihydrofolate reductase
(B) DNA gyrase
(C) muraminidase
(D) permease
(E) superoxide dismutase
17. A 27-year-old bank security guard is shot in the head during a robbery attempt. He survives in a comatose state for several days and then contracts bronchopneumonia from which he dies. Which of the following is the manner of death in this case?

(A) accident
(B) gunshot wound to the head
(C) homicide
(D) natural
(E) pneumonia

18. Fats stored in adipose tissue can serve as a carbon source for hepatic gluconeogenesis leading to net glucose production. Which of the following represents the source of the carbon atoms by which this conversion can occur?

(A) acetyl-CoA
(B) any fatty acid with an even number of carbon atoms
(C) arachidonic acid
(D) glycerol
(E) malonyl-CoA

19. A 17-year-old male experiences a severe asthma attack with marked respiratory distress, cyanosis, and minimal breath sounds. A blood sample taken at this time would reflect which of the following values compared to normal?

<table>
<thead>
<tr>
<th>Normal</th>
<th>HCO⁻³</th>
<th>pH</th>
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<td>(A)</td>
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<td>(C)</td>
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<td>(D)</td>
<td>36</td>
<td>7.34</td>
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<tr>
<td>(E)</td>
<td>28</td>
<td>7.44</td>
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20. Glaucoma results from an obstruction in the drainage of the aqueous humor of the eye leading to an increase in intraocular pressure. If left untreated, glaucoma can cause damage to the retina and eventual blindness. Which of the following constitutes the normal flow of the aqueous humor in the eye?

(A) anterior chamber to aqueous veins to canal of Schlemm to trabecular meshwork to posterior chamber to episcleral veins
(B) anterior chamber to posterior chamber to canal of Schlemm to trabecular meshwork to aqueous veins to episcleral veins
(C) canal of Schlemm to episcleral veins to aqueous veins to posterior chamber to anterior chamber to trabecular meshwork
(D) posterior chamber to anterior chamber to trabecular meshwork to canal of Schlemm to aqueous veins to episcleral veins
(E) posterior chamber to trabecular meshwork to anterior chamber to canal of Schlemm to aqueous veins to episcleral veins

21. Flumazenil is an effective antidote for overdosage with which one of the following drugs?

(A) buspirone
(B) diazepam
(C) ethanol
(D) morphine
(E) phenobarbital

22. The mother of a 4-year-old boy brings her son to his pediatrician due to repeated episodes of easy bruising and epistaxis. Blood work reveals a prolonged PTT, a normal PT, and a prolonged bleeding time. Platelet count is 285,000 per uL. Based on these laboratory findings, what is the most likely diagnosis?

(A) disseminated intravascular coagulation
(B) hemophilia B
(C) primary fibrinolysis
(D) vitamin K deficiency
(E) von Willebrand disease
23. Sensory receptors in the integumentary system monitor respond to a variety of stimuli. Which of the following mechanoreceptors responds to deep pressure?

(A) Meissner corpuscle
(B) Merkel disk
(C) naked nerve ending
(D) Pacinian corpuscle
(E) Ruffini end organ

24. Figure 11-3 represents five left ventricular pressure-volume loops, each labeled by a letter (A through E). Loop D shows the normal pressure-volume loop of a healthy adult at rest. Which curve represents a patient with mitral stenosis?

25. Which of the following is an ergot derivative that can be used to treat Parkinson’s disease?

(A) amantadine
(B) benztropine
(C) bromocriptine
(D) ropinirole
(E) tolcapone

26. A newborn baby boy developed respiratory distress soon after birth and died 1 week later. Based upon this image of pancreas shown in Figure 11-4, the event that led to his death is most likely which of the following?

27. A 14-year-old male patient who is a gang member has suffered a bullet wound to his left axilla. Neurologic examination reveals that he has weak flexion of the elbow and weak supination of the forearm. He also displays anesthesia of the lateral surface of the forearm. Which of the following nerves is most likely injured?

(A) median
(B) musculocutaneous
(C) posterior interosseous
(D) radial
(E) ulnar
28. A postoperative patient with a febrile episode is carefully monitored. Temperatures measured are rectal and given in degrees centigrade in Figure 11-5. At which point or period does the patient begin to behave as if in a hot environment (sweats and complains of “burning up”)?

(A) period A  
(B) point B  
(C) point C  
(D) period D  
(E) point E  
(F) point F  
(G) period G

29. A 27-year-old recent immigrant is hospitalized because of cyclic severe fevers occurring about every 72 hours due to infection by *Plasmodium malariae*. What is the pathogenic mechanism responsible for the recurrent quartan fever?

(A) cell-mediated cytokines invoke pyrogen production  
(B) central hypothalamic fever due to cerebral malaria  
(C) hepatocyte infestation with cyclic lysis  
(D) immune-mediated destruction of organisms by cytotoxic antimalarial antibodies  
(E) red cell lysis upon release of proliferating merozoites

30. An HIV-positive man has developed severe *Candida albicans* septicemia. Which of the following drugs is the treatment of choice?

(A) amphotericin B  
(B) clarithromycin  
(C) flucytosine  
(D) ketoconazole  
(E) vancomycin

31. A new test is available for a common disease (prevalence = 5%). The sensitivity is 95% and the specificity is 90%. You order the test for one of your patients and a positive result is reported. What is the probability (to the nearest whole number) of this result being a true positive rather than a false positive; that is, what is the predictive value positive?

(A) 10%  
(B) 33%  
(C) 50%  
(D) 67%  
(E) 90%  
(F) 95%

32. The camptothecins are an alkaloid class of anticancer drugs used in the treatment of colon and breast cancers. These compounds function by inhibiting the activity of which of the following enzymes?

(A) ATP-dependent DNA helicase  
(B) DNA ligase  
(C) DNA polymerase  
(D) histone deacetylase  
(E) topoisomerase I

33. Which of the following is the final step in the coagulation cascade, leading to clot formation?

(A) conversion of thrombin to prothrombin  
(B) plasmin catalyzed degradation of fibrin fibers  
(C) polymerization of prothrombin  
(D) release of tissue factor  
(E) thrombin catalyzed conversion of fibrinogen to fibrin
34. The pancreas plays an important role in the control of blood glucose by its secretion of insulin and glucagon. The release of insulin and glucagon is inhibited by somatostatin, which is also secreted by the pancreas. Which of the following cells of the pancreas secrete somatostatin?

(A) acinar cells  
(B) alpha cells  
(C) beta cells  
(D) delta cells  
(E) F cells

35. Which of the following drugs is most likely to be effective in the prevention of recurrent atrial fibrillation in a patient with long-standing severe heart failure?

(A) adenosine  
(B) amiodarone  
(C) digoxin  
(D) lidocaine  
(E) propafenone

36. A 3-month-old baby has been immunized with the poliomyelitis vaccine. Biochemical analysis of the baby’s serum 6 days following immunization indicates the presence of the immunoglobulin shown in Figure 11-6. Which of the following represents this immunoglobulin?

(A) IgA  
(B) IgE  
(C) IgD  
(D) IgM  
(E) IgG

37. Which of the following can be said of individuals infected with human immunodeficiency virus (HIV)?

(A) They can engage in kissing.  
(B) They may manifest a cortical but not subcortical dementia.  
(C) They may not safely masturbate.  
(D) They should not donate blood unless under triple therapy.  
(E) They should not engage in vaginal or anal intercourse under any circumstances.

38. Figure 11-7 shows the active, isometric-length tension curve for a mammalian skeletal muscle fiber. Which of the following statements about the region of this curve designated by the arrow is correct?

(A) Amount of tension mainly depends on the extent of overlap between thick and thin filaments.  
(B) Skeletal muscle fibers usually operate in this region of the curve.  
(C) Tension remains constant as a function of sarcomere spacing.  
(D) Tension varies primarily due to steric hindrance.  
(E) There is no overlap between thick and thin filaments in this region of the curve.
39. Severe anion-gap metabolic acidosis and retinal damage from formic acid is characteristic of intoxication by which of the following?
   (A) benzene
   (B) carbon tetrachloride
   (C) ethylene glycol
   (D) isopropanol
   (E) methanol

40. After a 2-week oral regimen of penicillin, an 8-year-old girl is free of an oral infection with *Streptococcus pyogenes*, thanks to the drug’s ability to effect which of the following?
   (A) break cell-wall glycan bonds
   (B) hydrolyze beta-lactamase
   (C) inhibit DNA synthesis
   (D) inhibit peptidoglycan formation
   (E) solubilize lipid

41. A firm, irregular prostatic nodule is discovered during annual physical examination of a 66-year-old patient. Biopsy reveals the presence of a moderately well-differentiated prostate carcinoma. Which of the following factors has the greatest prognostic impact for this patient?
   (A) degree of cellular atypia
   (B) histological grading
   (C) initial prostate-specific antigen level
   (D) pathological staging
   (E) presence of mitotic figures

42. Creatine phosphate is a critically important molecule for the storage of readily available energy in skeletal muscle. The synthesis of creatine phosphate requires the input of which of the following amino acids?
   (A) arginine
   (B) asparagine
   (C) aspartate
   (D) glutamate
   (E) glutamine

43. A nurse is infected with a virus that replicates in epithelial cells and infects B lymphocytes. Specific and nonspecific antibodies are produced against the virus that have diagnostic value. Which one of the following viruses is capable of causing such a response?
   (A) arenavirus
   (B) Epstein-Barr virus
   (C) poliovirus
   (D) rhabdovirus
   (E) rotavirus

44. A 10-year-old female patient is brought to the emergency room by her parents because of vague abdominal pain radiating to the back. The patient also has nausea and vomited during the trip to the hospital. Physical examination reveals a palpable lump in the abdomen and the attending physician orders a computerized tomography (CT) scan. The result shows in the patient a horseshoe-shaped kidney fused at the lower pole with the isthmus lying anterior to the aorta and inferior vena cava but posterior to the inferior mesenteric artery. During development, the parenchyma of the kidney containing the nephrons develops from which of the following:
   (A) metanephric diverticulum
   (B) metanephric mass of intermediate mesoderm
   (C) notochord
   (D) paramesonephric ducts
   (E) pronephroi

45. A patient who had a painful bee sting is now afraid of flies and birds. This would be an example of which of the following?
   (A) classical conditioning
   (B) flooding
   (C) operant conditioning
   (D) shaping
   (E) stimulus generalization
46. In emphysema there is a marked destruction of lung tissue. What would be the most likely consequence of this loss of tissue?

(A) airway resistance would decrease  
(B) functional residual capacity would decrease  
(C) lung compliance would increase  
(D) physiological dead space should decrease  
(E) residual volume would decrease

47. As a medical examiner, you are investigating a suspected suicide. The history suggests that the patient may have used an overdose of imipramine. You wish to confirm the presence of the drug in the victim. If a steady-state concentration of imipramine had been present in the systemic circulation and equilibration between the systemic circulation and tissue compartments had been achieved before death, which of these fluid compartments would have the largest total fluid: blood concentration ratio for the weak base imipramine (pKa = 9.5)?

(A) cerebrospinal fluid at pH 7.35  
(B) jejunum and ileum contents at pH 7.6  
(C) stomach contents at pH 2.0  
(D) synovial fluid at pH 7.3  
(E) urine in bladder at pH 6.0

48. A cervical lymph node biopsy from a 77-year-old man reveals metastatic nasopharyngeal carcinoma. Which of the following is most closely associated with development of this malignancy?

(A) alcohol consumption  
(B) allergic rhinitis  
(C) asbestos exposure  
(D) cigarette smoking  
(E) Epstein-Barr virus

49. Which of the following best defines a person’s “personality”?

(A) characteristic means of relating with reality  
(B) characteristic patterns of thought, behavior, and feelings  
(C) defensive armamentarium  
(D) ego  
(E) ego and superego combined

50. Maturity-onset diabetes in the young (MODY) is characterized by onset prior to age 25. All cases are the consequence of impaired beta-cell function due to specific gene defects. A defect in which of the following genes is known to result in MODY2?

(A) glucose-6 phosphatase  
(B) glucokinase  
(C) glycogen phosphorylase  
(D) hepatocyte nuclear factor-1-alpha (HNF-1α)  
(E) insulin promoter factor-1 (IPF-1)
Answers and Explanations

1. **(A)** Patients with multiple rib fractures or flail chest are likely to develop respiratory acidosis due to the pain and insufficient rib cage movements. In the acute phase, immediate tissue buffering elevates plasma bicarbonate only slightly, by about 1 mmol/L for each increase of 10 mm Hg in PCO\(_2\). Any increase in plasma bicarbonate beyond this expected value is due to renal compensation. Choice B is typical for a metabolic acidosis; the decrease in pH stimulates respiration and PCO\(_2\) is lowered. Typically, each 1 mmol/L decrement in plasma bicarbonate results in a decrease of PCO\(_2\) of about 1.2 mm Hg. Choice C represents a respiratory acidosis with renal compensation. Bicarbonate reabsorption in the kidneys is increased due to enhanced excretion of acid. Over a period of several days, plasma bicarbonate rises up to 3.5 mmol/L for each increase of 10 mm Hg in PCO\(_2\). Choice D is typical for a compensated respiratory alkalosis, with a 4–5 mmol/L fall in plasma bicarbonate for each decrease of 10 mm Hg in PCO\(_2\). Choice E represents an acute respiratory alkalosis. In acute hypocapnia, plasma bicarbonate falls approximately 2 mmol/L for each decrease in 10 mm Hg in PCO\(_2\).

2. **(B)** Cyclophosphamide is an oral prodrug effective in several types of cancer, including acute lymphocytic leukemia, non-Hodgkin lymphoma, neuroblastoma, and carcinoid. It is converted in the body to reactive molecules that alkylate DNA, primarily at guanine amino groups. Doxorubicin (choice A) is an antibiotic anticancer agent that intercalates with DNA strands and interferes with cell division. Methotrexate (choice C) is an antimetabolite that interferes with replication of all rapidly dividing cells, including neoplastic cells. Vinblastine (choice D) and etoposide (choice E) are both plant alkaloids with antitumor activity. They act by interfering with microtubule function, which is essential for cell division.

3. **(B)** Chronic myeloid leukemia is characterized as a pluripotent stem cell disease of the hematopoietic system that results from a consistent chromosomal translocation. This translocation is known as the Philadelphia chromosome and results from a translocation between chromosomes 9 and 22. The translocation occurs within the protooncogenic tyrosine kinase gene, c-abl on chromosome 9 and the bcr locus on chromosome 22 (t9:22). The ABL gene was first identified as the transforming protein of Abelson murine leukemia virus. Therefore, the term c-abl differentiates the cellular version from the viral version (v-abl). The bcr (breakpoint cluster region) locus is so named because it was a region on chromosome 22 identified in numerous chromosomal breakpoints. The result of the Philadelphia translocation is a fusion protein, bcr-abl, that has uncontrolled tyrosine kinase activity leading to the ability to transform cells. Burkitt lymphoma (choice A) results with high frequency due to a chromosomal translocation between chromosomes 8 and 14 (t8:14). The translocation occurs within the protooncogene MYC on chromosome 8 and the immunoglobulin heavy chain locus on chromosome 14. The result of the translocation is the placement of the strong immunoglobulin gene enhancer element near the MYC gene, leading to uncontrolled MYC expression. Fanconi anemia (choice C) is caused by chromosomal instability and frequent breakage leading to a predisposition to acute myelogenous leukemia. LFS (choice D) is a rare inherited form of cancer that involves breast and colon carcinomas, soft-tissue sarcomas, osteosarcomas, brain tumors, leukemia, and adrenocortical carcinomas. These tumors develop at an early age in LFS patients. The
tumor suppressor gene found responsible for LFS is p53. Mutant forms of p53 are found in approximately 50% of all tumors. The normal p53 protein functions as a transcription factor that can induce either cell cycle arrest or apoptosis (programmed cell death) in response to DNA damage. VHL syndrome (choice E) is an inherited form of renal carcinoma that is caused by mutations in a tumor-suppressor gene identified as the VHL gene.

4. (D) Melatonin is synthesized from tryptophan by way of serotonin. Choline (choice A) is a precursor in the synthesis of the neurotransmitter acetylcholine. Glucose (choice B) is the precursor for the synthesis of the neurotransmitter glutamate (choice C) which, in turn is the precursor for the synthesis of other neurotransmitters such as glycine and gamma aminobutyric acid (GABA). Tyrosine (choice E) is the precursor for the synthesis of the catecholamines (dopamine, norepinephrine, and epinephrine).

5. (C) All cancers may be associated with depression (choices A, B, D, and E). However, some neoplasms, particularly cancer of the tail of the pancreas, are particularly likely to cause, and often present with, clinical depression.

6. (F) Roughly 7–10 days following a large myocardial infarct, microscopic examination would be expected to reveal replacement of necrotic myocardium with ingrowth of granulation tissue, advancing from the periphery of the infarction. Neutrophils begin to appear in infarcted tissue toward the end of the first day, so one would expect to see extensive infiltration of neutrophils with prominent areas of eosinophilia (choice A) during the second and third day. Infiltration of macrophages (choice B) begins at approximately fourth day as they become active in phagocytosis of the dead muscle and continues into the second week. However, lymphocytes are not prominent participants in this process. Edema can be found in the infarction on the first day. Loss of myocardial cross-striations with nuclear pyknosis and few inflammatory cells (choice C) describes the changes seen at the end of the first day. Mixed inflammatory infiltrate of neutrophils and macrophages with extensive necrosis (choice D) would be seen at about three days. Pale, acellular area with abundant collagen and few fibroblasts (choice D) describes the appearance of a mature scar many weeks to months post-infarction.

7. (B) Heparin is a macromolecule that binds antithrombin III and Factor Xa. The complex of heparin and antithrombin III is approximately 1000-fold more efficient than antithrombin III alone. Hirudin (choice C) is the active anticoagulant derived from the saliva of the medicinal leech. It combines directly with and inhibits thrombin. It is now available as a recombinant protein drug. Alteplase (choice A) is a recombinant human tissue plasminogen activator. It has no direct effect on thrombin. Ticlopidine (choice D) is an antiplatelet drug that blocks ADP receptors on platelets. Warfarin (choice E) inhibits hepatic synthesis of clotting factors by inhibiting the reactivation of vitamin K epoxide.

8. (C) *G. lamblia*, an intestinal flagellate, is found in the duodenum and jejunum of humans and causes acute or chronic diarrhea if ingested in large numbers. Direct fecal contamination may occur in day care centers, institutions, or among male homosexuals. Pinworms (*E. vermicularis*) infect hundreds of millions of children, even in the United States, and can be readily transferred to others by infected hands. Both of these are routinely transmitted in day care settings. *D. fragilis* is an ameboflagellate in the same order as trichomonas. It is a parasite of many animals as well as humans. *N. americanus* is a hookworm, where human infection usually occurs by direct penetration by larvae of the host’s skin (choice A). *E. histolytica* cysts are usually ingested in contaminated water, while *I. belli* chronic infections occur most often in poorly nourished people living under unsanitary condition (choice B). *T. spiralis* (choice D) are obtained when infected host tissues are eaten. Cyst walls are digested and larvae migrate eventually to the muscle tissue of the new host. *T. saginata* (choice E) is acquired by ingesting undercooked infected beef. *B. coli* (choice E) is usually seen in tropical areas, but it is a rare infection.
9. (D) The photomicrograph (Figure 11-1) shows noncaseating granulomas. Given that similar lesions were found throughout her other organs, the most likely diagnosis is sarcoidosis. CREST syndrome (choice A) is a variant of progressive systemic sclerosis (choice C) in which there is calcinosis, Raynaud phenomenon, esophageal disease, sclerodactyly, and telangiectasia. Metastatic lung carcinoma (choice B) could have widespread involvement of the organs, but would demonstrate malignant cells, not granulomas. Progressive systemic sclerosis (choice C), also called scleroderma, is an uncommon connective tissue disorder in which there is vasculitis of small vessels and widespread collagen deposition. Tuberculosis (choice E) is an infectious granulomatous disease, but the granulomas usually have central caseous necrosis and do not usually involve all of the other organs as occurred in this case.

10. (D) Pompe disease, glycogen storage disease type II, is the result of defective acid alpha-glucosidase (acid maltase) activity. Deficiency in acid maltase leads to intralysosomal accumulation of glycogen of normal structure in numerous tissues. Accumulation is most marked in cardiac, hepatic, and skeletal muscle tissues of infants with the generalized form of the disorder. The skeletal muscle accumulation leads to hypotonia, and in the liver to hepatomegaly. The infantile form results in death due to cardiorespiratory failure usually before 2 years of age. Anderson disease (choice A), type IV glycogen storage disease (also called amylopectinosis), is the result of deficiencies in the glycogen branching enzyme. As a consequence of the enzyme defect, glycogen with an abnormal structure consisting of long outer chains with few branch points accumulates in the tissues. Hepatosplenomegaly and failure to thrive in the first few months of life are the common physical signs. This is followed by cirrhosis, ascites, and esophageal varices and death usually by 5 years of age. Forbes disease (choice B), type III glycogen storage disease, is caused by defects in the glycogen debranching enzyme. The defect leads to accumulation of glycogen with an abnormal structure consisting of very short outer chains reflecting a limit dextrin. Thus, the disease is also referred to as limit dextrinosis. Symptoms include hepatomegaly, short stature, hypoglycemia, cardiac, and skeletal myopathy. McArdle disease (choice C), type V glycogen storage disease, results from defects in muscle phosphorylase activity. Clinical findings of this disease usually do not appear until young adulthood and are characterized by exercise intolerance and muscle cramping. Many patients have burgundy-colored urine following exercise, due to myoglobinuria. Tarui disease (choice E), type VII glycogen storage disease, results from deficiencies in muscle phosphofructokinase. Clinical symptoms are similar to those seen in McArdle disease, that is, easy fatigue and exercise intolerance, cramping following exercise and myoglobinuria.

11. (B) The combination of a murmur (which may be variable and change with the course of the disease), tender nodules in the fingers (Osler nodes), evidence of bacteremia (fever; petechial hemorrhages of the skin), and embolism in the brain (right-sided weakness; confusion) and kidney (hematuria) makes infective endocarditis the most likely diagnosis. Acute rheumatic fever (choice A) presents with a high fever and may also display skin lesions (erythema marginatum; erythema nodosum), CNS involvement (chorea), and a murmur; however, these are distinctively different and cannot be confused with the findings in infective endocarditis. In addition, acute rheumatic fever is an immune phenomenon and would therefore not be associated with bacteremia; furthermore, as the vegetations do not embolize, there would be no evidence of embolic events. Rupture of an aortic aneurysm (choice C) is a catastrophic event with a mortality rate of over 50%. However, its presentation is related to the rate of blood loss and would not be characterized by the findings in the patient described above. Sepsis, secondary to bacterial myocarditis (choice D), would be an unusual circumstance. It would produce a fever and, depending upon the organism, could produce skin hemorrhages but, unless the sepsis led to an infective endocarditis, the other findings in this case would not be seen. Systemic polyarteritis nodosa
(choice E) is a vasculitis of medium-sized vessels in which acute necrotizing inflammation may lead to infarction or hemorrhage in multiple organs. Renal and visceral vessels are most commonly affected. Patients generally present with vague constitutional symptoms (weakness, malaise, myalgias), and while fever, hematuria, and a skin rash may all occur, bacteremia, a murmur, and embolic events are not typical findings.

12. (C) *Clostridium botulinum* is found in soil and strains produce eight types of toxins (A-G). The toxin is ingested and acts by blocking acetylcholine at synapses and neuromuscular junctions, causing flaccid paralysis and the described symptoms. None of the other choices (A, B, D, E) produce toxins that act specifically in this manner and by this mechanism.

13. (B) An audiogram is a graph that shows the softest sounds a person can hear at frequencies varying from low pitches (250 Hz) to high pitches (8000 Hz). In the left ear, the girl can hear frequencies between 250 and 3000 Hz at an intensity of 25 decibels (db) and better, while high-pitched sounds at 8000 Hz require a sound pressure level of 90 db to be heard by her. This indicates that the girl has a severe high-pitched hearing loss in the left ear since values up to 25 db are considered normal hearing, while values between 70 and 90 db indicate a severe hearing loss. Human vocalization is between 1000 and 4000 Hz, so that the girl can hear people speaking (eliminates choice A). Tinnitus (choice C) cannot be diagnosed by an audiogram. It is the perception of sound in the absence of external sounds. Tinnitus can have many different causes ranging from cochlear hair cell defects to genetic otologic disorders. Due to the principle of the frequency selectivity of the inner ear, called tonotopy, the perceived sounds can have particular frequencies. The girl does not have normal hearing in the right ear as stated in choice D, since her hearing threshold for all tested frequencies was between 80 and 95 db. The decibel scale is logarithmic. This means, for instance, that a 30 db louder sound is 1,000 times more powerful, or a sound at 120 db is reaching the threshold of pain. Presbycusis (choice E) is the hearing loss often occurring with increasing age, especially at high frequencies. Overall, without hearing aids, the girl will have trouble hearing the chirping of a bird or the ringing of a telephone. She will also have difficulties hearing and understanding speech from a distance or speech in a background of noise.

14. (C) Increase in the conductance of an ion, the equilibrium potential of which is negative with respect to the cell’s resting membrane potential, will cause the membrane potential to hyperpolarize (to become more negative). An inhibitory postsynaptic potential is a transient hyperpolarization of the membrane potential. Increased K⁺ permeability would cause hyperpolarization, an inhibitory postsynaptic potential. Increased Ca²⁺, Mg²⁺, or Na⁺ permeability would cause the cell membrane potential to depolarize (choices A, D, and E). Increased Cl⁻ permeability (choice B) would not alter membrane potential.

15. (C) This patient is suffering from primary hyperparathyroidism (HPT), in which signs and symptoms are due to the combination of elevated parathyroid hormone (PTH) and hypercalcemia. Approximately 80% of cases are due to a sporadic solitary adenoma, and most of the remaining cases are attributed to nodular or diffuse hyperplasia. A few percent occur in the form of hereditary primary HPT as a component of the various multiple endocrine neoplasia (MEN) syndromes. Elevation of PTH causes increased bone resorption, liberating both calcium and phosphate; however, PTH stimulates renal tubular reabsorption of calcium and inhibits reabsorption of phosphate, leading to hypercalcemia and hypophosphatemia. Alkaline phosphatase is present in a variety of tissues, but principally liver and bone—in the latter it serves as an indicator of osteoblastic activity. Hence, in conditions that lead to increased bone turnover, serum enzyme levels will be elevated. This explains the “high, low, high” correct answer for the respective assays (laboratory values assume normal kidney function, however, and would not apply to patients with renal disease). Roughly 50% of patients with primary
HPT are asymptomatic and the disease is brought to attention only upon discovery of an elevated serum calcium level in unrelated laboratory testing. The symptomatic 50% of patients present with varying degrees of the mnemonic tetrad, “stones, bones, groans, and moans.” Hypercalcemia leads to the formation of renal calculi (stones) and elevated levels of PTH cause bone lesions, the most characteristic of which is osteitis fibrosa cystica (OFC). In generalized OFC (also known as von Recklinghausen disease of bone), overstimulation of osteoclastic activity results in increased bone resorption (cortical > cancellous), ineffective osteoblastic repair, and replacement of affected areas and surrounding marrow spaces by fibrous tissue. Increased bone resorption leads to osteopenia, fibrosis of the intertrabecular zone, and cyst formation. The entire skeleton may be affected, although particularly vulnerable sites include vertebrae, long bones, mandible and hand bones. Bone loss predisposes to microfractures, which secondarily leads to hemorrhage, recruitment of multinucleated macrophages, and an ingrowth of reparative fibrous tissue. This reactive process creates a mass known as a “brown tumor,” a misnomer as the lesion is not a true neoplasm. The brown color results from hemorrhage and hemosiderin deposition; the “tumor” designation was most likely (mis) applied because the histological appearance of OFC (multinucleated giant cells, hemosiderin, reactive bone formation) may closely resemble that of a giant cell tumor of bone. OFC has become a rare occurrence with increased awareness and multiphasic screening of primary HPT. Both nephrolithiasis and bone lesions may cause considerable pain (groans). Other symptoms include neuromuscular changes (weakness, fatigue, muscle atrophy), CNS effects (depression, seizures [moans]), and GI disturbances (nausea, vomiting, peptic ulcer disease, constipation, pancreatitis). The alternative answers (choices A, B, D, E, and F) are not consistent with a diagnosis of primary HPT and individual laboratory value sets are not representative of any single disease.

16. (A) Trimethoprim blocks nucleic acid synthesis by inhibiting the enzyme dihydrofolate reductase, an enzyme necessary in the synthesis of deoxythymidine nucleotides and involving the interconversion of dihydrofolate to tetrahydrofolate. The mechanism of resistance to trimethoprim is acquisition of a plasmid that codes for the formation of trimethoprim-resistant dihydrofolate reductase. DNA gyrase (choice B) is involved in the sensitivity of bacteria to quinolones. Muraminidase (choice C) is responsible for the hydrolysis of peptidoglycan. Permease (choice D) is a cytoplasmic membrane protein that is involved in the transport of nutrients. Superoxide dismutase (choice E) converts toxic superoxide radicals and hydrogen ions to hydrogen peroxide.

17. (C) The manner of death refers to whether it is natural, an accident, a suicide, or a homicide. For a violent death, intent is considered. For example, a fatal gunshot wound could be accidental, a suicide, or a homicide. In this case, even though the bank guard survived for a few days and then succumbed to pneumonia, the act that initiated the sequence of events was homicide. Accident (choice A) indicates an accidental discharge of the gun; because this occurred during a robbery attempt, this is clearly not the case. Gunshot wound to the head (choice B) and pneumonia (choice E) are causes, not manners, of death. Natural death (choice D) refers to a nonviolent death that is usually the result of a disease process.

18. (D) When referring to de novo glucose synthesis via the gluconeogenesis pathway the term “net synthesis” means that the input of carbon atoms into glucose is greater than the loss of carbon atoms as CO₂. When fats are oxidized for energy production, the carbon skeletons are reduced to acetyl-CoA which enters the TCA cycle. The TCA cycle intermediate oxaloacetate can be drawn off for entry into the gluconeogenic pathway. However, when the carbon atoms are derived from fatty acids (choice A) and lipids (choice C) with equal numbers of carbon atoms, which are oxidized to acetyl-CoA (choice A), the net input of the two carbon atoms of acetyl-CoA into the TCA cycle are equaled by a net loss of two moles of CO₂. Therefore, there cannot be “net synthesis” of
glucose from the carbon atoms of these sources. The glycerol backbone of stored triacylglycerides can, however, provide net carbon input into glucose via gluconeogenesis. Malonyl-CoA (choice E), generated by carboxylation of acetyl-CoA, is an intermediate in de novo fatty acid synthesis and cannot be directed to gluconeogenesis.

19. (C). This young man is in acute respiratory acidosis. His inability to move air to his lungs makes him hypoxic (cyanosis) and hypercapnic (elevated $\text{Pa}_{\text{CO}_2}$). Because blood $\text{CO}_2$ is freely exchangeable with the $\text{H}_2\text{CO}_3/\text{HCO}_3^-$ buffer, elevations in $\text{CO}_2$ will cause elevations in $\text{HCO}_3^-$ and a reduction of pH. This pattern is reflected only in choice C and not in any of the other options (choice A, B, D, and E).

20. (D) The aqueous humor of the eye is produced by the epithelial lining of the ciliary processes. Its normal flow is from the posterior chamber to the anterior chamber to the trabecular meshwork to the canal of Schlemm to the aqueous veins and finally draining into the episcleral veins. Two forms of glaucoma can result from a defective drainage of the aqueous humor: an open-angle glaucoma results when the canal of Schlemm is obstructed and a close-angle glaucoma is due to the inability of the aqueous humor to reach the trabecular meshwork. Choices A, B, C, and E are all incorrect drainage flows of the aqueous humor.

21. (B) Flumazenil is a pharmacologic antagonist for benzodiazepines such as chlordiazepoxide and diazepam, but not other classes of sedative-hypnotics. Buspirone (choice A) is a nonsedating anxiolytic drug, but is not in the benzodiazepine class. Toxicity from overdosage is low and no antidote has been developed. Ethanol (choice C), another sedative-hypnotic drug, has no pharmacologic antagonists. It is sometimes used as an antidote in methanol and ethylene glycol intoxication because it is the favored substrate for aldehyde dehydrogenase and can prevent this enzyme from oxidizing the other alcohols to their more toxic metabolites. Fomepizole is a newer inhibitor of alcohol dehydrogenase. Overdosage with morphine (choice D), an opioid analgesic, is effectively reversed with naloxone. Phenobarbital (choice E), one of the prototype barbiturate sedative-hypnotics, has no direct antidote. Intoxication is treated symptomatically and by hemoperfusion.

22. (E) Partial thromboplastin time (PTT), prothrombin time (PT), bleeding time, thrombin time (TT) (not included in this example), and platelet count are key laboratory tests used to differentiate between bleeding disorders. PTT measures plasma clotting time after adding kaolin, cephalin, and calcium to patient plasma to assess the integrity of the intrinsic coagulation pathway (factors XII, XI, IX, VIII, X, V, prothrombin, and fibrinogen). PT measures plasma clotting time after the addition of tissue thromboplastin and calcium to patient plasma to assess the integrity of the extrinsic pathway (factors VII, V, X, prothrombin, and fibrinogen). TT measures plasma clotting time after thrombin is added to patient plasma to assess adequacy of fibrinogen levels as well as conversion of fibrinogen to fibrin. Bleeding time measures the time needed for a standard skin puncture to stop bleeding, and assesses platelet ability to form a hemostatic plug. von Willebrand disease results from deficiencies in both factor VIII and in von Willebrand factor (vWF), which combine to form a circulating complex. Synthesized by endothelial cells, vWF is important in the facilitation of platelet adhesion to subendothelial collagen; as a constituent in the factor VIII-vWF circulating complex, it serves to stabilize factor VIII and significantly increase its half-life; thus, a deficiency in vWF will cause a secondary decrease in factor VIII levels. von Willebrand disease demonstrates autosomal-dominant inheritance and is believed to be one of the most common inherited bleeding disorders. Patients show bleeding after minor trauma, with the most common sites including skin (easy bruising) and mucous membranes (epistaxis). Coagulation tests reveal a prolonged PTT, a normal PT, and a prolonged bleeding time; platelet count is normal. In disseminated intravascular coagulation (choice A), activation of the coagulation cascade results in widespread formation of thrombi in the microcirculation, causing the consumption of coagulation factors,
fibrinogen, and platelets. Hence, this would result in decreased PTT, PT, bleeding time, and a decreased platelet count as well. Hemophilia B (choice B), also known as Christmas disease, is a rare, X-linked recessive disease resulting from a deficiency of factor IX. The clinical picture of this disease is identical to hemophilia A (deficiency of factor VIII). As factor IX is involved in the intrinsic, but not extrinsic, coagulation pathway, PTT would be prolonged, but PT, bleeding time, and platelet counts would be normal. Primary fibrinolysis (choice C) may occur as a result of defects in the fibrinolytic system; these may include deficiencies in alpha-2 plasmin inhibitor or plasminogen activator inhibitors. Recall that plasminogen activators (e.g., tissue plasminogen activator, urokinase) will cleave plasminogen to plasmin, which will then interact with a hemostatic plug to initiate fibrinolysis by degrading fibrin; therefore, a deficiency of plasminogen or plasmin inhibitors to offset this process will lead to excessive fibrinolysis and bleeding. The term primary fibrinolysis refers to fibrinolytic defects that result separately from fibrinolysis associated with DIC, which is classified as secondary fibrinolysis. In primary fibrinolysis, both the PTT and PT are prolonged; bleeding time and platelet counts are normal. Vitamin K deficiency (choice D) will lead to a deficiency in the vitamin K-dependent coagulation factors, which include factors II (prothrombin), VII, IX, and X. Coagulation tests would thus reveal a prolonged PTT and PT, with a normal bleeding time.

23. (D) The pacinian corpuscle is located deep in the dermis and hypodermis. It is the receptor for deep pressure and responds to transient vibratory stimuli. The Meissner corpuscle (choice A) responds to touch and is located in the dermal papillae. The Merkel disk (choice B) found in the basal layer of the epidermis discriminates touch. The naked nerve ending (choice C) is activated by light pressure and touch stimuli. They are found in the epidermis. The Ruffini end-organ (choice E), located in the dermis, is sensitive to stretch.

24. (C) Mitral stenosis impedes the filling of the left ventricle, resulting in decreased end-diastolic filling volume. The actual preload on myocardial fibers is the stretch placed on them at the end of diastole just before the beginning of systole. This stretch determines the resting length of the fibers prior to contraction. For practical purposes, the end-diastolic volume is used as a convenient index of preload (the greater the end-diastolic volume, the greater the stretch). The pressure volume loop with the lowest end-diastolic volume, and therefore the lowest preload, is loop C. Choice A represents a negative inotropic effect (decreased sympathetic tone). Note that the stroke volume is reduced and the end-systolic volume (blood left in ventricle after systole) is increased. The other two curves (choices B and E) have stroke volumes greater than normal, but only one of these shows increased contractility. Which of the two has increased contractility that can be determined from the location of the end-systolic pressure-volume point? The end-systolic pressure-volume point for loop E is on the same line as for the normal individual (diagonal line in illustration). In contrast, loop B has an end-systolic pressure-volume point at a higher level (falls on an end-systolic pressure-volume line that begins at about the same intercept with the abscissa, but has a steeper slope than for normal contractility). Thus, loop B represents a pressure-volume loop for increased contractility. Loop E most closely resembles the pressure-volume loop one might expect if the venous return were increased, resulting in a larger filling volume of the ventricle.

25. (C) Bromocriptine is a D_{2}-receptor agonist that is useful in Parkinson’s disease and amenorrhea/galactorrhea syndrome. It is an ergot derivative. Amantadine (choice A) is an unusual drug with activity against the influenza virus and the ability to reduce the symptoms of Parkinson’s disease. The mechanism in Parkinson’s disease involves increased dopamine release from (or decreased reuptake into) neurons in the extrapyramidal system and possible action at NMDA receptors. Benztropine (choice B) is a muscarinic antagonist that enters the CNS readily and is useful in Parkinson’s disease. Ropinirole (choice D) is a newer, nonergot D_{2} agonist drug used in Parkinson’s disease.
Tolcapone (choice E) is a COMT inhibitor that increases the efficacy of levodopa by inhibiting its metabolism in the periphery, thus increasing brain levels.

26. (C) Figure 11-4 illustrates pancreas in which the islets of Langerhans are excessive in number and in size (macropolyendrosis). This infant was born to a mother whose diabetes was uncontrolled during her pregnancy. The excess glucose in the mother’s blood crosses the placenta into the fetus. The fetus responds by increasing the amount of islets in the pancreas and thus the amount of insulin that it can produce in an attempt to control blood glucose levels. These infants tend to be large at birth due to the anabolic effects of insulin but they are in fact usually premature. This is particularly apparent in the lack of adequate surfactant in the lungs, which leads to respiratory distress. These infants can also become profoundly hypoglycemic at birth when they no longer receive high levels of glucose from the mother. Acute necrotizing pancreatitis (choice A) would show necrotic fat cells and widespread necrosis of the pancreas. Cystic fibrosis (choice B) would show plugging of the ducts of the exocrine pancreas with atrophy and fibrosis in more severe cases. There is sparing of the endocrine pancreas. Multiple pancreatic islet tumors (choice D) are an extremely unlikely event. Zollinger-Ellison syndrome (choice E) is caused by a gastrinoma that in turn leads to peptic ulceration.

27. (B) The musculocutaneous nerve provides motor innervation for the biceps brachii, coracobrachialis, and brachialis muscle. Its terminal branch is the lateral cutaneous nerve of the forearm. Lesion of the musculocutaneous nerve results in weak flexion of the elbow since the biceps brachii and the brachialis will be paralyzed and this motion will only be performed by the brachioradialis muscle, which is innervated by the radial nerve. Weak supination is caused by the loss of innervation to the biceps brachii, a strong supinator of the forearm. This movement will now be performed only by the small supinator muscle. Anesthesia of the lateral surface of the forearm is due to loss of the lateral antebrachial cutaneous. Loss of the median nerve (choice A) and ulnar nerve (choice E) will result in loss of motor innervation to the flexors of the wrist and fingers. Lesion of the posterior interosseous nerve (choice C) will paralyze extensors of the wrist and fingers, whereas lesion of the radial nerve (choice D) will paralyze the extensor of the elbow as well as those of the wrist and fingers.

28. (E) In Figure 11-8 below, the patient’s temperature curve, given by the solid line, is overlaid by the hypothalamic set point, given by the dotted line. Endogenous and exogenous pyrogens, resulting from the presence of infecting pathogenic microorganisms, raise the hypothalamic set point and thereby cause a rise in body temperature (fever). If the factors originally responsible for the fever are successfully eliminated by the body’s immune system, the hypothalamic set point returns to normal, in the figure at point E. For a while, the body’s core temperature is above the now normal set point. This has the same effect as if the individual were too hot. The patient begins sweating and complains of “burning up” because of his hot skin (due to vasodilation). Whenever the body temperature matches his set point (choices A, D, G), the patient is comfortable. When the set point is first raised due to pyrogens (choice B), the body temperature is temporarily below the new, higher set point, just as if the body were too cool. The hypothalamus stimulates the usual responses to produce additional heat (shivering) and to conserve the heat.
present (skin vasoconstriction and lack of sweating). The patient subjectively feels chilled and seeks to raise his body temperature until he is more comfortable (piles on blankets, sits by the fire, or gets a heating pad). Once the patient’s temperature has risen to match the newer, higher set point (choice C), the patient is comfortable. Similarly, when the patient reaches his normal temperature at the end of the febrile episode (choice F), he once again feels comfortable since his body temperature matches his set point.

29. (E) The quartan fever that accompanies infection with P. malariae is secondary to cyclic release of proliferating merozoites from erythrocytes. The circulating ruptured red cell stroma and free hemoglobin are naturally-occurring pyrogens capable of invoking an abrupt febrile episode. Cell-mediated cytokines (choice A) are minimally active in Plasmodium infections. They do not engender sufficient pyrogenic activity to account for the severe cyclic fevers seen with P. malariae infections. Cerebral malaria is a grave prognostic finding. It does not cause cyclic central hypothalamic fever (choice B). Hepatocytes (choice C) serve as a nonlytic reservoir for P. malariae infection. Immune-mediated destruction of the organism (choice D) is a minor feature of malaria infection. It does not produce quartan fever.

30. (A) C. albicans is a fungus that often resides in the human pharynx and perineal area without causing clinical disease. Under certain conditions, especially immunosuppression, it can become invasive and cause local or even severe systemic disease. In severe septicemia, amphotericin B is the drug of choice for this (and many other) fungi. Clarithromycin (choice B) is a macrolide related to erythromycin that blocks protein synthesis in bacteria but not in fungi. It is effective against many gram-positive cocci, Chlamydia, and Mycobacterium avium complex. Flucytosine (choice C) is an antifungal prodrug that is converted in the fungus to 5-fluorouracil, which inhibits thymidylate synthase. It is not effective alone but is sometimes used as an adjunct to amphotericin in systemic C. albicans infections. Ketoconazole (choice D) is the prototype azole antifungal agent. It is often used topically in pharyngeal and vaginal candidiasis, but is too toxic for systemic use. Vancomycin (choice E) is a drug of choice for methicillin-resistant staphylococcal and other difficult gram-positive infections. It is not effective in fungal infections.

31. (B) In a population of 100,000, 5,000 will have the disease and 95,000 will be disease free (the prevalence of the disease equals 5%). The sensitivity is 95%, which indicates that in a population of people with the disease, 95% will have a positive test result (true positives) and 5% will have a negative test result (false negatives). The specificity equals 90%, which indicates that in a population of people without the disease, 90% will have a negative test result (true negatives) and 10% will have a positive test result (false positives). Thus, looking at the positive test results, there were 4,750 true positives (95% of the 5,000 people with the disease) and 9,500 false positives (10% of the 95,000 people without the disease). Therefore the chances of the test result being a true positive are (true positives)/(true positives + false positives) = (4,750)/(4,750 + 9,500) = 33%. Mathematically, 10% (choice A), 50% (choice C), 67% (choice D), 90% (choice E), and 95% (choice F) can be eliminated.

32. (E) The camptothecins were originally found in the bark of the Camptotheca acuminata tree and include irinotecan (Campto, Camptosar) and topotecan (Hycamtin). Camptothecins inhibit the action of topoisomerase I, an enzyme that induces single-strand breaks in DNA during replication. None of the other enzymes (choices A–D) are targets for the action of the camptothecin drugs.

33. (E) Thrombin is a plasma protease that converts fibrinogen to fibrin. Once formed, fibrin polymerizes with other fibrin monomers to form large, insoluble fibrin fibers. A clot consists of a meshwork of fibrin fibers. Tissue factor (choice D) is involved in coagulation but it participates in the initial step in the extrinsic pathway. Plasmin does degrade fibrin fibers (choice B) but this is part of clot lysis. Prothrombin (choices A and C) is a proenzyme
that is the precursor of the active enzyme thrombin. Prothrombin does not polymerize.

34. (D) Delta cells of the islet of Langerhans in the pancreas secrete somatostatin, a 14-amino acid peptide, which inhibits the release of insulin and glucagon. Delta cells also produce gastrin. Acinar cells (choice A) of the pancreas secrete digestive enzymes, which are released into the duodenum during digestion. Alpha cells (choice B) produce glucagon, whereas beta cells (choice C) release insulin. F cells (choice E) synthesize pancreatic polypeptide, a 36-amino acid peptide, which inhibits the release of somatostatin.

35. (B) Amiodarone is a broad-spectrum antiarrhythmic agent with unequaled efficacy and multiple toxicities. The molecular mechanisms for its antiarrhythmic actions are unclear but it blocks sodium, potassium (IKr), and calcium channels as well as beta adrenoreceptors. It is very heavily used in refractory arrhythmias of all types, but especially those associated with advanced heart failure. The most serious adverse effect of amiodarone is pulmonary fibrosis, but it also causes photodermatitis and thyroid dysfunction. The naturally occurring nucleoside adenosine (choice A) activates cardiac adenosine receptors that open a hyperpolarizing K⁺ channel. It is very short acting and is used almost exclusively in the treatment of acute AV-nodal reentrant arrhythmias. Digoxin (choice C) is a cardiac glycoside that has been traditionally used in atrial fibrillation, but has much lower efficacy than amiodarone. Its major benefit is control of ventricular rate, because it prolongs AV refractory period and reduces the number of atrial impulses transmitted into the ventricles. Lidocaine (choice D) is a group IB antiarrhythmic that is of no value in atrial arrhythmias, except those caused by digitalis overdose. It is most useful in the treatment of ventricular arrhythmias occurring immediately after myocardial infarction. Propafenone (choice E) is a group IC antiarrhythmic drug with some efficacy in both atrial and ventricular arrhythmias. Like other group IC agents, it is prone to causing new arrhythmias. It is not nearly as efficacious as amiodarone.

36. (D) Of the five immunoglobulin classes, only IgM has a pentameric configuration as displayed in Figure 11-6. IgM is the first immunoglobulin to appear in the serum upon initial exposure of an antigen to the immune system. Peak levels of IgM occur about 1 week after initial exposure to the sensitizing antigen. IgA (choice A) may be encountered as either a monomer or dimer, but not as a pentamer. IgE (choice B), IgD (choice C), and IgG (choice E) only exhibit a monomer configuration.

37. (A) Dry social kissing is considered to be safe. Unsafe sex and intravenous injection with a contaminated needle are the major causes of dissemination of HIV, and affected individuals should always prevent blood and semen from entering another person’s body. Therefore, choice E is incorrect. Safe sex with a condom, however, need not be prevented. Choice B is incorrect because HIV may cause an encephalopathy with prominent subcortical dementia. Choice C is incorrect because masturbation does not involve body fluids entering another person. Choice D is incorrect because affected individuals should not donate blood whether or not they are receiving treatment.

38. (A) As described by the sliding filament theory, active tension generated by a skeletal muscle fiber depends on the extent of overlap of thin and thick filaments. As the sarcomere is stretched from about 2.5 to 3.8 μm (the linear section of the curve, designated by the arrow) the extent of overlap decreases, and active tension falls. In this region of the curve, extent of filament overlap determines how much tension can be generated (choice A is correct). It is only when the sarcomere is shortened to less than about 2 μm that steric hindrance becomes an important factor in determining how much tension the fiber can generate (choice D). Tension remains constant as a function of sarcomere spacing over the flat portion of the curve, where tension is maximum (choice C). Skeletal muscle fibers normally operate on this maximal, flat part of the curve (choice B). The sarcomere has to be stretched to almost 4 μm before there is no longer overlap between thick and thin filaments (choice E). When there is no longer any overlap, no active tension can be generated.
39. (E) Methanol is a substrate for alcohol dehydrogenase and aldehyde dehydrogenase, yielding formic acid as the end product. Alcohol-addicted individuals who substitute methanol for ethanol consume large amounts, and the formic acid results in a significant anion gap acidosis. The end-product also damages the retina and can result in permanent blindness. Benzene (choice A) causes disorientation and disinhibition. Long-term toxicity includes bone marrow suppression. Carbon tetrachloride is associated with hepatic necrosis. Ethylene glycol (choice C) is another substrate for alcohol and aldehyde dehydrogenase and the product, oxalic acid, crystallizes in the renal tubule, resulting in acute renal shutdown. Isopropanol (choice D) is a less toxic alcohol but can cause CNS toxicity resembling that of ethanol.

40. (D) Penicillin’s initial step in inhibiting peptidoglycan cell wall synthesis is to bind the drug to cell receptors (PBPs). Some of the PBPs are enzymes involved in the transpeptidation reactions. After penicillin is attached to the receptors, peptidoglycan synthesis is inhibited as final transpeptidation is blocked. A final bactericidal event is the inactivation of an inhibitor of autolytic enzymes in the cell wall. Activation of the autolytic enzymes results in cell lysis. Penicillins do not actually break cell wall glycan bonds (choice A) once formed, nor can penicillin break down (hydrolyze) penicillasi (beta-lactamase, choice B). Penicillins do not inhibit DNA synthesis (choice C) nor solubilize lipids (choice E).

41. (D) Pathological staging of a tumor is important for the prognosis of almost all neoplasms, and in prostate carcinoma (CA), it has much greater prognostic impact than any other factor. Stage is determined by extent of tumor infiltration and metastasis. Although pathological staging criteria vary with different neoplasms, one attempt to standardize tumor staging is the TNM classification, which includes primary tumor size (T), lymph node involvement (N), and distant metastasis (M). Degree of cellular atypia (choice A) refers to the degree of differentiation of a tumor, and in concert with presence of mitotic figures (choice E), these two features comprise the histological grading criteria (choice B) of neoplasia. Although tumor grading is important, in general it has proved to be of less clinical significance than tumor staging. Most statistical data on cancer survival is related to tumor staging rather than tumor grading. Initial prostate-specific antigen (PSA) level (choice C) is not a reliable prognostic indicator for prostate CA as elevated PSA levels (>3.9 ng/mL) occur in up to half of patients with benign prostatic hyperplasia, and a significant number of patients with prostate CA have normal levels of PSA, regardless of clinical stage. PSA has, however, demonstrated value as a marker for monitoring prostate CA therapy (e.g., post-radical prostatectomy).

42. (A) Creatine and the energy reserve form phosphocreatine are present in skeletal muscle, brain, and blood. Creatine synthesis begins in the kidney from arginine and glycine. The products of the first reaction are ornithine and guanidoacetate. Guanidoacetate is transported to the liver, where it is converted to creatine by methylation from S-adenosylmethionine. Phosphorylation of creatine is carried out by creatine kinase (CK). CK plays an important role in the reversible transfer of phosphate from ATP to creatine when energy levels are high, and then from creatine to ADP when energy levels fall and demand for energy is high. Creatine can spontaneously cyclize to creatinine. Creatinine clearance by any given individual is amazingly constant from day to day and is proportional to muscle mass. None of the other amino acid choices (B, C, D, and E) are involved in creatine synthesis.

43. (B) Epstein-Barr virus is a B-cell-specific oncogenic organism that is responsible for Burkitt lymphoma that features a myc gene translocation. Arenaviruses (choice A) have sand-like particles (arena) on their surface and cause such diseases as the fatal hemorrhagic fever (Lassa fever) and lymphocytic choriomeningitis. Poliovirus (choice C) is associated with poliomyelitis. Rhabdoviruses (choice D), such as the rabies virus, can cause hallucinations, delirium, hydrophobia, coma, and death. Rotavirus (choice E) is the common cause of infantile diarrhea.
44. (B) The parenchyma of the kidney containing the nephrons (glomerulus, Bowman’s capsule, proximal convoluted tubule, loop of Henle, and distal tubule) develops from the metanephric mass of intermediate mesoderm. The metanephric diverticulum (choice A) gives rise to the ureter, renal pelvis, major and minor calyces, and collecting tubules. The notochord (choice C) is an embryonic structure, which participates in the formation of the central nervous system and not in the urinary system. The paramesonephric ducts (choice D) form the female uterine tubes and only participate in the formation of the female reproductive system. The pronephroi (choice E) are a transitory set of nonfunctional kidneys during the embryonic development.

45. (E) Stimulus generalization is a process through which a conditioned response is transferred from one stimulus to another stimulus that, in some sense, resembles the conditioned stimulus. In this case, the patient generalized the conditioned stimulus from bees to other flying objects—flies and birds. Classical conditioning (choice A), flooding (choice B), operant conditioning (choice C), and shaping (choice D) refer to other aspects of learning.

46. (C) In emphysema there is marked loss of elastic fibers, causing an increase in lung compliance. Physiological dead space is a function of all lung areas that do not contribute optimally to gas exchange. Elastic tissue helps to keep airways open. With a loss of elastic tissue, airways thus tend to collapse with a resultant increase in airway resistance (choice A). Because of increased lung compliance, functional residual capacity is increased (choice B). Loss of alveolar walls in emphysema causes the surface to volume ratio of the alveoli to decrease, thus impairing gas exchange. There is thus an increase in physiological dead space (choice D). Increased tendency of airways and alveoli to collapse also increases residual volume (choice E) since there is more air trapping in the lungs.

47. (C) Imipramine is a weak base with a pKa value of 9.5. The unprotonated form is uncharged and is the permeant species that crosses biological membranes. At equilibrium, the concentration of the permeant species is the same on both sides of the membrane, but the total amount (base + protonated form) present in each compartment depends on the pH of the compartment. For a weak base, the total amount is highest in the most acidic compartment. This is because lower pH values cause protonation of the base to the charged form and the charged base cannot cross the membrane. The lower the pH value for the compartment, the greater the total amount of drug present. Stomach contents at pH 2.0 have the lowest pH value. The value for the total amount at any pH may be calculated using the Henderson–Hasselbalch equation \[ \log \left( \frac{\text{protonated form}}{\text{unprotonated form}} \right) = \text{pK}_a - \text{pH} \].

48. (E) Epstein-Barr virus (EBV) has been implicated in the pathogenesis of nasopharyngeal carcinoma (NPC) and certain B-cell malignancies (Burkitt, Hodgkin lymphoma, lymphomas in immunocompromised patients). EBV DNA has been reported in virtually all cases of nasopharyngeal carcinoma cases worldwide. Although rare in the United States, NPC has a strikingly high incidence in southern China; certain areas in Africa and the Middle East also have a high incidence. Focal geographic distribution suggests a possibility that environmental or genetic cofactors, in addition to EBV, have a role in the pathogenesis of NPC. While alcohol consumption (choice A) and cigarette smoking (choice D) are both associated with several types of cancer, neither has an association with NPC. Asbestos exposure (choice C) increases the risk of mesothelioma. Allergic rhinitis (choice B) is a hypersensitivity type I immune reaction and is not associated with NPC.

49. (B) While all the other items (choices A, C, D, and E) are components of personality, patterns of thought, behavior, and feelings combined is the most comprehensive.

50. (B) Maturity onset type diabetes of the young (MODY) was previously considered to be a third form of Type II diabetes. However, with the discovery of specific mutations leading to MODY, it
is now classified under secondary or other specific types of diabetes. MODY is characterized by onset prior to age 25. All cases to date have shown impaired beta-cell function. Patients may also exhibit insulin resistance and late beta-cell failure. Evidence indicates that mutations in 10–12 different genes have been correlated with the development of MODY with 6 forms being well characterized as to the defective gene. MODY2 results from defects in pancreatic glucokinase. Von Gierke disease is caused by defects in glucose-6 phosphatase (choice A) Defects in glycogen phosphorylase (choice C) lead to hepatic (Hers) or muscle (McArdle) glycogen storage diseases. MODY3 is caused by defects in the transcription factor HNF-1-alpha (choice D). MODY4 is caused by defects in the homeodomain transcription factor insulin promoter factor-1 (choice E), more commonly called PDX1 derived from pancreas duodenum homeobox-1.
Practice Test 5
Questions

1. Which of the following drugs is the current drug of choice for treatment of trichinosis (Trichinella spiralis) infections?

   (A) dehydroemetine
   (B) diloxanide
   (C) mebendazole
   (D) metronidazole
   (E) praziquantel

2. A 35-year-old woman presents with a complaint of missing her last two menstrual cycles after having regular menstrual cycles for the last 5 years. She denies having headaches, double vision, or facial numbness. For the last 3 months, she is treating her gastroesophageal reflux disease by taking a prokinetic medicine, which acts by being a dopaminergic antagonist. Human chorionic gonadotropin is not detected in her blood. Serum TSH levels are normal. Which of the following is the most likely cause of her developing amenorrhea?

   (A) high prolactin levels
   (B) low prolactin levels
   (C) menopause
   (D) pregnancy
   (E) subclinical hypothyroidism

3. High plasma levels of the lipoprotein particle identified as lipoprotein(a) [Lp(a)] has been shown to be a primary risk factor for coronary heart disease and stroke. Lp(a) is a unique lipoprotein assembled from low-density lipoprotein (LDL) and a single glycoprotein called apolipoprotein(a) (apo[a]). Apo(a) is associated with LDL via a disulfide linkage to which other apolipoprotein?

   (A) Apo AI
   (B) Apo B_{48}
   (C) Apo B_{100}
   (D) Apo CII
   (E) Apo E

4. A 39-year-old woman undergoes a total hysterectomy and a section of her left fallopian tube is shown in Figure 12-1. What is the most likely diagnosis?

   (A) chronic salpingitis
   (B) ectopic tubal pregnancy
   (C) endometriosis
   (D) endosalpingiosis
   (E) serous papillary carcinoma
5. A 45-year-old woman is admitted to the ER with a chief complaint of substernal chest pain. An ECG shows marked cardiac ischemia. She has no prior history of cardiovascular disease but sees a physician regularly regarding severe migraine headache. Which of the following drugs has been used in migraine and has been associated with coronary vasospasm?

(A) acetaminophen  
(B) ergonovine  
(C) ibuprofen  
(D) propranolol  
(E) naproxen

6. A 33-year-old male patient returns from a 6-year tour of navy duty where he was stationed in Thailand. The patient presents with impairment of proprioception and vibratory sensation along with loss of deep tendon reflexes. When the patient walks or stands, he maintains a wide-base gait due to his sensory ataxia. When asked to stand feet together with his eyes closed, he displays Romberg’s sign (unsteady, swaying posture). He is diagnosed with tabes dorsalis due to tertiary neurosyphilis. What is the most likely location of this lesion?

(A) anterolateral system of the spinal cord  
(B) basal ganglia  
(C) cerebellum  
(D) dorsal columns of the spinal cord  
(E) ventral horns of the spinal cord

Questions 7 through 9

A 28-year-old woman is brought to the hospital because she had not come out of her room for 3 days, missing work. She would eat only when a tray was brought in.

7. Which of the following drugs might be used intravenously to reverse the mutism and immobility?

(A) amitriptyline  
(B) fluoxetine  
(C) lorazepam  
(D) risperidone  
(E) sertraline

8. Further history reveals that the patient had her first psychiatric hospitalization at age 20 when she made a suicide attempt. Otherwise, she is known to be a rather cheerful person. She is gainfully employed, but there are times when she has shopping sprees running up enormous credit card debt. There seems to be no history of substance abuse. Family history reveals that her maternal grandmother had died in a state hospital. Which of the following is the most likely diagnosis for this patient?

(A) bipolar disorder  
(B) delusional disorder  
(C) folie à deux  
(D) lewy body disease  
(E) schizophrenia

9. Given the most likely diagnosis above, which of the following would be the drug of choice?

(A) benztropine  
(B) chlordiazepoxide  
(C) fluoxetine  
(D) tranylcypromine  
(E) valproic acid

10. A 24-year-old man complains of a urethral discharge and painful urination. A gram-stain smear of the discharge shows many pus cells (neutrophils) but no bacteria. Of the following organisms, which is the one most likely to cause the discharge?

(A) Neisseria gonorrhoeae  
(B) Staphylococcus aureus  
(C) Streptococcus pyogenes  
(D) Treponema pallidum  
(E) Ureaplasma urealyticum

11. A 12-month-old female exhibits severe developmental delay with associated macrocephaly, dysmorphic facies, hypotonia, and hepatosplenomegaly. Clouding of the corneas is not evident. A pebbly ivory-colored lesion is
present over the infant’s back. The activity of iduronate sulfatase in the plasma is not detectable. These symptoms are indicative of which mucopolysaccharidosis?

12. In a skateboard accident, a young female patient has bitten severely into her tongue on the left side and bleeds profusely. A surgical resident tries to locate the lingual artery in order to clamp it, prior to surgical repair of the tongue. The normal location for this artery in the mouth is which of the following?

(A) between the buccinator muscle and the teeth
(B) between the lingual nerve and the submandibular duct
(C) lateral to the hyoglossus muscle, but medial to the lingual nerve
(D) lateral to the submandibular duct and the lingual nerve
(E) medial to the lingual nerve and the hyoglossus muscle

13. In the same patient, it is observed that the left opening of the submandibular duct atrophies over the next several days. The attending physician worries that the parasympathetic innervation has been injured. Of the following, which specific nerve carries the preganglionic parasympathetic innervation from the brain to the submandibular ganglion?

(A) chorda tympani
(B) hypoglossal nerve
(C) inferior alveolar nerve
(D) lingual nerve
(E) buccal nerve

14. An 87-year-old woman with vitamin C deficiency sustains a laceration on her left forearm. Her wound site is most likely to demonstrate which of the following?

(A) chronic infection
(B) excessive tissue necrosis
(C) keloid formation
(D) pallor due to ischemia
(E) poor wound healing

15. Which of the following is useful in the treatment of generalized anxiety disorder with the lowest incidence of sedation?

(A) alprazolam
(B) amitriptyline
(C) buspirone
(D) clozapine
(E) methylphenidate

16. A 68-year-old woman with a long history of alcoholism and chronic obstructive pulmonary disease presents to her primary care physician complaining of a recent fever, excessive and occasionally blood-streaked sputum production, a 10-lbs weight gain over the past 6 weeks, easy fatigability, bruising, and the formation of facial hair. Which of the following conditions would best explain this constellation of findings?

(A) chronic pancreatitis
(B) lung cancer
(C) new onset of diabetes mellitus
(D) pancreatic insulinoma
(E) Stein-Leventhal syndrome

17. A patient is diagnosed with problems in emptying the gallbladder. On a blood check-up, one hormone/peptide that is known to stimulate gallbladder contraction is inappropriately low. Which is the most likely one to cause the symptoms?

(A) cholecystokinin
(B) estrogen
(C) pancreatic polypeptide
(D) somatostatin
(E) vasoactive intestinal peptide
18. A 57-year-old man has abdominal surgery for the removal of a 3.2 × 4.4 cm retroperitoneal mass that was originally identified on CT scan. Microscopic examination of the lesion reveals poorly differentiated, highly pleomorphic cells arranged in a disorganized pattern. A few mitotic figures and tumor giant cells are noted and a moderate lymphocytic infiltrate is present. Immunohistochemistry is positive for S-100 protein and negative for vimentin. Based on these findings, this lesion is best classified as which of the following malignancies?

(A) adenocarcinoma
(B) B-cell lymphoma
(C) liposarcoma
(D) melanoma
(E) rhabdomyosarcoma
(F) T-cell lymphoma

19. Which of the following class of hypoglycemia-inducing drugs, used in the treatment of Type II diabetes, functions by activating the peroxisome proliferator-activated receptor-gamma (PPAR-gamma) proteins?

(A) biguanides
(B) meglitinides
(C) sulfonylureas
(D) thiazolidinediones

20. Which of the following correctly matches an antiepileptic agent with its primary toxicity?

(A) carbamazepine—trigeminal neuralgia
(B) ethosuximide—gingival hyperplasia
(C) lamotrigine—life-threatening dermatitis
(D) phenytoin—photosensitivity
(E) valproic acid—sedation

21. A 3-year-old girl who has not been immunized against the usual childhood viral diseases has fever, running nose, conjunctivitis, rash, a hacking cough, and red based, blue-white centered lesion in her mouth. Which of the following is most likely the virus responsible for this girl’s symptoms?

(A) adenovirus
(B) corona virus
(C) hantavirus

22. A 64-year-old man dies following a long history of multiple myeloma. H- and E-stained sections of tissues taken at autopsy reveal acellular, eosinophilic deposits around blood vessels and in many organs. Which of the following staining methods would be most useful in confirming a diagnosis in this case?

(A) Congo red
(B) methenamine silver
(C) mucicarmine
(D) periodic acid-Schiff
(E) Prussian blue

23. An elderly homeless woman is brought to the hospital with yellowish color of her skin. From her somewhat incoherent story, it can be determined that she has consumed substantial amounts of alcohol over the past 3 decades. The physician made the diagnosis of alcoholic liver cirrhosis, associated with extensive liver fibrosis. Which of the following changes in plasma and urinary levels of bilirubin are most likely?

<table>
<thead>
<tr>
<th>Unconjugated Bilirubin in Plasma</th>
<th>Conjugated Bilirubin in Plasma</th>
<th>Conjugated Bilirubin in Urine</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) decrease</td>
<td>decrease</td>
<td>decrease</td>
</tr>
<tr>
<td>(B) decrease</td>
<td>decrease</td>
<td>increase</td>
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<tr>
<td>(C) increase</td>
<td>decrease</td>
<td>increase</td>
</tr>
<tr>
<td>(D) increase</td>
<td>no change increase</td>
<td>increase</td>
</tr>
<tr>
<td>(E) no change or increase</td>
<td>increase</td>
<td>increase</td>
</tr>
</tbody>
</table>

24. An eruption of shingles over the cutaneous distribution of the ophthalmic nerve (herpes zoster ophthalmicus) is a common and often painful affliction. Your patient has involvement over the dorsum of the nose extending to the tip. Which of the following cutaneous branches of the ophthalmic nerve is involved?

(A) external nasal nerve
(B) lacrimal nerve
(C) supraorbital nerve
(D) supratrochlear nerve
(E) zygomaticotemporal nerve
25. A 35-year-old woman noticed a slowly growing mass in her left breast over the past 4 months. At surgery, the mass was found to be predominantly solid, tan-white, rubbery, well circumscribed, and measuring about $3 \times 3 \times 3$ cm. A representative photomicrograph of the lesion is displayed in Figure 12-2. Which of the following is the most likely diagnosis?

(A) fibroadenoma
(B) intraductal carcinoma
(C) medullary carcinoma
(D) paget disease of the breast
(E) scirrhouss carcinoma

![FIG. 12-2 (Also see color insert.)](image)

26. Which of the following drugs can be used to treat or prevent severe chemotherapy-induced emesis, motion sickness, dystonias, and hay fever?

(A) diphenhydramine
(B) diphenoxylate
(C) metoclopramide
(D) ondansetron
(E) scopolamine

27. Glucagon-mediated phosphorylation leads to a decrease in the activity of which of the following enzymes of lipid metabolism?

(A) acetyl-CoA carboxylase
(B) carnitine palmitoyltransferase I
(C) fatty acid synthase
(D) beta-ketothiolase
(E) medium-chain acyl-CoA dehydrogenase

28. A 61-year-old man with a history of left atrial fibrillation has a massive stroke and dies the following day. Autopsy findings include left atrial hypertrophy with a large mural thrombus, and mitral stenosis. The history and autopsy findings are most compatible with a diagnosis of which of the following?

(A) cardiac amyloidosis
(B) chronic interstitial lung disease
(C) dilated cardiomyopathy
(D) hypertrophic cardiomyopathy
(E) rheumatic heart disease

29. A well-nourished 21-year old woman presents with hypocalcemia. Her blood concentration of parathyroid hormone (PTH) is $150 \text{ pg/mL}$ (normal $10–65 \text{ pg/mL}$). Her blood concentration of $1,25$-dihydroxycholecalciferol is normal. Her BUN is normal. She is treated with a synthetic version of human PTH, and her blood calcium concentration normalizes. Which of the following is most likely causing her hypocalcemia?

(A) decrease in total number of PTH receptors in kidney
(B) deficiency of $1$-alpha-hydroxylase activity in kidney
(C) hepatocellular defect
(D) secretion of an inactive PTH hormone molecule
(E) severe vitamin D deficiency
30. Paramytonia congenita (PC) is a hereditary muscle disorder characterized by severe muscle stiffness that leads to weakness or even paralysis. Pathology is due to a missense mutation in the muscle voltage gated sodium channel which slows channel inactivation. Failure to repolarize causes prolonged muscle contraction (stiffness). This can eventually lead to muscle fatigue (weakness) and transitory paralysis. Which molecular change will occur during a bout of PC?

(A) decreased Ca\(^{2+}\)-ATPase activity in the muscle
(B) decreased Na\(^+\), K\(^+\)-ATPase activity in the muscle
(C) depletion of acetylcholine in the presynaptic terminal
(D) elevation of myoplasmic sodium concentration
(E) lowering of myoplasmic chloride concentration

31. Stool culture from a 19-year-old college student with diarrhea reveals a motile, microaerophilic gram-negative rod that is isolated by incubation at 41\(^\circ\)C on medium containing antibiotics. Which of the following is most likely the organism?

(A) Campylobacter jejuni
(B) Escherichia coli
(C) Proteus vulgaris
(D) Vibrio parahaemolyticus
(E) Yersinia enterocolitica

32. A 57-year-old male patient presents with progressive weakness of the upper and lower limbs. Atrophy of the muscles of the upper limb is observed. Neurologic examination reveals slight spasticity of the legs and generalized hyperreflexia. The patient displays Babinski sign in both lower extremities. All sensory modalities are intact and cerebellar tests are normal. A magnetic resonance (MR) scan confirms that the patient suffers from amyotrophic lateral sclerosis. Which of the following structures is most likely lesioned in this disorder?

(A) corticospinal tract
(B) dorsal column system
(C) spinocerebellar tracts
(D) spinoreticular pathway
(E) spinothalamic tracts

33. The drug metformin is an effective treatment for the hyperglycemia associated with diabetes. One of the major sites of action for metformin is the liver and its use is ideal for obese patients and for younger Type II diabetics with normal liver function. Given that the drug lowers circulating levels of glucose, which of the following hepatic enzymes is most likely activated as a consequence of metformin administration?

(A) AMP-activated protein kinase (AMPK)
(B) glycogen phosphorylase
(C) 6-phosphofructo-1-kinase (PFK-1)
(D) phosphoenolpyruvate carboxykinase (PEPCK)
(E) cAMP-dependent protein kinase (PKA)

34. A baby boy is delivered without complications at 31 weeks gestational age. However, soon after birth, he develops progressive respiratory distress, hypoxemia, and cyanosis, and requires artificial ventilation and oxygen. Which of the following prenatal laboratory tests could have best predicted these developments?

(A) alpha-fetoprotein levels in the mother’s blood
(B) chromosomal analysis of the fetal amniotic cells
(C) cytomegalovirus antibody levels in the mother’s blood
(D) lecithin:sphingomyelin ratio in the amniotic fluid
(E) toxicology screen of the mother’s urine

35. Which of the following antiretroviral drugs is most likely to cause pancreatitis?

(A) atazanavir
(B) didanosine
(C) efavirenz
(D) lamivudine
(E) tenofovir
36. A 54-year-old male smoker notices a slowly enlarging mass over the past 2 years within his right parotid gland. At the time of surgical excision, the mass measures 2.8 cm in diameter and is focally cystic. Microscopic examination reveals a tumor composed of benign papillary oncocytic epithelial fronds supported by benign lymphoid stroma. Which of the following is the most likely diagnosis?

(A) acute suppurative sialoadenitis  
(B) adenoid cystic carcinoma  
(C) mucoepidermoid carcinoma  
(D) pleomorphic adenoma  
(E) Warthin tumor (adenolymphoma)

37. Aspirin, which has antipyretic activity, has been widely used to lower body temperature in fever. In which of the following situations would aspirin most likely be employed?

(A) A 5-year-old boy becomes irritable. He complains of a sore throat and his body temperature is 105°F.  
(B) A 20-year-old college student has collapsed after a 10K run in mid-August. His skin is dry and his core body temperature is 104°F.  
(C) A 35-year-old woman is placed under general anesthesia for an elective surgical procedure. During the procedure she begins to exhibit muscle rigidity, her blood CO₂ levels dramatically increase, and her body temperature rapidly increases to 104°F.  
(D) A 60-year-old woman begins to experience flu-like symptoms. Her body temperature is 101°F.  
(E) An 80-year-old man is found unresponsive in his apartment. The apartment has no air conditioning and the daily ambient temperature has been over 95°F for the past week. The patient’s body temperature is 102°F.

38. Figure 12-3 shows equilibration of three different gases across the pulmonary capillary membrane. Pressures are shown in capillary blood, relative to the alveolar gas pressure. Alveolar pressures are equal to 10 mm Hg for gas A, 1 mm Hg for gas B, and 1 mm Hg for gas C. What is the pressure of gas A in arterial blood?

(A) 0 mm Hg.  
(B) 1 mm Hg.  
(C) 10 mm Hg.  
(D) 100 mm Hg.  
(E) It can’t be determined based on the available information.

39. A 9-year-old boy developed acute glomerulonephritis following a bacterial skin infection. This illness is most likely due to which of the following?

(A) antigenic mimicry  
(B) arthus reaction  
(C) delayed hypersensitivity  
(D) immediate hypersensitivity induced by penicillin  
(E) immune complexes
40. A 2-day-old boy delivered by normal labor (with no known prenatal risk factors) had become lethargic and required stimulation for feeding. When vomiting and hyperventilation ensued, routine laboratory results showed blood urea nitrogen (BUN) <1 mg/dL. The infant quickly lapsed into a coma and was placed on a ventilator. Bulging of the fontanel suggested an intracranial hemorrhage, but a CT scan revealed only cerebral edema. Within several hours, the infant died. Death was ascribed to sepsis; however, a postmortem analysis of the plasma samples taken at admission showed dramatically elevated serum ammonia and citrulline levels 100 times normal. Which of the following represents the enzyme deficiency associated with these severe neonatal symptoms?

(A) argininosuccinate synthetase (AS)
(B) carbamoylphosphate synthetase-I (CPS-I)
(C) 3-hydroxy-3-methylglutaryl-CoA (HMG-CoA) lyase
(D) medium-chain acyl-CoA dehydrogenase (MCAD)
(E) pyruvate carboxylase

41. A 1-day-old baby boy was diagnosed with Down syndrome. The chromosomal event that most likely led to his condition is which of the following?

(A) crossing over
(B) isochromosome formation
(C) mosaicism
(D) nondisjunction
(E) translocation

42. A drug with a half-life of 4 hours is administered by continuous IV infusion. How long will it take for the drug to reach 94% of its final steady-state level?

(A) 4 hours
(B) 8 hours
(C) 12 hours
(D) 16 hours
(E) 48 hours

43. A 34-year-old female patient suffers from an astroglia in the thalamus. The tumor is inoperable due to its location and grows very quickly. This mass-occupying lesion threatens to cause a caudal transtentorial herniation of the brain. Which part of the brain is immediately at risk in this type of herniation?

(A) basal ganglia
(B) brainstem
(C) cerebellum
(D) cingulate gyrus
(E) occipital lobes

44. *S. pyogenes* was isolated from a skin cellulitis lesion on a 12-year-old boy. Which one of the following bacterial components is most likely involved in the colonization of human epithelial cells?

(A) capsule
(B) cell wall
(C) cytoplasmic membrane
(D) flagella
(E) pili

45. Figure 12-4 shows the resting membrane potential ($V_M$) and the response of the membrane potential to addition, at the arrow, of either neurotransmitter A, B, C, or D. In the cell, resting $V_M = -80$ mV. The equilibrium potentials for relevant ions are as follows:

$E_{Ca} = +120$ mV, $E_{Na} = +40$ mV, $E_{Mg} = 0$ mV, $E_{Cl} = -80$ mV, and $E_K = -90$ mV. Which of the transmitters is inhibitory but does not alter the value of the membrane potential?

![FIG. 12-4](image-url)
46. A new drug is being studied for its cardiovascular effects. The graph in Figure 12-5 shows the blood pressure and heart rate effects recorded simultaneously in lightly anesthetized animals when the drug is given before (left) and after (right) an effective dose of prazosin. The new drug is most likely which of the following agents?

(A) amphetamine  
(B) epinephrine  
(C) isoproterenol  
(D) norepinephrine  
(E) phenylephrine

47. A 51-year-old man dies suddenly from a massive myocardial infarct. At autopsy, the lesion shown in Figure 12-6 is found in his stomach. This most likely represents which of the following?

(A) adenocarcinoma  
(B) adenomatous polyp  
(C) brunner gland adenoma  
(D) leiomyoma  
(E) peptic ulceration

48. Yesterday you explained to a patient that he had cancer of the prostate. Today, he asks you what his diagnosis is. Which of the following is likely to explain this phenomenon?

(A) dementia  
(B) denial  
(C) depression  
(D) malingering  
(E) repression

49. A contaminated meat dish infected 12 members of a church congregation gathered for a potluck meal. If food poisoning is assumed to be due to enterotoxin produced by Clostridium perfringens, final confirmation will rest upon which of the following?

(A) demonstration of spores in suspected food  
(B) enterotoxin production in food and neutralization by its antiserum  
(C) growth of gram-positive bacilli in thio-glycolate broth  
(D) the presence of antibodies against C. perfringens in the patient’s serum  
(E) the presence of many gram-positive rods in food
An 18-year-old male patient has suffered a severe laceration in the right forearm in a work-related accident in a machine shop. His right hand has no sensory function in the medial part of the palm and the medial one-and-half digits. When the patient attempts to flex the wrist joint, the hand is drawn to the lateral side. When you ask the patient to make a fist, the patient cannot flex his fourth or fifth digits at the distal interphalangeal joints. These signs are typical of a lesion of which of the following nerves?

(A) median

(B) palmar cutaneous branch of the ulnar

(C) radial

(D) superficial branch of the radial

(E) ulnar
1. (C) Mebendazole is useful in a variety of roundworm (nematode) infections including ascarsis, pinworm, whipworm, and trichinosis. It is not recommended for fluke infections but is an alternative drug for beef tapeworm. Dehydroemetine (choice A) is occasionally used in severe systemic amebiasis. It is very toxic and of no value in helminthic infections. Diloxanide (choice B) is the drug of choice for asymptomatic intestinal amebic infections but is not useful for helminthic infections. Metronidazole (choice D) is one of the most effective antiamebic agents for tissue infection. It is not used in helminthic infections. Praziquantel (choice E) is an effective anthelminthic drug for flukes (trematodes) and many tapeworms (cestodes). It is not useful in roundworm infections.

2. (A) Dopamine is the major prolactin-inhibiting factor that tonically suppresses prolactin secretion from the pituitary. Hence, a dopamine-blocking medication can lead to high prolactin levels. Besides stimulating milk production, prolactin also inhibits ovulation by inhibiting gonadotropin-releasing hormone (GnRH) so that hyperprolactinemia can lead to amenorrhea. Low prolactin levels (choice B) would support the possibility that the pituitary may have been invaded by a tumor that inhibits prolactin release and has also destroyed the gonadotropes. Such tumors increase pressures on the dura, the optic chiasm, and the cranial nerve III, causing headaches, visual defects, and facial numbness, all of which are absent in the patient. Menopause (choice C) is not the best answer due to the young age of the woman. Additionally, with the approach of menopause, menstrual cycles gradually become longer instead of being suddenly absent. Pregnancy (choice D) is excluded due to the absence of human chorionic gonadotropin (hCG). Blood hCG increases progressively after implantation and is detectable after 11 days in the virtually all pregnant women. Subclinical hypothyroidism (choice E) is diagnosed by elevated TSH levels, which are already elevated at an early stage when free thyroxine levels are still normal and symptoms are absent. TSH has a small FSH- and LH-like effect so that altered TSH levels can lead to disturbances of menstruation. The relationship between TSH, thyroid hormones, and sexual hormones is complex and excess or deficiency of TSH is known to cause either diminished or excessive menstrual blood flow.

3. (C) Apo(a) is a large glycoprotein with a striking degree of homology to the clotting factor plasminogen, in that apo(a) contains numerous kringle IV domains. There are more than 30 size alleles of apo(a) due to differing numbers of kringle IV domains, which in turn yield more than 500 potential different phenotypes of the protein. The apo(a) protein is disulfide bonded to apo B100 of LDLs, generating a lipoprotein particle identified as Lp(a). The size of apo(a) allows it to occupy the exterior surface of the resultant Lp(a) particle, exposing its kringle IV domains to the vasculature. The presence of the plasminogen-like kringle domains in apo(a) suggests that it interferes with the normal process of thrombosis at the endothelial cell surface by inducing a prothrombotic state, and evidence indicates that this does indeed occur. This leads to the deposition of fibrin clots and atherosclerotic plaque formation. Apo AI (choice A) is a major component of high-density lipoproteins (HDLs) necessary for the activation of lecithin-cholesterol acyltransferase (LCAT) and is not associated with apo(a). Apo B48 (choice B) is exclusively associated with chylomicrons and therefore is not found in association with apo(a). Apo CII (choice D) is required in chylomicrons, very low-density lipoproteins
(VLDLs), LDL, and intermediate-density lipoprotein (IDLs) for the activation of endothelial cell-associated lipoprotein lipase, but is not linked to apo(a). Apo E (choice E) is necessary for chylomicron remnant and LDL interaction with the hepatic LDL receptor and is not associated with apo(a).

4. (A) The photograph (Figure 12-1) displays a benign reactive plasmacytic and lymphocytic chronic inflammatory infiltrate. This inflammatory pattern is consistent with nonspecific chronic inflammation at various body sites. Chronic salpingitis is the only option listed that represents a chronic inflammatory disorder. Ectopic tubal pregnancy (choice B) would display chorionic villi and hemorrhage. The histology of endometriosis (choice C) features benign endometrial glands, benign endometrial stroma, usually accompanied by hemorrhage. Endosalpingiosis (choice D) is not a chronic inflammatory condition. Benign cervical glandular epithelium would be a necessary histologic attribute. The microanatomy of serous papillary carcinoma (choice E) is characterized by malignant glandular epithelium with micropapillary architecture. Chronic inflammation, if present, is a minor secondary phenomenon.

5. (B) The ergot derivatives are traditional agents for the treatment of migraine headache. In some patients these drugs may cause coronary artery constriction with signs of ischemia, which usually reverses before infarction occurs. Acetaminophen (choice A) and ibuprofen (choice C) are useful analgesics for mild to moderate migraine headache. Propranolol (choice D) is an effective migraine prophylactic drug in selected patients. Its mechanism is unknown. Effective prophylaxis is a major problem in many migraine patients and no single drug is useful in all patients. Naproxen (choice E) is an effective analgesic NSAID with a longer duration of action than ibuprofen.

6. (D) Loss of proprioception and vibratory sensation indicate a lesion of the dorsal columns (fasciculus gracilis and cuneatus) of the spinal cord. The loss of deep tendon reflexes is due to damage of the Ia afferent pathway and the patient displays Romberg’s sign because of the loss of proprioceptive input. The anterolateral system of the spinal cord (choice A) mediates pain and temperature sensations. The basal ganglia (choice B) and cerebellum (choice C) are motor centers of the CNS and do not mediate sensations. The ventral horns of the spinal cord (choice E) contain motoneurons and their lesion will result in paralysis.

7. (D) Lorazepam or amobarbital may be used intravenously to alleviate catatonia and reverse mutism temporarily. Choices A, B, and E are antidepressants that have no IV preparation and are not useful when the patient is mute and unresponsive. Antipsychotics such as risperidone (choice D) may be useful, but it does not have an IV preparation.

8. (A) Past history of serious depression, presence of manic/hypomaniac symptom (shopping sprees), gainful employment, age of onset, and presence of family history and absence of drug abuse indicates that bipolar disorder is the most likely diagnosis. Delusions (choices B and C) do not seem to be prominent, Lewy body dementia (choice D) occurs in later age, associated with parkinsonian symptoms, and gainful employment and periodic nature of her illness do not point to the diagnosis of schizophrenia (choice E).

9. (E) Valproic acid, a mood stabilizer, is indicated in bipolar illness. Choice A, an anticholinergic, is used for the extrapyramidal side effects of neuroleptics, choice B is a benzodiazepine antianxiety agent which may be useful but not the primary agent in bipolar illness, choices C and D are antidepressants that may be used in bipolar depression, but run the risk of a manic/hypomaniac episode without a mood stabilizer.

10. (E) *Mycoplasma* organisms are true bacteria that are extremely small (125–250 nm) and have no cell walls. They are the smallest free-living organisms and can grow on laboratory medium. Colonies on agar are embedded in the agar and are said to have “fried-egg” characteristics.
“T” (tiny) strains of mycoplasma have been reclassified into the *Ureaplasma* genus. *U. urealyticum* causes a small percentage of the non-gonococcal urethritis in men, but *Chlamydia trachomatis* causes the vast majority of those infections. If the urethral discharge was stained and examined for organisms, none would be visible in the light microscope due to the small size, although PMNs would be present, attempting to phagocytize the organisms. A laboratory report of “no organisms observed” would be, in reality, a false negative. *T. pallidum* (choice D) is a thin spirochete that does not gram stain well, but its size is average for bacteria. FA tests are usually used to observe these organisms. The remaining choices (A, B, C) are organisms that stain well in the gram-stain procedure and would be easily observable in the light microscope.

11. (A) Although multiorgan involvement, liver and spleen enlargement, and skeletal abnormalities are common to all the mucopolysaccharidotic (MPS) diseases, each encompasses specific and unique features. Each different MPS is caused by defects in different enzymes which allows for specific diagnosis. Hunter syndrome is characterized by progressive multiorgan failure and premature death. Hallmark features include enlargement of the spleen and liver, severe skeletal deformity, and coarse facial features (which are associated with the constellation of defects referred to as dystosis multiplex). Unlike Hurler syndrome, the symptoms of which are similar (but more severe), Hunter syndrome does not cause corneal opacities. Hunter syndrome results from a defect in iduronidate sulfatase activity and this activity can be measured in the plasma. Hurler syndrome (choice B) has features similar to Hunter, but with the added symptom of corneal clouding. Hurler syndrome results from a defect in alpha-L-iduronidase. Maroteaux-Lamy syndrome (choice C) encompasses symptoms similar to Hunter syndrome, but with normal mental development. Maroteaux-Lamy syndrome results from a defect in *N*-acyetylglactosamine-4-sulfatase (also called arylsulfatase B). Morquio syndrome (choice D) comprises two related disorders (Morquio A and B), both of which are characterized by short-trunk dwarfism, fine corneal deposits, and a skeletal dysplasia (spondyloepiphysseal) distinct from other MPS. Morquio B results from a defect in beta-galactosidase. Sanfilippo syndrome (choice E) comprises four recognized types (A, B, C, and D), all of which result from defects in the degradation of heparan sulfates. Sanfilippo syndromes are characterized by severe CNS degeneration with only mild involvement of other organ systems. Symptoms do not appear until 2–6 years of age. Sanfilippo A is the result of defects in alpha-N-acetyl-d-glucosaminidase.

12. (E) The lingual artery lies medial to the hyoglossus muscle. The latter serves as a useful anatomical landmark, separating the lingual nerve laterally from the lingual artery medially. All other choices (A through D) are incorrect.

13. (A) The chorda tympani carries the preganglionic parasympathetic innervation from the brain to the submandibular ganglion. It joins with the lingual nerve (choice D) in the infratemporal fossa to course to submandibular ganglion, but the lingual nerve itself does not contain parasympathetic nerve fibers for this structure. The hypoglossal nerve (choice B) innervates the voluntary muscles of the tongue. The inferior alveolar nerve (choice C) enters the mandibular foramen to supply all teeth and gums of the mandible. The buccal nerve (choice E) is sensory to the inside of the cheek.

14. (E) One of the most important functions of vitamin C is the hydroxylation of proline and lysine which are necessary steps in the synthesis of fully functional collagen. Since collagen is an essential element of the repair process, vitamin C-deficient individuals may display impaired wound healing. Vitamin C deficiency has no direct role in any of the other processes listed (choices A through D).

15. (C) Buspirone is an atypical anxiolytic drug with no hypnotic or anticonvulsant action and practically no sedative effect. Its mechanism of action does not involve the GABA system (unlike typical sedative-hypnotics). Its efficacy...
as an anxiolytic may involve partial agonist action at 5-HT_{1A} receptors. Alprazolam (choice A) is a benzodiazepine with modest but significant sedative actions. It is particularly useful in panic disorder. Amitriptyline (choice B) is a first-generation tricyclic antidepressant. It is not an anxiolytic. Clozapine (choice D) is an atypical antipsychotic agent that is notable for its lack of extrapyramidal toxicity and its selectivity for D₄ rather than D₂ dopamine receptors. Methylphenidate (choice E) is an amphetamine analog that is used in attention-deficit hyperkinetic disorder.

16. **(B)** These findings are best explained by the presence of a lung cancer-associated paraneoplastic syndrome. Paraneoplastic syndromes give rise to signs and symptoms in cancer patients that cannot be explained either by elaboration of hormones indigenous to the tumor cells or by metastatic disease. Several paraneoplastic syndromes have been recognized in association with many different forms of cancer. Lung carcinoma (CA) may produce a number of such syndromes; small-cell undifferentiated lung CA in particular has been associated with the production of adrenocorticotropic hormone (ACTH), as in this case, which results in Cushing syndrome, and with the production of antidiuretic hormone (ADH), leading to hyponatremia from increased ADH secretion. Other lung cancers associated with ectopic hormone production include parathormone production by squamous cell lung CA, resulting in hypercalcemia, and serotonin production by bronchial carcinoid (and rarely, squamous cell tumors), causing carcinoid syndrome. In this clinical case, general characteristics of lung CA include recent fever and blood-streaked sputum. The weight gain, easy fatigability, bruising, and formation of facial hair can all be explained by the increased secretion of cortisol secondary to ACTH production. Chronic pancreatitis (choice A) may be associated with fever and certainly may occur in conjunction with alcoholism; however, although it could possibly explain the easy fatigability and bruising if enough islet destruction had occurred to lead to the development of diabetes mellitus, it would not explain the weight gain or formation of facial hair, and additionally does not consider the reason for the blood-streaked sputum. Similarly, new onset of diabetes mellitus (choice C) would be incorrect for similar reasons. Pancreatic insulinoma (choice D) would result in symptoms stemming from attacks of hypoglycemia, such as confusion, weakness, or loss of consciousness, and would not account for any of the features mentioned here. Stein-Leventhal syndrome (choice E), which describes polycystic ovarian disease and associated oligomenorrhea, leads to an increase of androgens, and thus could account for the formation of facial hair, but would not explain the other clinical features.

17. **(A)** Although bile is made continuously, it does not enter the small intestine until the gallbladder contracts to release the stored bile. The principal stimulus for this is cholecystokinin, which is released into the blood when food enters the small intestine. Other hormones involved in stimulation of gallbladder contraction are gastrin, secretin, and motilin, but their physiological contribution is much smaller than that of cholecystokinin. Although estrogen receptors have been found in the gallbladder (choice B), no direct effects of these hormones on gallbladder contractility have been elucidated. Peptides that inhibit gallbladder motility include pancreatic polypeptide (PP, choice C), somatostatin (choice D), and vasoactive intestinal peptide (VIP, choice E). PP is produced by pancreatic islet cells as a negative feedback regulator for pancreatic enzymes and bicarbonate secretion. It also seems to have a physiological inhibitory influence on gallbladder function. Somatostatin acts as an endocrine and as a paracrine messenger. Its function is to inhibit the secretion of many other hormones. It further inhibits the motility and tone of many GI parts including the gallbladder. VIP was originally isolated from intestinal extracts and shown to be a potent vasodilator. It was then shown that VIP is widely distributed in the peripheral and central nervous system and is thus more considered to be a peptide transmitter of the enteric nervous system than a GI hormone. A huge number of biological effects have been attributed to VIP.
Concerning the gallbladder, it seems to induce smooth muscle relaxation.

18. (D) Immunohistochemistry is often utilized to assist with diagnosis of anaplastic neoplasms, which by definition lack the histological criteria necessary for determination of tissue type. Antibodies to various cellular components or cell-surface markers are employed in this process. S-100 protein is an acidic protein that serves as a useful tumor/tissue marker for identification of melanomas, neural tissue, and dendritic cells. A variety of cytokeratin tumor markers may be used to identify poorly differentiated epithelial-derived (carcinomas) malignancies (choice A). Vimentin is an intermediate filament that is common to almost all sarcomas (choices C, E), which are mesenchymal-derived malignancies. A multitude of different CD (cluster of differentiation) antigens are frequently employed to diagnose hematopoietic malignancies; tumor markers primarily associated with B-cell lymphomas (choice B) include CD 10, 19, 20, and 21; those primarily associated with T-cell lymphomas (choice F) include CD 2, 3, 4, and 8.

19. (D) The thiazolidinediones (TZDs), such as rosiglitazone (Avandia) and pioglitazone (Actos) have been proven useful in treating the hyperglycemia associated with insulin-resistance in both Type II diabetes and nondiabetic conditions. The TZDs function as agonists for the transcription factor, PPAR-gamma. PPAR-gamma is a member of a superfamily of transcription factors that also include the closely related members, PPAR-alpha and PPAR-delta. PPAR-gamma exists as a heterodimer with the nuclear retinoid X receptors, RXRs. The heterodimer binds to PPAR response elements (PPREs) in a number of target genes. Without ligand bound, the heterodimer is associated with a co-repressor complex that includes a histone deacetylase. Deacetylated histone keeps DNA in a transcriptionally repressed state. When ligand binds to PPAR-gamma the co-repressor complex dissociates and a coactivator complex containing histone acetylase associates resulting chromatin structural changes and transcriptional activation. The net effect of the TZDs is a potentiation of the actions of insulin in liver, adipose tissue and skeletal muscle, increased peripheral glucose disposal, and a decrease in glucose output by the liver. Genes shown to be affected by PPAR-gamma action include those encoding glucokinase, GLUT4, malic enzyme, lipoprotein lipase, fatty acyl-CoA synthase, and adipocyte fatty acid-binding protein. Given that PPAR-gamma is predominantly expressed in adipose tissue, the effects of PPAR-gamma agonists seen in the liver and skeletal muscle may be exerted via endocrine signaling from adipocytes. Recently it was shown that mutations in the PPAR-gamma gene were correlated to familial insulin resistance. The biguanides (choice A) are a class of drugs that function to lower serum glucose levels by enhancing insulin-mediated suppression of hepatic glucose production and enhancing insulin-stimulated glucose uptake by skeletal muscle. Metformin (Glucophage) is a member of this class and is currently the most widely prescribed insulin-sensitizing drug in current clinical use. The meglitinides (choice B) repaglinide (Prandin) and nateglinide (Starlix) are non-sulfonylurea insulin secretagogues that are both fast acting and of short duration. Sulfonylureas (choice C) function by binding to and inhibiting the pancreatic ATP-dependent potassium channel that is normally involved in glucose-mediated insulin secretion from the pancreas.

20. (C) Lamotrigine causes a variety of minor adverse effects, but its most serious toxicity is a potentially life-threatening dermatitis. Carbamazepine (choice A) is effective in the treatment of trigeminal neuralgia. Its major toxicities involve diplopia and ataxia in overdose. Ethosuximide (choice B) causes sedation as its primary toxicity. Vigabatrin causes visual field defects that may be irreversible. Phenytoin (choice D) causes diplopia, ataxia, and gingival hyperplasia. It has been associated with fetal abnormalities when taken by pregnant women. Valproic acid (choice E) rarely causes sedation. It is associated with a low but significant incidence of hepatic impairment. The cause is unknown, but the incidence is highest in patients less than 2 years of age and in those
taking multiple medications, fatalities have resulted.

21. (D) The infection caused by measles virus is characterized by hacking cough, fever, runny nose, conjunctivitis, rash, and the presence of the red based, blue-white centered oral lesions known as Koplik’s spots. Adenovirus (choice A), coronavirus (choice B), or orthomyxovirus (choice E) produces influenza-like infections without rash or Koplik’s spots. Hantavirus (choice C) is the etiological agent of the Korian hemorrhagic fever. This disease causes petechial hemorrhages, renal failure, fever, and shock, but it does not produce Koplik’s spots.

22. (A) The history of multiple myeloma and the finding of acellular, eosinophilic deposits in various tissues make the diagnosis of amyloidosis highly probable. Of the staining methods listed, Congo red is the only one that demonstrates amyloid. Methenamine silver (choice B) demonstrates basement membranes and many fungi. Mucicarmine (choice C) is, not surprisingly, used for mucin. Periodic acid-Schiff (choice D) is a technique used to elaborate carbohydrates such as glycogen. Prussian blue (choice E) demonstrates iron.

23. (E) Jaundice occurs from buildup of bilirubin metabolites, which are products of hemoglobin degradation. During degradation, first unconjugated bilirubin is generated, which is then taken up from the plasma by the liver. The liver conjugates bilirubin with glucuronic acid and releases it via bile into the GI tract. Excessive and long-term alcohol consumption damages hepatocytes and leads to increased total bilirubin, mostly conjugated, in plasma. Although the mechanism is not fully defined, the increase in conjugated plasma bilirubin might be due to release from damaged hepatocytes, reduced disposition within hepatocytes, and reduced secretion from hepatocytes. It is also possible that the liver damage resulted in obstruction of bile flow, which leads to a backup of largely conjugated bilirubin in the blood stream. Conjugated bilirubin is eventually removed by the kidneys and results in increased conjugated bilirubin in urine. Alcoholism might also lead to an increase in unconjugated plasma bilirubin, in the case that the ability of hepatocytes to remove unconjugated bilirubin from plasma is grossly impaired. As with all chronic diseases, alcoholism may present with a wide spectrum of symptoms. However, decreases in bilirubin (choices A, B, and C) are generally not due to a clinical defect, but instead due to a compromised measurement. For instance, high levels of lipids in blood can lead to low bilirubin values. Although hypertriglyceridaemia and fatty liver can be seen in alcoholics, it is rare in patients with cirrhosis (lowered capacity to produce blood lipids) and homeless patients (overindulgence is unlikely). An increase in unconjugated plasma bilirubin with no concomitant increase in conjugated bilirubin (choice D) points toward accelerated erythrocyte hemolysis or an inherited disorder, in which bilirubin cannot be conjugated. The latter, referred to as Gilbert syndrome, is typically diagnosed during childhood or adolescence.

24. (A) The external nasal nerve is the terminal cutaneous branch of the anterior ethmoidal nerve (from the nasociliary branch of the ophthalmic nerve). It emerges from the inner surface of the nasal bone to be distributed to the skin down the dorsum of the nose. The lacrimal nerve (choice B) is a branch of the ophthalmic nerve that supplies the lacrimal gland and then becomes cutaneous to supply the conjunctiva and skin of the upper eyelid. The supraorbital nerve (choice C) is a cutaneous branch of the frontal nerve (from the ophthalmic nerve) and is distributed to the skin of the forehead, scalp, and upper eyelid. The supratrochlear nerve (choice D) is a cutaneous branch of the frontal nerve (from the ophthalmic nerve) and is distributed to the skin of the lower medial forehead. The zygomaticotemporal nerve (choice E) is a cutaneous branch of the maxillary nerve.

25. (A) Figure 12-2 depicts a fibroadenoma, a common benign tumor of the female breast. The microscopic features of this tumor include compressed benign ducts, which are surrounded by nonatypical and normally cellular
connective tissue. Intraductal carcinoma (choice B) displays a proliferation of atypical epithelial cells within the ducts. Medullary carcinoma (choice C) displays syncytial groups of anaplastic epithelial cells with a peripheral lymphoplasmacytic inflammatory reaction. Paget disease (choice D) is an intraepidermal adenocarcinoma that presents clinically as an ulcerated or scaly lesion of the nipple. In most instances, a palpable mass is not present. Scirrhous carcinoma (choice E) is a common form of breast malignancy characterized by anaplastic epithelial cells in a fibrous reactive stroma.

26. (A) Diphenhydramine, an older H1-blocking antihistamine, has actions on multiple receptors, including H1 (but not H2) histamine receptors, alpha adrenoceptors, muscarinic receptors, and dopamine receptors. Its value in reducing emesis in the situations listed has been reported extensively, and it is a first-line agent for acute dystonias associated with antipsychotic drugs. It is one of the most sedating antihistamines and has been used as a night-time hypnotic in hospitals. It is the only drug in the list with the broad spectrum of effects described. Diphenoxylate (choice B) is an opioid with primarily gastrointestinal effects (it is the primary ingredient in Lomotil) but no analgesic or addicting effects. Metoclopramide (choice C) is a dopamine antagonist that has some efficacy in preventing chemotherapy-induced vomiting. Ondansetron (choice D) is a 5-HT3 antagonist that is very useful in chemotherapy-induced vomiting. Scopolamine (choice E) is effective in preventing motion sickness.

27. (A) ACC is the rate-limiting (committed) step in fatty acid synthesis. This enzyme is activated by citrate and inhibited by palmitoyl-CoA and other long-chain fatty acyl-CoAs. ACC activity also is affected by phosphorylation. The primary phosphorylation of ACC occurs through the action of AMPK. However, equally important are the glucagon-mediated increases in kinase activity. Glucagon-stimulated increases in PKA activity result in phosphorylation and inhibition of ACC. Additionally, glucagon activation of PKA leads to phosphorylation and activation of phosphoprotein phosphatase inhibitor-1, PPI-1, which results in a reduced ability to dephosphorylate ACC maintaining the enzyme in a less active state. The activities of CPT I (choice B), FAS (choice C), beta-ketothiolase (choice D), and MCAD (choice E) are not influenced by glucagon-mediated phosphorylation events.

28. (E) Nearly all cases of mitral stenosis are the result of chronic rheumatic heart disease. Because of resistance to passage of blood through the stenotic valve, there is a compensatory left atrial hypertrophy and dilation. The decreased and altered flow in this enlarged chamber increases the likelihood of mural thrombus formation (with subsequent thromboembolism) as does the atrial fibrillation. Cardiac amyloidosis (choice A) can produce a restrictive cardiomyopathy, but there is no involvement of the valves. Dilated cardiomyopathy (choice C) also has no involvement of the valves. Hypertrophic cardiomyopathy (choice D) can mimic aortic stenosis, but the mitral valve is not involved. Chronic interstitial lung disease (choice B) (as well as other causes of pulmonary hypertension) would be expected to lead to right ventricular hypertrophy, not left atrial hypertrophy.

29. (D) PTH promotes calcium reabsorption from distal tubules of the nephron. A high-PTH value is the body's normal response to a low level of calcium in the blood. The facts that the woman responds normally to synthetic human PTH, and that her BUN is normal, exclude kidney failure as a cause of her hypocalcemia and make the release of an inactive PTH the best choice. For the same reasons, a kidney defect resulting in a decrease in the total number of PTH receptors (choice A), is not a likely cause for her hypocalcemia. The ability of the kidney to transform 25-hydroxycholecalciferol into 1,25-dihydroxycholecalciferol by 1-alpha-hydroxylase (choice B) is not affected due to her normal blood serum levels of 1,25-dihydroxycholecalciferol. Severe vitamin D deficiency (choice E), including vitamin D3 (ergocalciferol) from diet and vitamin D3 (cholecalciferol) in skin, can lead to hypocalcemia. However, before becoming
active, vitamin D₂ and D₃ have to be converted to 1,25-dihydroxycholecalciferol, which was determined to be in the normal range in the patient. These transitions happen partly in the liver, which makes a hepatocellular defect unlikely (choice C).

30. (D) Delayed inactivation causes prolonged depolarization with a resultant increase in sodium influx and increased intracellular sodium concentration. Since the defect involves the muscle membrane sodium channel, transmitter content in the presynaptic terminal should be preserved (choice C). Prolonged depolarization would, if anything, increase intracellular chloride (choice E). Elevated intracellular [Na⁺] would stimulate the Na⁺, K⁺-ATPase (choice B), while high intracellular [Ca²⁺] (released from the SR due to the depolarization) would stimulate Ca²⁺-ATPase activity (choice A).

31. (A) C. jejuni is a common human pathogen, mainly causing enteritis. This organism is at least as common as salmonellae and shigellae as a cause of diarrhea. It is a gram-negative, comma-shaped motile rod. Culture requires a selective medium and reduced O₂ (microaerophilic) conditions. Primary incubation of suspected C. jejuni cultures should be done at 41–42°C. This higher temperature inhibits most of the other fecal bacteria, making isolation and identification of C. jejuni easier. Infection occurs by the oral route from contaminated food, drink, or animal products, with onset manifesting crampy abdominal pain, profuse diarrhea that may be grossly bloody, malaise, and fever. Shigellae enteritis is probably closest to that caused by Campylobacter organisms. While the other options (choices B, C, D, and E) may cause enteritis and diarrhea, these organisms are usually inhibited by the 41–42°C initial incubation procedure.

32. (A) Amyotrophic lateral sclerosis (Lou Gehrig disease) is characterized by lesion of the corticospinal tract as well as lower motoneurons in the ventral horns of the spinal cord, resulting in signs characteristic of upper and lower motoneuron lesions. The dorsal column system (choice B) mediates fine touch, proprioception, and vibration sense which are intact in this patient. The spinocerebellar tracts (choice C) transmit sensory information on movement and position to the cerebellum. The spinothalamic tracts (choice D) mediate sensations of deep and chronic pain and the spinoreticular pathway (choice E), sensations of crude touch, sharp pain, and temperature.

33. (A) The major sites of action of the diabetes drug, metformin, are the liver and skeletal muscle. In the liver, metformin exerts a secondary effect on hepatic glucose production. The primary cause of the decreased circulating levels of glucose in metformin-treated individuals is a consequence of an increased rate of skeletal muscle cell glucose usage. However, in both liver and muscle the primary regulator of the cellular responses to metformin is AMPK. AMPK is the central regulator of the cellular-signaling system designed to constantly measure the cellular energy charge. As a consequence of activation of AMPK, there is increased synthesis and transport of GLUT4 glucose transporters to the surface of skeletal muscle cells and an increase in the rate of glycolysis in both hepatocytes and skeletal muscle. Both of these events deplete the circulating level of glucose. None of the other enzymes (choices B–E) is affected as a direct consequence of metformin administration.

34. (D) The baby boy was born prematurely and had insufficient pulmonary surfactant to prevent the collapse of the alveoli during expiration. This led to the respiratory distress syndrome described in the history. Surfactant is made up of several polylipids, including lecithin and sphingomyelin. Its composition changes as the fetus matures; lecithin levels increase rapidly as the fetus approaches term. When the ratio of lecithin to sphingomyelin is above 2, this is an indication of sufficient lung activity for the baby to breathe normally without getting respiratory distress syndrome. Alpha-fetoprotein levels in the mother’s blood (choice A), if increased, may indicate a neural tube defect in the fetus. For unknown reasons, a decrease is associated with the trisomies.
Chromosomal analysis of fetal amniotic cells (choice B) could aid in the prenatal diagnosis of chromosomal abnormalities, but would not be useful in this case. Cytomegalovirus antibody levels in the mother’s blood (choice C) are not of value because there is no indication that the baby has been infected with this virus. Toxicology screening of the mother’s urine (choice E) would not be useful in the absence of any evidence for drug effects upon the infant.

35. **(B)** Didanosine is the antiretroviral agent most often associated with pancreatitis. Atazanavir (choice A) is more often associated with hepatitis and peripheral neuropathy. ECG changes have also been reported. Efavirenz (choice C) is more commonly associated with CNS effects, rash, and elevated liver enzymes. Lamivudine (choice D) causes nausea, vomiting, and fatigue. Tenofovir (choice E) causes asthenia, nausea and vomiting, and renal impairment.

36. **(E)** The clinical history, surgical findings, and described microscopic pattern all support the diagnosis of Warthin tumor, a benign neoplasm of the major salivary glands. Acute suppurative sialoadenitis (choice A) would have a more acute clinical history, pus may be observed at the time of surgery, and the histology would confirm an acute inflammatory process rather than neoplasm. Adenoid cystic carcinoma (choice B) and mucoepidermoid carcinoma (choice C) are both malignant neoplasms of the salivary gland. Neither displays the benign histology described for Warthin tumor. Pleomorphic adenoma (choice D) is also a common benign neoplasm of the salivary glands. However, it differs from Warthin tumor in several aspects. Pleomorphic adenoma is rarely cystic, usually lacks significant oncocytic epithelial elements, and the stroma is myxoid rather than lymphoid.

37. **(D)** When blood cells phagocytize bacteria or bacterial breakdown products interleukin-1 is generated, interleukin-1 elevates the body’s set point temperature by inducing production of prostaglandins in the hypothalamus. When the hypothalamic set point is elevated, the body activates heat generating mechanisms, elevating core body temperature until it matches the new set point. Aspirin exerts its antipyretic effects by inhibiting prostaglandin production, thereby blocking the rise in hypothalamic set point. Other mechanisms that do not involve an altered hypothalamic set point can also increase core body temperature. These include increased metabolic activity as well as elevated ambient temperature. Aspirin only effectively lowers a rise in core body temperature that is secondary to increased hypothalamic prostaglandin levels. Aspirin would reduce the fever described in scenario “A,” since this rise in temperature is due to a prostaglandin-induced increase in hypothalamic set point. However, aspirin would not be used here since the patient is 5 years old. Aspirin is contraindicated in this situation due to the possibility of inducing Reye syndrome. In scenario “B,” high ambient temperature, exercise, and fluid loss have combined to overwhelm the body’s ability to dissipate heat. Aspirin would not effectively lower core body temperature in this situation. Case “C” describes a case of malignant hyperthermia. In this syndrome, skeletal muscle calcium levels increase due to an anesthesia-triggered opening of calcium release channels in the sarcoplasmic reticulum. Excessive muscle contraction generates enormous heat which then elevates core body temperature. Again aspirin would have no effect. Finally, aspirin would not be effective in scenario “E” because the temperature increase is caused by very high ambient temperatures which have overwhelmed this patient’s thermoregulatory mechanisms.

38. **(C)** The graph shows that gas A is a perfusion-limited gas since it equilibrates between alveolar air and the blood. Since equilibrium is reached, pressures in alveolar air and blood must be equal, and the pressure of gas A in alveolar air is 10 mm Hg. Answer C excludes answers A, B, D, and E.

39. **(E)** Acute glomerulonephritis (AGN) is believed to be caused by the deposition of antigen-antibody complexes on the glomerular basement membrane. This disease may occur 1-2 weeks after improper antibiotic treatment of
pharyngitis or skin group-A streptococcal infection. AGN is associated with \textit{S. pyogenes} possessing M protein types 1, 2, 4, 12, 18, 25, 49, 59, 60 and 65. Type 49 is most frequently involved. AGN is not due to delayed (choice C), or immediate hypersensitivity (choice D), Arthus reaction (choice B), or antigenic mimicry (choice A).

40. (A) The clinical presentation of patients with defects in several enzymes of urea synthesis are virtually identical. These enzymes are CPS-I, ornithine transcarbamoylase (OTC), AS, and argininosuccinase. The hallmark of these urea cycle enzyme defects is a normal birth with no known prenatal risk factors. Within 24–72 hours after birth, the infant becomes lethargic and requires stimulation for feeding. Additional symptoms develop within hours, including vomiting, increased lethargy, hypothermia, and hyperventilation. The hyperventilation is often misdiagnosed as pulmonary disease. Sepsis is often suspected. Routine blood work indicates a reduced BUN. Lack of proper intervention will lead to coma and death. Correct analysis of hyperammonemia is paramount to proper treatment as this is indicative of a urea cycle defect, when presenting in the newborn. Analysis of plasma amino acids can aid in the differentiation of the defective enzyme. Elevated citrulline (to 100 times normal levels) results from a deficiency in AS. Several other inborn errors in metabolism are associated with neonatal hyperammonemia, such as CPS-I (choice B), MCAD deficiency (choice D), HMG-CoA lyase deficiency (choice C), and pyruvate carboxylase (choice E) deficiency. Careful clinical assessment accompanying appropriate laboratory studies (e.g., plasma pyruvate and lactate levels and urinalysis) can distinguish these disorders. In MCAD deficiency, fatty acid oxidation and gluconeogenesis are impaired, whereas they would not be in an infant with a urea cycle defect. HMG-CoA lyase deficiency is associated with an increase in 3-hydroxy-3-methylglutaric, 3-methylgluta-conic, and 3-hydroxyisovaleric acids in the urine.

41. (D) Down syndrome in 95% of cases is caused by a trisomy of chromosome 21. The most common cause of this is meiotic nondisjunction in which the pair of chromosomes 21 fails to separate during meiosis and go to one of the daughter cells and none goes to the other. Fertilization of these by a normal gamete results in a trisomy and a monosomy, respectively. Crossing over (choice A) is the reciprocal exchange of a block of genes between a pair of homologous chromosomes during meiosis. Isochromosome formation (choice B) occurs when one arm of the chromosome is lost and the remaining arm is duplicated. Mosaicism (choice C) refers to the situation in which an individual has two or more populations of genetically different cells. This more commonly occurs with the sex chromosomes. Translocation (choice E) refers to part of a chromosome being transferred to another. A well-known example is the Philadelphia chromosome (chronic myelogenous leukemia) in which there is a reciprocal translocation between chromosomes 9 and 22. Down syndrome can infrequently result from a translocation, but these cases only account for a few percent so it is not the most likely cause.

42. (D) During a constant dosing regimen (constant infusion), the kinetics for the approach to the steady-state concentration are controlled by drug clearance and can be predicted from the elimination half-life. The concentration traverses half of the remaining distance to the steady state in each half-life. In this case, after 4 hours (one half-life), the concentration is 50% of the steady-state level. After 8 hours (two half-lives), the concentration is 75% of steady state. After 12 hours (3 half-lives), the concentration is approximately 87% of the steady-state level, and after 4 half-lives (16 hours), approximately 94%.

43. (B) The tentorium cerebelli demarcates the supratentorial compartment from the infratentorial compartment in the skull. The anterior border of the tentorium cerebelli is named the incisura. The brainstem runs from the infratentorial compartment to the supratentorial compartment, anterior to the incisura. In this position, the brainstem is most vulnerable to caudal (downward) transtentorial herniation, which can distort its vital regulatory centers.
for consciousness, blood pressure regulation, and respiration. The basal ganglia (choice A), cingulate gyrus (choice D), and occipital lobes (choice E) are not immediately at risk since they are located superior to the level of the herniation. The cerebellum (choice C) would eventually be affected but after the damage to the brainstem has occurred.

44. (E) Pili are hair-like structures that play an important role in the colonization of human epithelial cells. Capsules (choice A) serve as virulence factors because they inhibit phagocytosis. The bacterial cell wall (choice B) maintains the shape of bacteria, interacts with the components of host defense, plays a role in cell division, and is used in serological identification. The bacterial cytoplasmic membrane (choice C) is involved in active transport of nutrients, energy production, secretion of toxins and enzymes, biosynthesis of peptidoglycan, lipopolysaccharide, capsule, and other bacterial macromolecules. Flagella (choice D) are organs of locomotion and their antigens are used for identification.

45. (C) An inhibitory transmitter can act by increasing the conductance of an ion the equilibrium potential of which is either equal to or more negative than the resting membrane potential. If the inhibitory transmitter does act on an ion the equilibrium potential of which equals the resting membrane potential (as in choice C) then the level of the resting potential does not change with transmitter application. The effect of the transmitter is inhibitory since the cell’s membrane potential is clamped more tightly at its resting level. If the inhibitory transmitter acts on an ion the equilibrium potential of which is more negative than the resting membrane potential then the membrane potential becomes more negative upon transmitter application (choice D). This change in membrane potential is inhibitory because the membrane potential is drawn away from the threshold of action potential generation. Both traces C and D show responses to excitatory transmitters.

46. (E) Note that the new drug’s effects on both blood pressure and heart rate are almost or completely eliminated by the alpha-blocking drug prazosin. Bradycardia is caused by activation of muscarinic receptors in the sinoatrial node, but none of the drugs given in the answer list has muscarinic effects. The bradycardia produced by the new drug before alpha blockade thus appears to be a reflex response to the increase in blood pressure. Blockade of the pressor effect would therefore eliminate the reflex bradycardia. Since phenylephrine has no significant beta adrenoceptor affinity, it has no direct effect on heart rate. Amphetamine (choice A) increases the amount of norepinephrine transmitter in noradrenergic synapses (including the heart) and would be expected to cause tachycardia in the presence of prazosin. Epinephrine, isoproterenol, and norepinephrine (choices B, C, and D) have significant direct beta-adrenoceptor affinity and would also cause tachycardia in the presence of prazosin.

47. (E) Figure 12-6 depicts a chronic peptic ulcer. There is a loss of mucosal continuity, an ulcer bed with necrotic tissue, and fibrosis of the submucosa. Peptic ulcers are associated with increased gastric acid secretion and Helicobacter pylori mucosal infestation. Hemorrhage, perforation, and penetration may complicate an ulcer. Adenocarcinoma (choice A) may form an ulcer. Within the ulcer, however, there would be diagnostic malignant glandular epithelium. Adenomatous polyps (choice B) are not associated with gross ulcer formation. Histologically, there are an increased number of benign glandular elements. Brunner gland adenoma (choice C) frequently presents as a duodenal mass. The microanatomy reveals hyperplasia of submucosal Brunner glands. A leiomyoma (choice D) is a benign smooth muscle tumor. The figure does not display a neoplasm.

48. (E) Repression is the psychological defense mechanism that relegates unpleasant memories into the unconscious. The mechanism of denial blocks perception and therefore unpleasant facts never become processed as memory. The patient had given consent yesterday, indicating that the reason for the biopsy was understood then. The other options (choices A–D) are obviously inappropriate.
49. (B) In bacterial food poisoning caused by *Clostridium perfringens*, final confirmation rests upon toxin production by *C. perfringens* and its neutralization by specific antiserum. Demonstration of the presence of spores (choice A) or large gram-positive rods (choice E) in the suspected food is not very helpful for the identification of *C. perfringens* because of confusion with other clostridia or because large bacilli in thioglycolate broth (choice C) will not allow classification of the various anaerobic large gram-positive rods. Demonstration of spores in food indicates that a spore-forming organism contaminates the food, but it does not prove that *C. perfringens* caused food poisoning. Demonstration of antibodies against *C. perfringens* (choice D) in the patient’s serum indicates exposure of the patient to *C. perfringens*, but does not prove that *C. perfringens* caused food poisoning.

50. (E) The signs displayed by this patient are characteristic of a lesion of the ulnar nerve in the forearm. Loss of sensory function in the medial part of the palm and the medial one-and-half digits indicate lesioning of the palmar cutaneous and the dorsal cutaneous branches of the ulnar nerve. The lateral drawing of the hand in flexion of the wrist shows that adduction of the hand is impaired, resulting from loss of ulnar innervation to the flexor carpi ulnaris muscle. Finally, the inability to flex the fourth and fifth digits at the interphalangeal joints suggests paralysis of the medial half of the flexor digitorum profundus muscle, which is normally innervated by the ulnar nerve. The median nerve (choice A) is not lesioned because it normally innervates the lateral part of the palm and the lateral three-and-a-half digits. The palmar cutaneous branch of the ulnar nerve (choice B) is not injured by itself because the extensive neurologic signs point to an injury of the ulnar nerve at a point more proximal than this branch. A lesion of the radial nerve (choice C) results in the inability to extend the hand (wrist drop); this patient displays impairments with flexion not extension. The superficial branch of the radial nerve (choice D) provides sensory innervation to the lateral side of the dorsum of the hand and the sensory loss in this patient does not correspond to this territory.
1. Over several years, an 11-year-old student developed multiple infections caused by organisms normally of low virulence (*Staphylococcus epidermidis, Aspergillus*) and was diagnosed as having chronic granulomatous disease (CGD). This immune deficiency is due to which of the following?
   (A) inability of neutrophils to kill bacteria
   (B) inability of phagosomes to fuse with lysosomes
   (C) inability of polymorphonuclear leukocytes to ingest bacteria
   (D) loss of complement components
   (E) reduced levels of immunoglobulins

2. An internist tells the psychiatric consultant that she is having difficulty with a patient. The patient is very upset about the “sloppiness” of the hospital personnel. He insists on having all medicine administered exactly at the scheduled minute, on the dot. He complains if his medicine is only 5 minutes late. Which of the following is the most likely trait of this patient?
   (A) antisocial personality
   (B) borderline personality
   (C) dependent personality
   (D) narcissistic personality
   (E) obsessive personality

3. A 30-year-old woman presents to her primary care physician complaining of a recent nodular growth on her left neck. Further history reveals a 16-lbs weight loss and intermittent fevers over the past 3–6 months. Physical examination reveals the presence of a firm, mobile, non-tender, 2.5-cm lower cervical lymph node in the woman’s left neck. A biopsy is performed and the pathology report indicates the presence of a few large cells with multilobate nuclei, abundant pale cytoplasm, and significant bands of sclerosis. Immunohistochemistry is positive for the presence of CD15 and CD30 cell markers. These findings are most consistent with which of the following neoplasms?
   (A) acute lymphoblastic lymphoma
   (B) Hodgkin lymphoma (HL)
   (C) lymphoplasmacytic lymphoma
   (D) mantle zone lymphoma
   (E) mycosis fungoides

4. Which of the following agents used in combination therapy for HL has pulmonary fibrosis as its most serious toxicity?
   (A) bleomycin
   (B) cisplatin
   (C) doxorubicin
   (D) mechlorethamine
   (E) vincristine
5. Figure 13-1 shows the resting membrane potential ($V_M$) and the response of the membrane potential to addition, at the arrow, of either neurotransmitter A, B, C, or D. In the cell, resting $V_M = -80$ mV. The equilibrium potentials for relevant ions are as follows: $E_{Ca} = +120$ mV, $E_{Na} = +40$ mV, $E_{Mg} = 0$ mV, $E_{Cl} = -80$ mV, and $E_{K} = -90$ mV. Which ion conductance could be increased by transmitter D?

(A) $Ca^{2+}$  
(B) $Cl^{-}$  
(C) $K^{+}$  
(D) $Mg^{2+}$  
(E) $Na^{+}$

6. Which of the following represents the enzyme of porphyrin biosynthesis the activity of which is negatively affected by hemin?

(A) delta-aminolevulinic acid dehydratase (ALA dehydratase)  
(B) delta-aminolevulinic acid synthase (ALA synthase)  
(C) porphobilinogen deaminase (PBG deaminase)  
(D) porphobilinogen synthase  
(E) protoporphyrinogen IX oxidase

7. Which of the following is a predictable adverse effect of treatment with haloperidol?

(A) diarrhea  
(B) excessive salivation  
(C) hyperprolactinemia  
(D) nausea and vomiting  
(E) Tourette syndrome

8. In Figure 13-2 the vertical axis depicts the renal filtered, reabsorbed, or excreted glucose in mg/min. Which point in Figure 13-2 depicts the excreted glucose in a 62-year-old fasting male with untreated Type II diabetes mellitus?

(A) A  
(B) B  
(C) C  
(D) D  
(E) E

9. An 18-year-old college freshman is transported to the emergency room by his roommate who states that he complained of fever, headache, and photophobia a few hours ago and has now started behaving erratically. A number of skin petechiae and purpura can now be seen scattered over his entire body. Despite immediate treatment, his condition declines rapidly and he becomes hypotensive, progresses into shock, and dies within 3 hours of admission. An autopsy is performed and among the findings are widespread purpura of the skin and hemorrhages involving all major organs with particularly severe involvement of both adrenal glands. Infection with which of the following agents is the most likely cause of this patient’s death?

(A) A  
(B) B  
(C) C  
(D) D  
(E) E
Questions 10 and 11

An adult male patient presents with multiple episodes of severe and spontaneous pain lasting several minutes. He describes the sensation as stabbing pain triggered by normal stimulation of the face including shaving and touch. Even the cold draft from the open driver’s window in his car can trigger excruciating pain. By magnetic resonance image (MRI), the patient is diagnosed with trigeminal neuralgia (tic douleureux) due to compression of the trigeminal nerve by a blood vessel in the posterior cranial fossa. Treatment with carbamazepine (800 mg/d) is instituted but the patient develops severe side-effects of vertigo and ataxia to the pharmacological therapy. A surgical treatment consisting of vascular decompression is successfully performed.

10. What is the location of the nerve cell bodies for the pain fibers from the face area?
   (A) mesencephalic trigeminal nucleus
   (B) motor trigeminal nucleus
   (C) principal sensory trigeminal nucleus
   (D) spinal (descending) trigeminal nucleus
   (E) trigeminal (gasserian) ganglion

11. A major vessel which can compress the trigeminal (fifth cranial) nerve, causing trigeminal neuralgia is the anterior inferior cerebellar artery. This artery is a branch from which of the following?
   (A) basilar artery
   (B) external carotid artery
   (C) internal carotid artery
   (D) posterior cerebral artery
   (E) vertebral artery

Questions 12 through 14

A 37-year-old woman came to the clinic for evaluation of a movement disorder.

12. If the patient is observed to have a resting tremor, determining her history relative to which of the following would be important for diagnosis?
   (A) alcoholism
   (B) exposure to influenza
   (C) family history of multiple sclerosis
   (D) treatment with an antipsychotic drug
   (E) treatment with an anxiolytic drug

13. In addition to the resting tremor, the patient shows slow, writhing movement of the extremities. Which of the following would be a useful test to perform?
   (A) ask the patient to close her eyes and smile
   (B) ask the patient to open her mouth, then protrude her tongue
   (C) ask the patient to tongue
   (D) Hoover test
   (E) Romberg’s test

14. If history reveals that the patient also has progressive dementia and visual hallucinations, which of the following would be the most likely diagnosis?
   (A) Alzheimer disease
   (B) Lewy body disease
   (C) multiple sclerosis
   (D) Sydenham chorea
   (E) tardive dyskinesia
15. Three of four family members presented with bloody diarrhea following a cookout at the local park where rare, grilled ground beef was served. Laboratory tests established that the etiological agent for this illness was due to a lactose-positive, straight bacillus that on the differential EMB (eosin-methylene-blue) medium formed large colonies with a unique metallic green sheen. Which one of the following organisms most likely was the cause of bloody diarrhea?

(A) *Campylobacter jejuni*  
(B) *E. coli* 0157/H7  
(C) *Entamoeba hystolytica*  
(D) *Salmonella typhi*  
(E) *Shigella dysenteriae*

16. A 12-year-old boy without diabetes exhibited extensive eruptive xanthomas, hepatosplenomegaly, and milky plasma. The milky plasma was due to a massive accumulation of chylomicrons and triglycerides. On switching to a fat-free diet, the lipemia and all other symptoms disappeared. A deficiency in which apolipoprotein (apo) would account for the observed symptoms of hyperlipoproteinemia?

(A) Apo AI  
(B) Apo B _100_  
(C) Apo CII  
(D) Apo D  
(E) Apo E

17. Which of the following immunosuppressive agents produces renal damage as its dose-limiting toxicity?

(A) azathioprine  
(B) cyclophosphamide  
(C) cyclosporine  
(D) mycophenolate mofetil  
(E) prednisone

18. A 78-year-old woman is concerned that she may have a certain life-threatening condition. To reassure her that she does not have this condition, you agree to order a laboratory test that will rule out the possibility. Ideally, which of the following properties related to this laboratory test would you most want to be 100%?

(A) accuracy  
(B) precision  
(C) predictive value positive  
(D) sensitivity  
(E) specificity

19. The primary site of hematopoiesis changes location during development. In the fetus, by the eighth month of intrauterine life, the primary site of hematopoiesis is in which of the following locations?

(A) bone marrow  
(B) liver  
(C) spleen  
(D) thymus  
(E) yolk sac

20. Which of the following drugs used in treatment of gouty arthritis interferes with the function of microtubules?

(A) allopurinol  
(B) colchicine  
(C) indomethacin  
(D) piroxicam  
(E) probenecid

21. A 25-year-old male prostitute was infected with a lentivirus and developed almost complete immune dysfunction. The virus responsible for this infection has which of the following characteristics?

(A) destroys CD4+ T lymphocytes  
(B) has a double-stranded genome  
(C) is a member of the adenovirus group  
(D) lacks a viral envelope  
(E) lacks reverse transcriptase

22. A 71-year-old man is diagnosed with osteogenic sarcoma of the femur. What preexistent condition would most likely account for development of this malignancy?
23. A 73-year-old female patient has suffered a unilateral vascular infarct in the territory of branches of the anterior spinal artery and medial branches of the vertebral artery. The patient presents with inferior alternating hemiplegia. Which of the following cranial nerves is involved in inferior alternating hemiplegia?

(A) eighth (vestibulocochlear)
(B) ninth (glossopharyngeal)
(C) tenth (vagus)
(D) eleventh (accessory)
(E) twelfth (hypoglossal)

24. A 55-year-old male has a long-term history of alcoholism with associated cirrhosis of the liver. His medications include a potassium-sparing diuretic, spironolactone, which helps control his severe ascites. Which letter in Figure 13-3 depicts the tubular location of epithelial cells that are inhibited by potassium-sparing diuretics such as spironolactone?

(A) A
(B) B
(C) C
(D) D
(E) E

25. A 28-year-old female airline steward is 3 weeks pregnant and consults her doctor about whether her fetus will be able to “breathe” while she is flying. To help put her pregnancy in context, her doctor discusses the difference between fetal and adult blood circulations. During fetal life, which vessels carry blood with the highest oxygen content?

(A) aorta
(B) pulmonary arteries
(C) pulmonary veins
(D) umbilical arteries
(E) umbilical vein

26. Hemoglobin is nonenzymatically glycosylated as glucose enters erythrocytes. Because erythrocytes routinely die and are replaced, the level of glycosylated hemoglobin is a good measure of the length of time glucose levels were elevated. Which of the following is the designation for the glycosylated form of hemoglobin?

(A) HbA\textsubscript{1c}
(B) HbA\textsubscript{2}
(C) HbC
(D) HbG
(E) HbS
27. A 49-year-old transplant recipient, who had been receiving immunosuppressive therapy for the past 11 months, presented in an acute confusional state accompanied by headache and hemiparesis. MRI studies demonstrated multiple ring-enhancing intracerebral lesions. The patient did not respond to therapy and subsequently died. At autopsy, multiple lesions were found in the cerebral cortex with many other organs also being involved. One of these was the heart, a section of which is shown in Figure 13-4. Based upon the information given, the most likely diagnosis is which of the following?

(A) candidiasis  
(B) coccidioidomycosis  
(C) cryptococcosis  
(D) pneumocystosis  
(E) toxoplasmosis

28. Initial gastrointestinal toxicity, including hematemesis, followed by slow but progressive pulmonary edema, alveolitis, and irreversible fibrosis is characteristic of intoxication by which one of the following?

(A) dichlorophenyltrichloroethane (DDT)  
(B) dioxin  
(C) paraquat  
(D) polychlorinated biphenyls (PCBs)  
(E) rotenone

29. Figure 13-5 shows a Lead II electrocardiogram from a normal 30-year-old female at rest. If an alpha-adrenergic agonist, such as phenylephrine is administered intravenously to this woman, what will be her resulting heart rate?

(A) 60 beats per minute  
(B) 75 beats per minute  
(C) 85 beats per minute  
(D) 95 beats per minute  
(E) 120 beats per minute

30. A 59-year-old woman is involved in a traffic accident and suffers a skull fracture. She is taken to the emergency room where radiographs reveal a fractured right temporal bone. You should be most concerned about this patient developing which of the following conditions?

(A) epidural hematoma  
(B) ruptured berry aneurysm  
(C) subarachnoid hemorrhage  
(D) subdural hematoma  
(E) temporal lobe contusion  
(F) ventricular hemorrhage

31. A 21-year-old student who has experienced watery rhinorrhea and itching of the nose and palate has been informed by his physician that he is suffering from allergic rhinitis. Which of the following statements concerning his allergy is correct?

(A) Administration of sodium cromolyn will increase the release of histamine.  
(B) His allergic antigen-antibody reactions do not neutralize the toxicity of the antigen.  
(C) His immunological responses are highly unspecific.
(D) His type of allergy does not lead to IgE production.
(E) The mast cells in his circulation do not possess any immunoglobulin on their surface.

32. The lectins are proteins that recognize and bind to specific types of carbohydrate structures displayed on other proteins and/or lipids. Perhaps the most important homeostatic function of the animal lectins is their roles in the regulation of immune responses and autoimmunity. Which of the following classes of lectins has a member that exhibits potent anti-inflammatory effects due to its ability to induce apoptosis in activated T cells?

(A) collectins
(B) ficolins
(C) galectins (S-type lectins)
(D) pentraxins
(E) siglecs (I-type lectins)

33. During a clinician-shadowing experience, a first-year medical student is coming in contact with a comatose patient for the first time. Which of the following is safe to assume that the patient will not do?

(A) constrict pupils in response to light
(B) move in response to a simple command
(C) move in response to pain
(D) move in response to sound
(E) move in response to touch

34. A 14-year-old boy has severe and worsening asthma that has been responsible for three hospitalizations in the last 18 months. He has been using an albuterol inhaler, two puffs four times daily. He is referred for consultation on modification of his therapy. Which of the following regimens is most likely to reduce the incidence and severity of his attacks?

(A) aminophylline twice daily and albuterol four times daily
(B) beclomethasone twice daily and albuterol for acute attacks
(C) cromolyn once daily and salmeterol for acute attacks

(D) prednisone once daily and montelukast for acute attacks
(E) terbutaline six times daily

35. A 41-year-old man who is employed in a nuclear power plant was accidentally exposed to 35 cGy 8 days ago. As you examine him now, what clinical symptoms do you expect to observe?

(A) acute radiation syndrome
(B) cerebral syndrome
(C) GI syndrome
(D) hematopoietic syndrome
(E) none

36. Muscles arising from the second pharyngeal arch mesoderm include which of the following?

(A) masseter
(B) mylohyoid
(C) stapedius
(D) stylopharyngeus
(E) superior pharyngeal constrictor

37. While on your medicine rotation, you review the following laboratory results on a 52-year-old male patient: serum calcium—increased; serum phosphorus—decreased; PTH—decreased. Which of the following conditions do you conclude would be most compatible with the results obtained for this patient?

(A) chronic renal disease
(B) multiple myeloma
(C) parathyroid adenoma
(D) parathyroid hyperplasia
(E) squamous cell carcinoma of the lung

38. A 67-year-old sailor presents with a respiratory tract infection caused by a virus that had a segmented genome composed of eight pieces of negative-sense, single-stranded RNA. Which one of the following viruses is the most likely etiological agent?

(A) adenovirus
(B) coronavirus
(C) influenza A virus
(D) respiratory syncytial virus
(E) rhinovirus
39. One way to diagnose chronic stress is to monitor cortisol levels in the bloodstream. Due to the fact that high levels of cortisol would worsen his/her already existing symptoms, it would be prudent to monitor cortisol levels in a patient with which of the following symptoms?

(A) chronic inflammation  
(B) low serum sodium  
(C) hyperpigmentation  
(D) low vasomotor tone  
(E) type II diabetes

40. A 43-year-old man has complained for some time about an intermittent pain in the left chest and left shoulder. The pain is more prominent when lying down compared to when sitting. Symptoms occur especially after eating. Examination reveals normal body temperature, a blood pressure of 140/80 mm Hg, a heart rate of 80 beats per minute. His breathing is normal, with a respiratory rate of 16 breaths per minute. His ECG shows no signs of a past heart attack. Serum creatine kinase levels and white blood cell values are normal. The man's tongue shows a white coating. On questioning, he describes symptoms consistent with gastritis. Which of the following is the most likely initial diagnosis?

(A) functional heart disease  
(B) lung embolism  
(C) pericarditis  
(D) recurring myocardial infarction  
(E) reflux esophagitis

41. A 49-year-old woman had a total hysterectomy 5 years ago for uterine prolapse. Her current vaginal Pap smear demonstrates clusters of benign glandular cells suggestive of vaginal adenosis. Researching this patient's past history would likely reveal an in utero exposure to which of the following?

(A) aspirin  
(B) diethylstilbestrol  
(C) methotrexate  
(D) radiation  
(E) rubella virus

42. Which of the following drugs blocks the heart rate response to isoproterenol but does not block the heart rate response to norepinephrine in intact subjects?

(A) atropine  
(B) guanethidine  
(C) hexamethonium  
(D) phentolamine  
(E) propranolol

43. A 17-year-old boy with chills, dry cough, high fever with muscle aches, and malaise was diagnosed with probable influenza and has a hemagglutination inhibition (HI) titer of 1:400. Which one of the following statements is correct?

(A) A 400-fold dilution of his serum will have no effect in a hemagglutination inhibition assay.  
(B) A 400-fold dilution of his serum will prevent agglutination of red blood cells.  
(C) Each red blood cell can bind 400 viral particles.  
(D) There are 400 hemagglutinins on each red blood cell.  
(E) There are 400 viral particles per milliliter of serum.

44. A 5-month-old infant who has been experiencing lethargy, recurrent vomiting, respiratory distress, and muscular hypotonia is brought to the emergency room near comatose. Laboratory results indicate severe metabolic ketoacidosis associated with an extreme accumulation of methylmalonic acid in the blood and urine. Negative findings for pernicious anemia or other hematologic or neurologic symptoms of cobalamin deficiency indicate that the infant is suffering a defect in which of the following enzymes?

(A) malonyl-CoA decarboxylase  
(B) methionine synthase  
(C) methylmalonyl-CoA mutase  
(D) methylmalonyl-CoA racemase  
(E) propionyl-CoA carboxylase

45. When exercising in a warm as opposed to a cool environment, additional demands are
placed on the circulatory system to adequately perfuse working muscle. Which of the following contributes to the decrease in blood volume seen in exercise?

(A) a shift in water from the interstitial to the intravascular space
(B) a redistribution of blood volume to the skin circulation
(C) a redistribution of blood volume to the splanchnic circulation
(D) a redistribution of blood volume to the cerebral circulation
(E) an increase in the fraction of cardiac output that goes to the pulmonary circulation rather than to the systemic circulation

46. A 20-year-old female college student presents to the emergency room with a fever, nasal discharge with purulence, anosmia, and complains of facial pressure and pain, especially over the frontal bone and bridge of the nose. She reports that her symptoms have worsened over a week and is diagnosed with acute frontal sinusitis. The pain in the frontal sinus is mediated by which of the following nerves?

(A) anterior superior alveolar nerves
(B) middle superior alveolar nerves
(C) posterior ethmoidal nerves
(D) posterior superior alveolar nerves
(E) supraorbital nerves

47. A 25-year-old man has a painless, non-transilluminating mass in his left testis surgically removed. A representative section of the specimen is shown in Figure 13-6. Which of the following is the most likely diagnosis?

(A) choriocarcinoma
(B) embryonal carcinoma
(C) seminoma
(D) teratoma
(E) yolk sac carcinoma

48. Which toxicity do amiodarone and bleomycin have in common?

(A) lupus erythematosus syndrome
(B) mucositis
(C) ototoxicity
(D) pulmonary fibrosis
(E) torsade de pointes arrhythmia

49. An autopsy heart from a 4-year-old boy with a premortem history of cyanotic congenital heart disease displays right ventricular hyperplasia, pulmonary stenosis, ventricular septal defect, and dextroposition of the aorta. What term best defines this disorder?

(A) anomalous pulmonary venous drainage
(B) dextrocardia
(C) ebstein malformation
(D) transposition of the great arteries
(E) Tetralogy of Fallot

50. A 10-year-old girl exhibits the following symptoms: marked hepatomegaly, variceal bleeding, chronic bilateral pulmonary infiltrates, chronic liver disease, hepatic encephalopathy, and only 5% of normal sphingomyelinase activity in peripheral blood leukocytes. What is the most likely diagnosis?

(A) Fabry disease
(B) Gaucher disease
(C) Krabbe disease
(D) Niemann-Pick disease type IB
(E) Tay-Sachs disease

FIG. 13-6 (Also see color insert.)
1. (A) CGD is due to a deficiency in neutrophil NADPH oxidase that leads to an inability of neutrophils to destroy bacteria. Defective phagocytosis results from a leukocyte adhesion deficiency (choice C). Individuals with CGD have normal levels of serum immunoglobulins (choice E), and they do not have defects in the fusion of phagosomes with lysosomes (choice B), or in complement components (choice D).

2. (E) The patient is an exacting, orderly, controlling person who is very conscious of punctuality. The other personalities (choices A, B, C, and D) do not explain his preoccupation with exactness.

3. (B) These morphological findings are consistent with the diagnosis of nodular sclerosing HL, the most commonly occurring HL subtype (65–75%). The other HL subtypes include mixed cellularity (20–40%), lymphocyte predominant (<10%), and lymphocyte depleted (<10%). These four subtypes have prognostic, therapeutic, and epidemiologic differences. The distinguishing cell in HL is the Reed-Sternberg (RS) cell, a large cell that contains bilobed or multilobed nuclei with prominent nucleoli, and abundant cytoplasm. In the nodular sclerosis subtype of HL, RS cell variants often have multilobate nuclei and abundant pale cytoplasm (known as lacunar cells). This subtype also features broad bands of collagen that separate lymphoid tissue into circumscribed nodules. Immunophenotype of RS cells is positive for CD15 and CD30 in all but lymphocyte-predominant HL. Hodgkin disease is one of the most common forms of malignancy in young adults (ages 15–35), and has a bimodal age incidence, with another peak occurring in old age. Acute lymphoblastic lymphoma (usually pre-T-cell type) (choice A) typically manifests in childhood, and morphologically demonstrates normal tissue architecture with rather homogeneous lymphoblasts containing scant cytoplasm and numerous mitoses. Lymphoplasmacytic lymphoma, or Waldenström macroglobulinemia (choice C), typically infiltrates bone marrow, but may also be present in lymph nodes, spleen, or liver. This is a B-cell neoplasm in which a substantial fraction of cells undergo terminal differentiation into plasma cells. In lymph nodes, an interfollicular plasma cell infiltrate may be seen. Neoplastic clones usually produce high levels of monoclonal IgM that produce a spike on serum electrophoresis; presentation is almost exclusively in the elderly. Mantle zone lymphomas (choice D) are B-cell neoplasms that may demonstrate either a loosely nodular pattern in which tumor cells surround non-neoplastic germinal centers, or a diffuse pattern. In either case, proliferation consists of a homogeneous population of small-to-intermediate sized lymphoid cells with irregular, occasionally cleaved nuclei, and scant cytoplasm; typical presentation is around 60 years of age. Although mycosis fungoides (choice E) may progress to additionally include lymph nodes, spleen, and blood, it is typically a cutaneous T-cell lymphoid neoplasm that is confined to the epidermis and dermis. Morphologically, it is characterized by larger than normal lymphocytes with compact chromatin and markedly infolded nuclear membranes, imparting a cerebriform appearance to the nuclei; this disease typically affects people over the age of 40.

4. (A) Bleomycin is an antibiotic chemotherapeutic agent that produces single- and double-strand breaks. It is useful in combination therapy for Hodgkin disease because it produces little myelosuppression, but it does produce serious toxicity involving the lung, including life-threatening pulmonary fibrosis. Cisplatin (choice B) is used alone and in combination to treat a wide variety of carcinomas. Toxicity is expressed as renal damage. Doxorubicin (choice C) is
another natural product used in Hodgkin disease that acts by DNA intercalation. The primary toxicity of doxorubicin is cumulative cardiac damage, so that lifetime dosage of the drug must be limited. Mechlorethamine (choice D) is a nitrogen mustard compound used in Hodgkin disease that alkylates DNA, especially at the N7 position of guanine. Its primary toxicity is myelosuppression. Vincristine (choice E) is a natural product derived from the vinca plant and acts by interfering with microtubule assembly. It is useful in HL. Its primary toxicity is peripheral neuropathy, manifested as numbness, tingling, and pain. A very similar vinca alkaloid, vinblastine, has the same mechanism of action, but causes myelosuppression rather than neuropathies.

5. (C) Transmitter D causes the membrane potential \( V_{M} \) to become more negative. This can only occur if it increases the conductance of an ion the equilibrium potential of which is more negative than the level of the resting membrane potential. Only potassium has an equilibrium potential more negative than \( V_{M} \). Increasing the conductance to calcium, sodium, or magnesium (choices A, D, and E) would make the membrane potential more positive. Increasing the chloride conductance (choice B) would not change the value of \( V_{M} \).

6. (B) The enzyme ALA synthase is the rate-limiting enzyme of heme biosynthesis. In hepatocytes, heme is required for incorporation into the cytochromes, in particular, the P450 class of cytochromes that are important for detoxification. In addition, numerous cytochromes of the oxidative-phosphorylation pathway contain heme. The Fe\(^{3+}\) oxidation product of heme is termed hemin. Hemin acts as a feedback inhibitor on ALA synthase. Hemin also inhibits transport of ALA synthase from the cytosol (its site of synthesis) into the mitochondria (its site of action), as well as represses synthesis of the enzyme. None of the other enzymes of heme biosynthesis (choices A, C–E) are regulated by hemin.

7. (C) Prolactin secretion from the anterior pituitary is under negative regulation by dopamine released by the hypothalamus. Therefore, blockade of dopamine receptors by the older D\(_2\)-blocking neuroleptic agents increases prolactin secretion. Prolactinemia is associated with galactorrhea, amenorrhea, and infertility in women, and infertility, impotence, and galactorrhea in men. Butyrophenones such as haloperidol possess weak antimuscarinic activity that causes decreased, not increased, salivation (choice B). Similarly, the weak antimuscarinic activity of the butyrophenones may cause constipation rather than diarrhea (choice A). Nausea and vomiting (choice D) are common effects with many drugs, but the D\(_2\)-blocking neuroleptic agents have antiemetic actions on the chemoreceptor trigger zone. Tourette syndrome (choice E) consists of chronic multiple motor and vocal tics of unknown etiology. Although the cause is unknown, the symptoms are often controlled with haloperidol treatment, suggesting excess dopamine activity in a brain region.

8. (C) In Type II diabetes mellitus, the body’s ability to take up and use glucose is impaired due to insulin resistance. Hence, fasting glucose levels are elevated. At this level of hyperglycemia, the ability of the kidney to reabsorb all filtered glucose has been exceeded and glucose appears in the urine. Choices A and B depict the filtered and reabsorbed glucose in such a hyperglycemic individual. Choice D depicts the filtered and reabsorbed glucose in a fasting normoglycemic nondiabetic individual, while choice E depicts the zero-excreted glucose in nondiabetic individual.

9. (D) The patient’s initial presentation strongly suggests acute meningitis which would have been confirmed by examination of his CSF. The patient’s age, the clinical signs, and the autopsy findings of extensive hemorrhages, particularly severe in the adrenal glands, all support a diagnosis of fulminant meningococcemia. The collective findings of meningitis-associated septicemia, cutaneous purpural/petechial lesions, and hemorrhagic infarction of the adrenal glands are known as Waterhouse-Friderichsen syndrome; it is most associated with \( N. meningitides \) infection, but may also occur with other bacterial infections. Meningitis epidemiology varies according
to geographical location and patient age. Generally speaking, in the United States, *S. pneumoniae* (choice E) is the leading cause of bacterial meningitis (~50% of cases), and most frequently affects infants and older adults. *N. meningitides* accounts for approximately 25% of all bacterial meningitis cases and largely affects adolescents and young adults. *Listeria monocytogenes* (choice C) is the causative pathogen in roughly 10% of cases, and occurs in neonates, patients >60 years, pregnant women, and immunocompromised individuals of any age. *H. influenzae* meningitis (choice B) is typically associated with infants and young children although incidence has dramatically decreased since the introduction of vaccination. *E. coli* (choice A) meningitis most commonly occurs in the newborn and neonatal populations.

10. (E) Pain fibers from the face area have their neuronal cell bodies located in the trigeminal (gasserian) ganglion. The mesencephalic trigeminal nucleus (choice A) contains the perikarya of the proprioceptive fibers of the muscles of mastication. The motor trigeminal nucleus (choice B) receives innervation from the mesencephalic trigeminal nucleus and in turn innervates the muscles of mastication. The principal sensory trigeminal nucleus (choice C) receives somatosensory fibers from the face, gums, teeth, and anterior two-thirds of the tongue. The spinal (descending) trigeminal nucleus (choice D) receives fibers conveying pain and temperature sensations, originating from the trigeminal (gasserian) ganglion.

11. (A) The anterior inferior cerebellar artery originates from the basilar artery. The external carotid artery (choice B) provides only meningeal vessels and branches to the brain. The internal carotid artery (choice C) provides branches to supply the orbit (ophthalmic artery) and anterior aspect of the cerebrum (anterior and middle cerebral arteries). The posterior cerebral arteries (choice D) are end branches of the basilar artery. The vertebral arteries arise from the subclavian artery at the base of the neck and unite past the foramen magnum to form the basilar artery.

12. (D) Neuroleptic-induced pseudoparkinsonism, including pill-rolling tremor, should be ruled out because it can be treated effectively with anticholinergic drugs. While the influenza pandemic of 1918 and 1919 often resulted in Parkinson’s disease, there is no evidence that current exposure to influenza is associated with tremors (choice B). Multiple sclerosis (choice C) is associated with intention tremor rather than resting tremor. The other items (choices A and E) are of importance in history taking, but not as important in this case as a history of taking neuroleptic drugs.

13. (B) When tardive dyskinesia is suspected, the abnormal involuntary movement scale (AIMS) is useful. A part of the test includes asking the patient to open his mouth and observe his tongue (it may have slow movements), and to protrude the tongue (it may show movements, or there may be quick withdrawal of the tongue). All the other tests (choices A, C, D, and E) are unlikely to document involuntary movements associated with tardive dyskinesia.

14. (B) Lewy body dementia often begins with psychiatric symptoms, especially visual hallucinations and delusions as well as progressive dementia and parkinsonian symptoms. Alzheimer disease (choice A) usually occurs at a later age, and not usually associated with parkinsonian features. Multiple sclerosis (choice C) is associated with intention tremor and other neurologic signs, and Sydenham chorea (choice D) is predominantly a disease of childhood not associated with athetoid movements. Tardive dyskinesia (choice E) is a side effect of prolonged neuroleptic use, and symptoms of psychosis should have antedated the movement disorder and dementia by some time.

15. (B) *E. coli* 0157/H7 causes bloody diarrhea and is a lactose-positive straight rod that forms large colonies on the differential medium with a unique green sheen. *C. jejuni* (choice A) causes bloody diarrhea but it is a curved, lactose-negative rod, and its colonies do not have metallic green sheen. *E. histolytica* (choice C) is an intestinal protozoon that may cause bloody diarrhea, and abscesses in the liver, lung, brain, or
spleen. This organism exists as a trophozoite and cyst. *S. typhi* (choice D) is a lactose-negative, straight rod that causes typhoid fever, and additional possible complications as arthritis, hepatitis, meningitis, nephritis, or myocarditis. *S. dysenteriae* (choice E) can cause bloody diarrhea but it is a lactose-negative rod and it does not form colonies with a metallic green sheen on EMB.

16. (C) Apo CII is required to activate the enzyme lipoprotein lipase, present on the surfaces of vascular endothelial cells. The function of lipoprotein lipase is to hydrolyze fatty acids from the triglycerides present in chylomicrons and very low-density lipoproteins (VLDLs). Therefore, a lack of this enzyme results in the inability to remove the dietary fatty acids packaged in chylomicrons. Afflicted individuals exhibit extremely elevated plasma levels of both chylomicrons and triglycerides. A deficiency in apo CII is one type of a family of three related inherited disorders that lead to chylomicronemia and triglyceridemia. The other two related disorders are due to a deficiency in lipoprotein lipase and a familial inhibitor of lipoprotein lipase. The restriction to a fat-free diet prevents elevations in plasma chylomicrons and triglycerides. Apo AI (choice A) is a major protein of high-density lipoproteins (HDLs) and is required for the activation of lecithin:cholesterol acyltransferase (LCAT). Deficiency in apo AI results in Tangier disease, characterized by a severe deficiency in HDLs in the plasma. This leads to the accumulation of cholesteryl esters in tissues throughout the body. Apo B₁₀₀ (choice B) is found associated with VLDLs and LDLs and is required in conjunction with apo E for LDL receptor recognition of LDLs. Abetalipoproteinemia is due to loss of apo B, whereas familial hypobetalipoproteinemia is due to mutant forms of apo B. The former disorder is characterized by the virtual absence of VLDLs and LDLs from the plasma, and the liver and intestine accumulate triglycerides, and erythrocytes exhibit a thorny appearance (acanthocytosis). The latter disorder is characterized by dramatically reduced levels of plasma VLDLs and LDLs. Apo D (choice D) is also called cholesterol ester transfer protein (CETP) and is found associated with HDLs. No identified disorders are associated with apo D. Apo E (choice E) is required for LDL interaction with the LDL receptor. Familial dysbetalipoproteinemia results in persons with a mutant form of apo E (apo E₂). Symptoms include hypercholesterolemia and hyper-triglyceridemia.

17. (C) Cyclosporine is one of the most useful organ rejection-suppressing drugs available and does not cause myelosuppression, but its nephrotoxicity is dose-limiting. Azathioprine (choice A) is an antimetabolite that is useful in immunosuppression in autoimmune diseases. Its toxicities are directed at the bone marrow and GI tract. Cyclophosphamide (choice B) is an alkylating agent used in cancer treatment as well as immunopharmacology. Its primary toxicity is myelosuppression. Mycophenolate mofetil (choice D) is a prodrug that is useful in organ transplant rejection reactions. Its toxicity includes gastrointestinal and bone marrow damage. Prednisone (choice E) in very high doses is often used in organ transplant rejection. Its toxicities are relatively low in acute use, but cushingoid effects are common when it is used chronically.

18. (D) To use a laboratory test result to exclude a certain disease, all negative test results must be true negatives; therefore, false negative results would be unacceptable in an exclusion test. This necessarily means that all patients with the disease must have a positive test result, which is the definition of 100% sensitivity (i.e., all individuals in a population with disease have a positive test result). Accuracy (choice A) refers to the degree to which the laboratory value obtained duplicates the real value but this does not help to determine if the patient does or does not have the disease. Precision (choice B) is an indication of the degree to which a test gives the same result when it is run multiple times on the same sample which, again, is of no value in determining who does or does not have a disease. Predictive value positive (choice C) is the proportion of true positive test results among all of the positive test results. One is willing to accept false positives in an exclusion test so predictive value positive is of less concern. Specificity (choice E) refers to the probability of obtaining a negative test result in
patients without the disease. When a test limit is raised to increase specificity, sensitivity is reduced. Thus, a test with 100% specificity allows for a greater potential number of false negative test results, which are unacceptable in an exclusion test.

19. (A) The bone marrow becomes the primary site of hematopoiesis during the seventh month of intrauterine life. The liver (choice B) and then the spleen (choice C) are primary sites after the second trimester of pregnancy. The thymus (choice D) does not participate in hematopoiesis. Islands of hematopoiesis are found in the yolk sac (choice E) during the first trimester of intrauterine life.

20. (B) All of the drugs listed are used in gout. Colchicine is an inhibitor of microtubule function that brings relief in an acute gout attack by inhibiting the motility of granulocytes and reducing the formation of mediators of inflammation of leukocytes. It has a very low therapeutic index and is usually used in very low dosage to prevent recurrences of acute gouty attacks. Allopurinol (choice A) and its metabolite alloxanthine inhibit xanthine oxidase, thus preventing conversion of xanthine and hypoxanthine to uric acid, a less soluble product. Indomethacin (choice C) is an NSAID that inhibits cyclooxygenase and prevents formation of prostaglandins and eicosanoids involved in the inflammatory process and pain perception in an acute episode of gouty arthritis. Piroxicam (choice D) is another NSAID; it has a long half-life that allows once-a-day dosing. Piroxicam is also used to treat rheumatoid arthritis and osteoarthritis. Probenecid (choice E) is a uricosuric agent. Renal uric acid excretion is determined by the balance between the amount filtered plus that actively secreted and the amount undergoing passive and active reabsorption in the S2 segment of the proximal tubule. At low doses, probenecid inhibits active secretion and thus promotes retention of uric acid. At higher (clinical) doses, both active secretion and active reabsorption are inhibited, with the result that excretion is enhanced. The decreased plasma level of uric acid reduces deposition of uric acid crystals in joints or tophi.

21. (A) The HIV multiplies in CD4 lymphocytes and this multiplication leads to severe lymphopenia due to the lysis of CD4+ lymphocytes. HIV is a member of the retrovirus group (choice C) that contains a single-stranded RNA genome (choice B) and reverse transcriptase (RNA-dependent DNA polymerase) (choice E) that synthesizes DNA from its RNA genome upon infection of host cells. HIV also has an envelope (choices D).

22. (D) Osteogenic sarcoma is principally a disease of adolescence but a small number of cases occur in individuals (usually over 60) who have Paget disease of bone. Osteoarthritis (choice A), osteomalacia (choice B), osteoporosis (choice C), and rheumatoid arthritis (choice E) are not associated with sarcomatous change.

23. (E) Branches of the anterior spinal artery and medial branches of the vertebral artery supply the medullary pyramid, the laterally adjacent fibers of the hypoglossal nerve, and part or all of the medial lemniscus. Thus, a unilateral infarct results in inferior alternating hemiplegia, also known as alternating hypoglossal hemiplegia. A lateral medullary or Wallenberg syndrome resulting from an infarct in the territory of the posterior inferior cerebellar artery would involve cranial nerves VIII (choice A), IX (choice B), X (choice C), and XI (choice D).

24. (E) Potassium-sparing diuretics such as spironolactone are aldosterone antagonists that target the epithelial cells of the collecting duct, which normally respond to aldosterone by increasing sodium reabsorption and increasing potassium secretion. Hence, inhibition of this tubular segment has a potassium-sparing action. Choices A and B denote the proximal tubule and thin loop of Henle segments, respectively; which do not have these properties. Choices C and D denote the thick ascending loop of Henle and early distal tubule, respectively; targets of the loop and thiazide diuretics, which are not potassium-sparing in their actions.

25. (E) During pregnancy the oxygenated blood from the placenta travels first through the umbilical vein, hence this blood has the highest
oxygen content. At the ductus venosus, the umbilical vein blood mixes with unoxygenated blood in the inferior vena cava and passes to the right heart and is largely shunted to the left heart via the foramen ovale. Unoxygenated superior vena cava blood from the head enters the right heart and is pumped through the pulmonary arteries (choice B), the nonfunctional lungs, and the pulmonary veins (choice C). From there the left heart pumps the mixed blood through the aorta (choice A) into the umbilical arteries (choice D) to the placenta for oxygenation.

26. (A) The anomic hydroxyl group of glucose derivatizes the amino groups of lysine side chains in hemoglobin as well as the amino terminals of the globin monomers. When glycosylated, hemoglobin can be separated from normal adult hemoglobin (designated HbA) by ion exchange chromatography. To distinguish glycosylated hemoglobin it is given the designation, HbA\textsubscript{1c}. Other modifications of adult hemoglobin occur, such as with glucose-6-phosphate and fructose-1, 6-bisphosphate and these modified hemoglobins are given designations with subscripts like that for glycosylated hemoglobin (e.g., HbA\textsubscript{1a1} or HbA\textsubscript{1b}). Normal levels of glycosylated hemoglobin represent about 5% of the total. About 2–3% of normal adults contain a version of hemoglobin that is composed of two beta chains and two gamma chains (instead of two beta chains). This hemoglobin is designated HbA\textsubscript{2} (choice B). The other choices designate defective forms of hemoglobin found in various disease states. HbC (choice C) results when a lysine is substituted for glutamate at position 6 of the beta chain. HbE (choice D) is the most common hemoglobin variant in man. It results from a substitution of lysine for glutamate at position 26 of the beta chain. HbS (choice E) is the form of hemoglobin found in sickle cell anemia. This hemoglobin results from a substitution of valine for glutamate at position 6 of the beta chain.

27. (E) The image in Figure 13-4 shows a Toxoplasma gondii pseudocyst containing bradyzoites within a myocyte. This coccidian organism is quite common and can infect a range of animals. A significant percentage of the human population has serological evidence of exposure, but it does not usually cause a problem in immunocompetent individuals. However, immunosuppressed patients are at risk for getting acute toxoplasmosis acquired either as activation of a previous infection or as a new infection acquired from undercooked meat or from cat feces. The morphology of the other choices does not match that of the image. Candidiasis (choice A) is seen as pseudohyphae with yeast forms. Coccidioidomycosis (choice B) appears as large non-budding spherules containing endospores and usually is associated with a granulomatous reaction. Cryptococcosis (choice C) demonstrates encapsulated yeasts with narrow-based budding and can also produce a granulomatous response. All three of these can cause brain infections in immunocompromised patients. Pneumocystosis (choice D) is caused by cup-shaped organisms that can be demonstrated by silver stains and is more usually associated with pneumonia in immunocompromised individuals.

28. (C) Paraquat is a herbicide that is nontoxic by inhalation or skin exposure, but causes lethal effects when ingested. Initial symptoms include nausea, with vomiting and diarrhea, but these give way to much slower and progressive pulmonary effects that are frequently lethal. There is no antidote for paraquat intoxication, so removal of the toxin from the GI tract as soon as possible after exposure is the best treatment. DDT (choice A) is an insecticide that interferes with sodium channel function. In humans, it causes neurologic abnormalities, including convulsions. Because of its very lipophilic nature, it accumulates in the food chain for predators. Dioxins (choice B) are contaminants of the herbicide 2,4,5-T (agent orange). The best-documented effect of dioxins is chloracne and other dermatologic conditions, but the substance has been suspected of involvement in immunologic and hepatologic abnormalities and neoplastic disease. PCBs (choice D) have a poorly defined toxicity that includes dermatitis, hepatic alterations, and elevated triglycerides. Rotenone (choice E) is another insecticide that causes local irritation.
in humans, including conjunctivitis, dermatitis, rhinitis, and cough.

29. (A) From inspection of Figure 13-5, the R-R interval (time between heart beats) at rest is 0.83 seconds. Sixty seconds/minute divided by 0.83 yields a resting heart rate of 72 beats/minute. Alpha adrenergic agonists do not directly change heart rate, but the peripheral vasoconstriction resulting from stimulation of arterial alpha adrenergic receptors will raise arterial blood pressure and indirectly trigger a baroreflex decrease in heart rate. The only choice smaller than 72 beats/minute is (A), 60 beats/minute.

30. (A) The middle meningeal artery runs under the temporal bone and a fracture of that bone has the possibility of rupturing the artery and producing an epidural hematoma. A berry aneurysm develops from a congenital weakness of a cerebral artery—typically at a vessel bifurcation in the circle of Willis. When a berry aneurysm ruptures (choice B) it occurs spontaneously, is not associated with trauma, and produces a subarachnoid hemorrhage (choice C), not an epidural hematoma. A subdural hematoma (choice D) is typically seen in elderly patients following minimal trauma and is due to rupture of veins running from the cerebral cortex to the superior sagittal sinus. Contusion of the temporal lobe (choice E) or other areas of the brain is usually the result of acceleration-deceleration injury and although this is the result of trauma, it is of far less concern than an epidural hematoma. Ventricular hemorrhage (choice F) can result from extension of nearby hemorrhage into a ventricle and is, for example, a fairly common occurrence in subarachnoid hemorrhage. Again, this is not the major concern here.

31. (B) In contrast to a classical antigen-antibody reaction, allergic reactions do not result in the neutralization of toxicity or antigen. For example, in type I hypersensitivity IgE binds to the surface of mast cells. Thus, IgE is produced in type I allergy such as allergic rhinitis (choice D). Administration of sodium cromolyn prevents release of histamine (choice A) from mast cells, and it is used to treat type I allergy. Type I allergy begins with the formation of IgE which then binds on the mast cells. Therefore, mast cells in circulation have IgE on their surface (choice E). The reaction of IgE with its allergen is highly specific (choice C).

32. (C) The galectins are all defined by a canonical carbohydrate recognition domain (CRD) having an affinity for beta galactosides. To date, 14 galectins have been identified in mammals. One of the most crucial functions of the galectins is in regulation of the inflammatory response. Galectin-1 is expressed by antigen-stimulated T cells, activated B cells, and by macrophages. The action of galectin-1 in these systems is to stimulate apoptosis resulting in cell death. Negative growth effects of galectin-1 are also seen in breast and prostate cancer cell lines. Although the collectins (choice A), ficolins (choice B), pentraxins (choice D), and siglecs (choice E) all have roles in modulating immune responses, none have been shown to have the potent apoptosis-inducing effect of galectin-1.

33. (B) If a patient is comatose, the nervous system is being affected at the brainstem level or above. In a comatose patient, the brainstem suppresses the reticular activating system, which normally maintains a state of arousal, and is not perceptive to input from higher brain areas. Hence the patient cannot understand and follow commands, not even the simplest ones. Testing brainstem reflexes is an important diagnostic tool to assess the cause of the coma. The reflexes should be intact if the coma is induced by high blood sugar, or electrolyte imbalances. If a brain injury is the cause of the coma, only certain reflexes will be intact, dependent on the location of the brain lesion. For instance, an intact pupillary reaction to light (choice A) indicates normal functioning of the midbrain and cranial nerve III. Sensory receptors and free nerve endings of a comatose patient will respond normally to changes in the environment, including pain
(choice C) and touch (choice E), by creating generator potentials. These in turn create action potentials that are transmitted to the spinal cord and from there on to nuclei of the brainstem and the thalamus. Touch and deep pain have the capacity to elicit reflex muscle contraction. The neural pathways for sound (choice D) involve several relay stations in the brainstem such as the cochlear nucleus and the superior olive. Movements of comatose patients due to sound could be simple reflexes comparable to the muscular reflexes in response to touch. They also could be signs of innate responsiveness, in which case speaking and singing to the patient might help his or her recovery.

34. (B) All of the drugs listed have been used in asthma, but only the combination of beclomethasone and albuterol is rational as described. Beclomethasone is a very effective corticosteroid for preventing attacks, although it is not a bronchodilator. When used by the inhalation route, it has very low corticosteroid toxicity and can be used on a regular schedule. Albuterol is a very effective, short-acting, beta-2—selective bronchodilator that should be used for acute symptoms, not on a regular four-times-daily schedule. Aminophylline (choice A) is a long-acting bronchodilator that is rarely used except for control of nocturnal asthma. Albuterol should be used for acute attacks, not on a regular schedule. Cromolyn (choice C) is a mast cell stabilizer that is sometimes effective for prophylaxis, but salmeterol is also a prophylactic agent; there is no drug for managing acute attacks in this regimen. Prednisone (choice D) is reserved for patients who cannot be managed with inhaled steroids because it must be given systemically and has a high incidence of chronic toxicities. Montelukast is a leukotriene receptor blocker that is used prophylactically. Terbutaline (choice E) is a short acting beta-2 agonist that should only be used for acute symptoms. This regimen lacks any drug for prophylaxis.

35. (E) Some tumors such as squamous cell carcinoma of the lung and renal cell carcinoma can produce a parathyroid hormone-related protein (PTH-RP), which mimics the action of parathyroid hormone (PTH), producing increased calcium levels and decreased phosphate levels which lead to decreased production of PTH. Since PTH-RP is not detected by the PTH immunoassay, decreased levels of PTH are recorded. Chronic renal disease (choice A) produces secondary hyperparathyroidism. The reduced glomerular filtration rate leads to phosphate retention and hyperphosphatemia, which in turn leads to reduced calcium levels. In 50 and 200 cGy usually produce acute radiation syndrome (choice A) characterized by fatigue, nausea, and vomiting. Hematopoietic syndrome (choice D) is characterized by leukopenia and thrombocytopenia, in addition to the clinical findings of acute radiation sickness. Exposure dosages are usually between 200 and 600 cGy. The acute mortality rate is between 20% and 50%. Exposures of 600–1000 cGy may produce mucosal ulceration, diarrhea, and electrolyte loss as part of the GI syndrome (choice C). Acute mortality rates are between 50% and 100%. The cerebral syndrome (choice B) has a 100% mortality rate and is seen with acute doses above 1000 cGy.
response to the hypocalcemia, the parathyroids increase their production of PTH. Multiple myeloma (choice B) and tumor metastases producing lysis of bone lead to increased levels of calcium and phosphate, which depress PTH levels. Parathyroid adenoma (choice C) and parathyroid hyperplasia (choice D) both lead to increased PTH levels with increased calcium and decreased phosphate.

38. (C) Influenza virus is a common organism associated with respiratory tract infections. It has a single-stranded, negative polarity, 8-segmented genome. Adenoviruses (choice A) are double-stranded DNA organisms. They cause pharyngitis, conjunctivitis, and pneumonia in immunocompromised hosts. Another group of unsegmented viruses which are associated with the common cold are the coronaviruses (choice B). These organisms have a single-stranded, positive polarity RNA genome, and petal-like projections on their envelope called a corona. Respiratory syncytial virus (choice D) can induce respiratory distress, as well as bronchiolitis and pneumonia, especially in infants. It is a single-stranded, negative polarity RNA virus. Rhinoviruses (choice E) are another significant cause of respiratory infections. They have unsegmented, single-stranded, positive polarity RNA genomes.

39. (E) Cortisol is gluconeogenic by promoting breakdown of proteins into amino acids, which are then transaminated in the liver to form glucose, and by promoting the conversion of lactate into glucose. The resulting high blood glucose levels stimulate pancreatic beta cells to release insulin. When beta cells are continuously stimulated, they eventually become exhausted and fail to produce insulin, which further worsens already existing conditions of Type II diabetes. Cortisol inhibits, not promotes inflammation (choice A). Cortisol’s mechanism of action as anti-inflammatory agent is multifold including inhibition of pro-inflammatory cytokines and prostaglandins, stabilization of lysosomal membranes, and decrease of capillary permeability. Negative feedback influence by cortisol will diminish the secretion of corticotropin-releasing hormone (CRH) and pro-opiomelanocortin (POMC). Since POMC is the precursor of melanocyte-stimulating hormone, hyperpigmentation will diminish or remain unaltered, but it will not be exacerbated by cortisol (choice B). High levels of cortisol cause renal tubular reabsorption of sodium leading to high, not low serum sodium (choice C). This is mediated via aldosterone receptors in the kidney, to which cortisol will bind to a significant extent at high concentrations. Normal levels of cortisol are necessary to maintain normal vasomotor tone and integrity of the vascular system. Hence, advancement of low vasomotor tone (choice D) toward vascular collapse would be expected in the absence, not the presence of cortisol.

40. (E) Reflux esophagitis, probably caused by hiatal hernia, is the most likely initial diagnosis. The dependence of the symptoms on body position and dietary intake, the coating of the tongue, and the gastritic symptoms are all consistent with this diagnosis. Patients with functional heart disease (choice A) often show tachycardia and restlessness, and the chest pain would also be present during periods of rest. Lung embolism (choice B) typically presents with dyspnea. Symptoms of pericarditis (choice C) have a more acute onset. Additionally, leukocytosis and fever would be expected. Chest pain associated with myocardial infarction (choice D) would typically not change when changing body position. Furthermore, it is not likely that the patient’s symptoms would remain at the same intensity for a long period of time. Lastly, creatine kinase and leukocytes would be expected to be elevated. Although cardiovascular problems are less likely in this case to cause the man’s symptoms, the choice and number of tests performed to definitely rule them out depends on the patient.

41. (B) About 40–50 years ago diethylstilbestrol was actively used to prevent miscarriages. Surviving female fetuses exposed to this agent later demonstrated an increased incidence of vaginal adenosis. The development of vaginal adenosis is not known to be associated with aspirin ingestion (choice A), administration of
methotrexate (choice C), radiation (choice D), or rubella virus (choice E).

42. (E) The heart rate response to isoproterenol is tachycardia. This is mediated by beta adrenoceptors in the SA node and can be effectively blocked only by beta-blocking drugs. The rate response to norepinephrine in intact subjects is bradycardia (due to hypertension and the baroreceptor reflex) and is mediated by the vagus nerve acting through the vagal ganglion and muscarinic receptors in the SA node. It can therefore be blocked at multiple sites.

43. (B) A hemagglutination inhibition titer of 400 means that when a patient’s serum is diluted 400-fold it will prevent agglutination of the assay red blood cells.

44. (C) TCA cycle-mediated oxidation of propionyl-CoA, derived from the beta oxidation of fatty acids with an odd number of carbon atoms or from catabolism of several amino acids (e.g., valine and isoleucine), requires that it first be converted to succinyl-CoA. Methylmalonyl-CoA mutase is the terminal enzyme in this conversion process. The most common physical symptoms seen in patients with defective methylmalonyl-CoA mutase activity are failure to thrive, lethargy, vomiting, muscular hypotonia, and respiratory distress. Characteristic laboratory findings will be methylmalonic acidemia. Malonyl-CoA decarboxylase (choice A) is a mitochondrial enzyme involved in the catabolism of malonyl-CoA derived from the carboxylation of acetyl-CoA by propionyl-CoA carboxylase (the enzyme is not completely specific for propionyl-CoA). Deficiency in malonyl-CoA decarboxylase leads to developmental delay, hypotonia, seizures, metabolic acidosis, ketosis, and lactic acidemia. Clinical laboratory findings are characterized by malonic aciduria. Methionine synthase (choice B) is a vitamin B₁₂ (cobalamin) requiring enzyme that converts homocysteine to methionine while simultaneously regenerating tetrahydrofolate (THF) from methyl-THF. Functional methionine synthase deficiency results from deficiencies in cobalamin and because of the role of the enzyme in THF regeneration, will lead to deficient thymidine nucleotide biosynthesis. Methylmalonyl-CoA racemase (choice D) is another enzyme in the conversion of propionyl-CoA to succinyl-CoA and no specific deficiencies in this enzyme have been identified. Propionyl-CoA carboxylase (choice E) is the first enzyme in the conversion of propionyl-CoA to succinyl-CoA. Deficiency in propionyl-CoA carboxylase is a major cause of ketotic hyperglycemia syndrome. Accumulation of propionic acid is evident in the blood of afflicted individuals.

45. (B) Effective circulating blood volume falls during exercise in the heat. Since a redistribution of blood volume to the skin circulation occurs during exercise in the heat (an adaptation to increase heat loss) this response does contribute to a fall in circulating blood volume. In exercise, water shifts from the intravascular to the interstitial space (choice A), primarily due to increased capillary hydrostatic pressure. In response to baroreceptor signals, blood flow to the splanchnic circulation decreases in exercise (choice C). This helps to maintain circulating volume. Changes in blood flow to the cerebral circulation (choice D) during exercise do not significantly impact the circulating blood volume. Since the systemic and pulmonary circulations (choice E) are arranged in series, each circulation receives the entire cardiac output.

46. (E) The frontal sinus is innervated by branches of the supraorbital nerves from V₁. The anterior (choice A), middle (choice B), and posterior (choice D) superior alveolar nerves are derived from the infraorbital nerve from V₂ and supply sensory innervation to the maxillary sinus. The posterior ethmoidal nerves (choice C) along with the anterior ethmoidal nerves innervate the ethmoidal sinuses.

47. (C) The clinical presentation is typical for a germ cell tumor of the testis. The microscopic appearance, as demonstrated in Figure 13-6, consists of uniform round cells with centrally-placed nuclei and prominent nucleoli. Running between groups of these cells are fibrous trabeculae containing many lymphocytes. This
appearance is classic for a seminoma which is the most common germ-cell tumor in males. Choriocarcinoma (choice A) is recognized by the presence of both cytotrophoblasts and syncytiotrophoblasts and the secretion of human chorionic gonadotropin and is often associated with areas of hemorrhage. Embryonal carcinoma (choice B) is composed of highly undifferentiated cells that may be arranged in papillary, glandular, or tubular configurations, or in sheets. Mitoses and tumor giant cells are frequently seen and there may be areas of necrosis. A teratoma (choice D) has a mixture of various tissues derived from all three germ layers. A mature teratoma, typically seen in infancy and childhood, is a benign tumor composed of differentiated tissues whereas an immature teratoma seen in adult patients should be considered malignant until proven otherwise and may, in fact, have frank areas of malignancy in one or more of the tissue components. Yolk sac tumor (choice E) shows evidence of differentiation toward yolk sac-like structures and is positive for alpha fetoprotein. It is important to note that the majority of germ cell tumors of the testis are actually mixtures of the various “pure” types described above.

48. (D) Amiodarone is an important antiarrhythmic, while bleomycin is an antibiotic cancer chemotherapeutic drug that acts to cause DNA strand breaks and inhibits DNA replication. Both drugs cause pulmonary fibrosis, which is dose limiting and may be fatal. Amiodarone also causes hyper or hypothyroidism and photosensitivity. Bleomycin also causes chills, fever, alopecia, and blister formation.

49. (E) Tetralogy of Fallot includes right ventricular hyperplasia, pulmonary stenosis, ventricular septal defect, and dextroposition of the aorta. It is a cyanotic congenital heart disorder with a dismal prognosis, unless surgically corrected. Anomalous pulmonary venous drainage (choice A) occurs when there is aberrant drainage of the pulmonary veins into the left atrium. Dextrocardia (choice B) is a mirror image inversion of the heart. Ebstein malformation (choice C) is a congenital abnormality of the tricuspid valve and right ventricle. Transposition of the great arteries (choice D) is a congenital heart disease defined as the aorta arising from the right ventricle and the pulmonary artery originating from the left ventricle.

50. (D) Niemann-Pick disease (NPD) comprises two distinct but related types of lipid storage disorder, type I and type II. In addition, both comprise two subtypes. Type I A (NPA) and type I B (NPB) both result from a defect in acid sphingomyelinase. NPA is a disorder that leads to infantile mortality. NPB is variable in phenotype and is diagnosed by the presence of hepatosplenomegaly in childhood and progressive pulmonary infiltration. Pathologic characteristics of the type I NPDs are the accumulation of histiocytic cells that result from sphingomyelin deposition in cells of the monocyte-macrophage system. Fabry disease (choice A) is an X-linked disorder that results from a deficiency in alpha-galactosidase A. This leads to the deposition of neutral glycosphingolipids with terminal alpha-galactosyl moieties in most tissues and fluids. Most affected tissues are heart, kidneys, and eyes. With increasing age, the major symptoms of the disease are due to increasing deposition of glycosphingolipid in the cardiovascular system. Indeed, cardiac disease occurs in most hemizygous males. Three types of Gaucher disease (choice B) have been characterized and are caused by defects in lysosomal acid beta glucosidase (glucocerebrosidase). Defects in this enzyme lead to the accumulation of glucosylceramides (glucocerebrosides), which leads primarily to CNS dysfunction, and also hepatosplenomegaly and skeletal lesions. Krabbe disease (choice C), also called globoid-cell leukodystrophy, results from a deficiency in galactocerebrosidase (galactocerebroside beta galactosidase). This disease progresses rapidly and invariably leads to infantile mortality. Tay-Sachs disease (choice E) results from a defect in hexosaminidase A leading to the accumulation of GM1 gangliosides, particularly in neuronal cells. This defect leads to severe mental retardation, progressive weakness, and hypotonia, which prevents normal motor development. Progression of the disease is rapid and death occurs within the second year.
1. An infant was born with Leigh disease caused by a maternal inheritance pattern with abnormal mutations in mitochondrial DNA. The patient displays central nystagmus with rotary and horizontal components, nuclear ophthalmoplegia, and irregular respiration. As the child begins to walk, truncal ataxia and intention tremor become evident. Magnetic resonance imaging (MRI) reveals symmetric lesions in the caudate putamen and globus pallidus. The medial segment of the globus pallidus sends fiber projections to which of the following?

(A) caudate nucleus  
(B) pars compacta of the substantia nigra  
(C) subthalamic nucleus (of Luys)  
(D) ventral anterior nucleus of the thalamus  
(E) ventral posterior lateral nucleus of the thalamus

2. Arrow 1 in Figure 14-1 points to which of the following structures in bone?

(A) chondroblast  
(B) osteoblast  
(C) osteoclast  
(D) osteocyte  
(E) osteoid

Questions 3 and 4

A 35-year-old single woman complains of fatigue, insomnia, and depression.

3. A family history of which of the following would be most useful in treating this patient at this point?

(A) bipolar disorder  
(B) dysthymia  
(C) schizophrenia  
(D) somatization disorder  
(E) suicide

4. If this patient turns out to have schizophrenia, which of the following pharmacologic agents is most likely to be helpful?

(A) buspirone  
(B) fluoxetine  
(C) risperidone  
(D) tranylcypromine  
(E) valproic acid
5. A 28-year-old woman is brought to the hospital because she had not come out of her room for 3 days. She would eat only when a tray was brought in. All of a sudden she becomes mute and immobile. When you raise her hand, it stays in that position. Which of the following best describes this phenomenon?

(A) agitation
(B) cataplexy
(C) catatonia
(D) frontal lobe syndrome
(E) hebephrenia

6. Urinalysis on a sick 3-month-old baby boy shows negative results with the dipstick glucose test, but a subsequent Clinitest analysis gives a 4+ reading. Which of the following is the most likely reason for this discrepancy between the two tests?

(A) A high alkaline urinary pH of 8.5 does not allow for the normal dipstick enzymatic reaction.
(B) An increased fraction of urine solutes yields an erroneously negative glucose dipstick reaction.
(C) The baby has an undetected intrinsic renal disease.
(D) The baby is secreting a reducing substance that is not reactive with the glucose dipstick.
(E) The Clinitest has greater sensitivity than a dipstick for glucose measurement.

7. A new drug was recently approved that acts as an antagonist at vasopressin V₁a and V₂ receptors. Which of the following represents the probable clinical application for this drug?

(A) hypertension due to Cushing disease
(B) hypokalemia due to Cushing disease
(C) hyponatremia due to heart failure
(D) nephrogenic diabetes insipidus
(E) severe edema due to hepatic cirrhosis

8. A 45-year-old elementary school teacher presents to her otolaryngologist for a consultation due to increasing hoarseness and throat irritation. She is otherwise asymptomatic. Past medical history is remarkable only for mild hypertension and a 3-year history of gastroesophageal reflux disease (GERD). On laryngeal examination, a single, pedunculated nodule is observed on her vocal cord and is surgically excised. Microscopy of the lesion reveals the presence of hyperplastic squamous epithelium surrounding a myxomatous stroma with dilated vascular spaces and scattered fibrosis. Based on this information, what is the most likely diagnosis?

(A) chronic inflammatory changes secondary to GERD
(B) laryngeal nodule
(C) laryngeal squamous papilloma
(D) metastatic squamous cell carcinoma of the oral cavity
(E) squamous cell carcinoma of the larynx

9. Use the graph associated with Figure 14-2 to answer the following question. Assume that the uptake of gas C is 40 mL/minute at normal cardiac output. What will the uptake of gas C be if cardiac output is doubled?

(A) 20 mL/min.
(B) 40 mL/min.
(C) 80 mL/min.
(D) 160 mL/min.
(E) It can’t be determined based on the available information.
10. A 5-month-old baby had to be hospitalized because she was experiencing a constant, non-productive cough, wheezing, and a temperature of 100°F. Radiographs and laboratory tests indicate that the baby has viral bronchiolitis. Which one of the following viruses is most likely to cause this illness?

(A) adenovirus  
(B) influenza virus  
(C) parainfluenza serotype 3 virus  
(D) respiratory syncytial virus  
(E) rotavirus

11. Shortly after birth, an infant presents with severe lactic acidemia, hyperammonemia, citrullinemia, and hyperlysinemia with the presence of alpha ketoglutarate in the urine. Definitive diagnosis of the causes of severe lactic acidemia is difficult, and although these symptoms overlap those seen with some of the urea cycle defect diseases, this is not the case with this neonate. A defect in which of the following enzymes would be expected to present with these findings?

(A) acetyl-CoA carboxylase  
(B) electron transfer flavoproteinubiquinone oxidoreductase (EFT-QO)  
(C) glutamic acid decarboxylase (GAD)  
(D) phosphoenolpyruvate carboxykinase (PEPCK)  
(E) pyruvate carboxylase

12. A 33-year-old man is diagnosed with duodenal carcinoma. A large number of hamartomatous polyps are found throughout his GI tract and he is also observed to have pigmented macules on his lips and buccal mucosa. Which of the following conditions is the most likely explanation for all of these findings?

(A) familial polyposis coli  
(B) Gardner syndrome  
(C) juvenile retention polyps  
(D) Peutz–Jeghers syndrome  
(E) Turcot syndrome

13. Most sedative-hypnotic, anxiolytic drugs act through modulation of GABA receptor channel signalling. Which of the following agents is anxiolytic and does not act via this mechanism?

(A) buspirone  
(B) eszopiclone  
(C) triazolam  
(D) zaleplon  
(E) zolpidem

14. A section of a biopsy taken from a 58-year-old woman is shown in Figure 14-3. Which of the following diagnoses is most likely in this case?

(A) adenocarcinoma of the colon  
(B) basal cell carcinoma of the skin  
(C) fibroadenoma of the breast  
(D) fibroma of the ovary  
(E) leiomyosarcoma of the uterus  
(F) undifferentiated small-cell carcinoma of the lung

FIG. 14-3 (Also see color insert.)
15. A 6-year-old female has been suffering from recurrent necrotic and indolent infections of the skin, mucous membranes, and intestinal tract with persistent leukocytosis. Other distinguishing clinical factors of this patient include unique facial features and severe growth and mental retardation. An additional feature of this child is that she harbors the rare Bombay (hh) blood type at the ABO locus and she also lacks the Lewis blood group antigens. These findings are consistent with the child suffering from which of the following disorders?

(A) congenital disorder of glycosylation Ia (CDG Ia)
(B) fucosidosis
(C) GM₂ gangliosidosis
(D) leukocyte adhesion deficiency syndrome II (LAD II)
(E) Schindler disease

16. Intestinal epithelial cells possess two transport mechanisms to move glucose across the plasma membrane, a facilitated glucose carrier (GLUT 2) as well as a sodium-dependent secondary active transporter (SGLT 1). Which of the following attributes distinguishes these two transport modalities with respect to net glucose transport?

(A) directly depends on ATP hydrolysis
(B) from a region of low to a region of high glucose concentration
(C) is carrier mediated
(D) is saturable
(E) is sensitive to competitive substrate inhibition

17. While crossing the street in a pedestrian crosswalk, a 21-year-old woman is struck by a car and sustains extensive injuries. She is rushed to the emergency room where she becomes unconscious and hemodynamically unstable, with a BP of 62/40 mm Hg and a pulse of 146 per minute. She is immediately typed and screened before undergoing emergency exploratory surgery and found to be group B, Rh (−). Abdominal hemorrhage discovered during surgery necessitates blood transfusion. Unfortunately, the hospital does not have any group B, Rh (−) blood in its inventory. Consequently, which of the following would be the best alternative to give this patient?

(A) group A, Rh (−) red blood cells
(B) group A, Rh (−) whole blood
(C) group B, Rh (+) red blood cells
(D) group B, Rh (+) whole blood
(E) group O, Rh (−) red blood cells
(F) group O, Rh (−) whole blood

18. Which of the following drugs is a dopamine D₂ agonist used in parkinsonism and restless legs syndrome?

(A) amantadine
(B) bromocriptine
(C) entacapone
(D) rasagiline
(E) ropinirole

19. The graph shown in Figure 14-4 shows a viral multiplication curve. Which one of the following statements is correct?

![Viral Multiplication Curve](image)

(A) During the time period of 0–6 hours the virus retains its infectivity.
(B) The time from 0 to 6 hours represents the eclipse period.
(C) The time from 6 to 8 hours represents the appearance of immature virus.
(D) The time from 6 to 8 hours represents the uncoating of the viral particle.
(E) The viral growth curve is similar to bacterial growth curve.
20. A newborn who developed seizures 2 days after birth was diagnosed with elevated serum NH₄⁺, glutamate, and alanine. A neonatal urea cycle defect was suspected so a urinalysis was performed to assay for orotic acid and serum assayed for citrulline. The levels of both were found not to be significantly above normal. A defect in which enzyme of the urea cycle would account for the symptoms observed in this infant?

(A) arginase
(B) argininosuccinate lyase
(C) argininosuccinate synthetase
(D) carbamoyl phosphate synthetase I (CPS I)
(E) ornithine transcarbamoylase (OTC)

21. Your patient seems very trusting of you, and when you try to explain laboratory results, she says, “Just tell me the good news.” She seems to be quite impressionistic and friendly. If she turns out to have a newly diagnosed serious medical condition, which of the following is appropriate?

(A) Ask the patient if she would like to hear the bad news.
(B) Tell the family about the diagnosis, and tell the patient she should discuss it with the family.
(C) Tell the patient about the diagnosis in great detail.
(D) Tell the patient about the diagnosis in very general terms, and ask if she would like more detail.
(E) Withhold the information from the patient.

22. A 78-year-old woman dies suddenly following a long history of chronic renal failure. Upon autopsy, the pathologist reports the gross finding of a wedge-shaped, sharply demarcated region of her left kidney that is pale and shrunken. On histological examination of a section of this kidney lesion, which of the following is the pathologist most likely to observe?

(A) amorphous, eosinophilic material surrounded by giant cells and a rim of T-lymphocytes
(B) complex, branching papillomatous structures with numerous fronds projecting into a cystic space
(C) extensive collagen deposition with minimal fibroblasts and capillaries
(D) mixture of neutrophils, extensive hemorrhage and necrotic debris
(E) tubular necrosis and marked lymphocytic infiltration of the interstitium

23. The newer atypical antipsychotic drugs differ from the traditional antipsychotic neuroleptic agents. Which of the following correctly describes the differences in these atypical agents?

(A) are free of QT-prolonging effects
(B) are less effective versus the negative symptoms of schizophrenia
(C) cause fewer blood dyscrasias
(D) cause less extrapyramidal toxicity
(E) produce less increase in body weight

24. A 68-year-old man is planting a tree in his backyard when he experiences a very severe substernal pain that radiates to his neck and jaw and persists for 2 hours. When his wife returns home she insists on calling an ambulance, and he is transported to the emergency room 6 hours after the onset of his pain. Which of the following tests is most likely to aid in the diagnosis of his condition?

(A) amylase
(B) aspartate aminotransferase
(C) creatinine
(D) glucose
(E) lipase
(F) troponin I
25. You are studying the effects of the addition of a potential pharmaceutical compound on the activity of your enzyme of interest. You find that the addition of the compound results in an increase in the $K_m$ of the reaction but does not affect the $V_{max}$. Which of the following defines the inhibitory action of the compound?

(A) competitive  
(B) noncompetitive  
(C) suicide  
(D) uncompetitive

26. A 40-year-old woman with severe manic-depressive episodes is given lithium to control her symptoms. Unfortunately, this results in the onset of nephrogenic diabetes insipidus which was most evident from her constant thirst and drinking. If she is prevented from drinking, which of the following changes from normal would reflect this condition?

<table>
<thead>
<tr>
<th>Hematocrit</th>
<th>Extracellular Fluid Osmolality</th>
<th>Intracellular Fluid Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) decreased</td>
<td>increased</td>
<td>decreased</td>
</tr>
<tr>
<td>(B) decreased</td>
<td>increased</td>
<td>increased</td>
</tr>
<tr>
<td>(C) increased</td>
<td>decreased</td>
<td>increased</td>
</tr>
<tr>
<td>(D) increased</td>
<td>increased</td>
<td>decreased</td>
</tr>
<tr>
<td>(E) increased</td>
<td>increased</td>
<td>increased</td>
</tr>
</tbody>
</table>

27. Intravenous inulin is infused continuously, until a steady state plasma inulin concentration of 1 mg/mL is obtained. During this time 20 mL of urine are collected in a 20-minute period. The concentration of inulin in this urine is 100 mg/mL. If the renal plasma flow in both kidneys is estimated to be 500 mL/min, what fraction of the plasma flowing into the kidneys ends up in the Bowman’s capsule as tubular fluid?

(A) 5%  
(B) 10%  
(C) 15%  
(D) 20%  
(E) 25%

28. Osteopetrosis is an inherited disease characterized by defective osteoclasts that lack the ruffled border characteristic of this cell type. An expected consequence of osteoclast inactivity is which of the following?

(A) abnormal deposits of calcium in arterial walls and the kidneys  
(B) elevation in blood Ca$^{2+}$ levels  
(C) enlarged marrow spaces  
(D) low concentration of circulating parathyroid hormone (PTH)  
(E) overgrowth and thickening of bones

29. A 41-year-old woman complains of increasing pain in her wrists. There is stiffness of these joints in the morning, which decreases during the day. Physical examination reveals tenderness of the metacarpophalangeal and proximal interphalangeal joints with no other findings. Based on this information, which of the following histological findings would you most likely expect to see in one of this patient’s affected joints?

(A) acute synovial inflammation with precipitation of monosodium urate crystals  
(B) cartilage degradation with PMN infiltration, synovial proliferation, and vascular thrombosis  
(C) irregular areas of chondrocyte depletion and fibrocartilaginous repair, with vertical cleft formation  
(D) severe synovitis with mononuclear infiltration and marked synovial hyperplasia  
(E) synovial fibrosis, intracellular iron accumulation, and minimal mononuclear infiltration

30. Which of the following drugs prevents clotting by acting directly on the active site of the enzyme thrombin?

(A) clopidogrel  
(B) eptifibatide  
(C) heparin  
(D) lepirudin  
(E) reteplase
31. You are undertaking a surgical dissection of the posterior triangle of the neck to remove a small tumor mass. Which of the following structures is at risk in the posterior triangle?

(A) accessory nerve  
(B) superior thyroid artery  
(C) thoracic duct  
(D) vagus nerve  
(E) vertebral artery

32. A 24-year-old male has a long history of an obsessive personality disorder. Which pain-control technique may be most efficacious for this patient?

(A) as needed pain medication (prn medication)  
(B) general anesthesia  
(C) hypnosis  
(D) patient-controlled analgesia (PCA)  
(E) placebo

33. An 18-year-old white male high school student visited the school clinic complaining of a diffuse, painful rash extending from his mid-thigh to his navel region. He indicates that one of his football teammates gave him topical hydrocortisone to initially treat a minor groin rash. Which one of the following tests is likely to be of little value for the diagnosis of this fungus?

(A) agglutination assays  
(B) cultivation on Sabouraud’s medium at pH 5.5  
(C) examination of the fungal colonies  
(D) growth on Sabouraud’s agar plates at a temperature of 25°C  
(E) microscopic examination of skin scrapings, hair, and nails

34. A 52-year-man who received an organ transplant during the previous year develops an acute, rapidly progressive pneumonia. Chest x-ray reveals a densely consolidated area in the lung which is subsequently biopsied. Based upon this information and the biopsy histology demonstrated in Figure 14-5, which of the following is the most likely diagnosis?

(A) aspergillosis  
(B) candidiasis  
(C) cryptococcosis  
(D) histoplasmosis  
(E) pneumocystosis

35. A 34-year-old male is referred to the Otorhinolaryngology department by his primary care physician because of repeated nasal infections. The patient presents with left-sided nasal swelling and obstruction, along with nasal discharge. A careful examination reveals a squamous cell carcinoma localized on his middle nasal concha. The latter is vascularized by which of the following vessels?

(A) anterior and posterior ethmoidal arteries  
(B) facial artery  
(C) greater palatine artery  
(D) superior labial artery  
(E) maxillary artery
36. An 18-month-old boy was referred to the pediatrics clinic because of persistent anemia and associated failure to thrive. Laboratory analysis confirmed a microcytic anemia and revealed blood lead-levels of 50 mg/dL (2 times normal levels) and high levels of coproporphyrinogen III in the urine. The child was put on chelation therapy and recovered uneventfully. The cause of the child’s difficulty was most likely due to the effects of lead which is the inhibition of which of the following enzymes of heme biosynthesis?

(A) delta-aminolevulinic acid (ALA) dehydratase  
(B) ferrochelatase  
(C) porphobilinogen (PBG) deaminase  
(D) proporphyrinogen III cosynthase  
(E) uroporphyrinogen decarboxylase

37. A previously healthy, 24-year-old man presents with a fever of 103°F, severe headache, vomiting, and a stiff neck of approximately 7 hours duration. Laboratory findings reveal blood glucose 115 mg/dL; WBC 17,000 per μL (75% PMNs, 12% bands, 10% lymphocytes, 3% monocytes); CSF cloudy, with glucose 20 mg/dL, protein 110 mg/dL, and 2,100 cells per μL with 95% PMNs. Of the following, which is the most likely diagnosis?

(A) amebic meningoencephalitis  
(B) cryptococcal meningitis  
(C) herpetic meningoencephalitis  
(D) intracerebral hemorrhage  
(E) meningococcal meningitis  
(F) subarachnoid hemorrhage

38. Which of the following describes the likely mechanism of action by which ezetimibe reduces LDL cholesterol?

(A) binding to peroxisome proliferator activator receptor-alpha (PPAR-α)  
(B) inhibition of HMG-CoA reductase and therefore cholesterol synthesis in the hepatocyte  
(C) inhibition of lipoprotein lipase in adipose tissue  
(D) inhibition of the NPC1L1 cholesterol transporter in the intestinal epithelium  
(E) reduction in VLDL secretion from the liver

39. After a weekend drinking binge, a 45-year-old male is bothered enough by his racing heart to go to the emergency room to get “fixed up.” Before administering any drug therapy to reduce his tachycardia, manual external massage of the carotid sinus is attempted. Which of the following changes can result from carotid sinus massage?

(A) decreased electrocardiographic R-R interval  
(B) decreased vagal tone to the heart  
(C) increased cardiac sympathetic nerve activity  
(D) increased carotid artery blood flow  
(E) increased carotid sinus afferent nerve activity

40. The activity of ACC is regulated, in part, by its state of phosphorylation. Within hepatocytes, in the presence of insulin and glucose, ACC will be unphosphorylated and active. However, if one were to mildly poison the cells with cyanide, leading to a partial block to oxidative phosphorylation, ACC becomes rapidly phosphorylated and inactivated, even if the insulin and glucose levels are unchanged. This phosphorylation is mediated by which of the following enzymes?

(A) AMPK  
(B) calmodulin-dependent protein kinase  
(C) glycogen synthase kinase 3 (GSK3)  
(D) PKA  
(E) PKC

41. A 7-year-old boy is brought to your office because he had developed some facial swelling and his urine was an unusual color. On physical examination, he is found to have moderate periorbital edema and mild hypertension. His mother states that, other than a sore throat 2 or 3 weeks ago, he has been in good health. Urinalysis reveals proteinuria with RBCs, WBCs, and cellular casts. Serum creatinine
levels are increased. The most likely diagnosis is which of the following?

(A) acute postinfectious glomerulonephritis
(B) acute pyelonephritis
(C) focal segmental glomerulonephritis
(D) lupus nephritis
(E) minimal change disease

42. “Clue” cells were discovered in a clinical specimen taken from a college sophomore experiencing vaginitis. Which organism listed below caused this infection?

(A) Candida albicans
(B) Escherichia coli
(C) Gardnerella vaginalis
(D) Mycoplasma hominis
(E) Trichomonas vaginalis

43. Which of the following drugs blocks bacterial but not mammalian topoisomerase?

(A) azithromycin
(B) clindamycin
(C) etoposide
(D) levofloxacin
(E) linezolid

44. A 57-year-old male patient is brought to a medical mission in a tropical country with tachycardia, tachypnea, hypotension, and fever. The patient displays abdominal tenderness and guarding. He has diminished bowel sounds but lung auscultation reveals basilar rales. The patient is diagnosed with acute pancreatitis and a parasitological test reveals ascaris blocking the pancreatic outflow. The pancreatic duct normally opens into which of the following?

(A) first part of the duodenum
(B) fourth part of the duodenum
(C) pylorus of the stomach
(D) second part of the duodenum
(E) third part of the duodenum

45. A non-vaccinated child experienced coughing, redness of the eyes, blue-white buccal lesions, and a rash. Which one of the following viruses produces a rash and has an RNA genome?

(A) herpesvirus
(B) measles virus
(C) molluscum contagiosum virus
(D) papovavirus
(E) variola virus

46. Which of the following is a drug that selectively inhibits the tyrosine kinase domain of the Bcr-Abl oncoprotein and is effective in chronic myelogenous leukemia?

(A) anastrozole
(B) fludarabine
(C) imatinib
(D) paclitaxel
(E) trastuzumab

47. A 65-year-old woman with a mild heart failure is climbing a flight of stairs and has to stop to rest because of acute dyspnea. At this time, the sympathetic nerves to the heart are causing which of the following?

(A) decreased atrial contractility
(B) decreased ventricular contractility
(C) depolarization of the atrioventricular node cells
(D) hyperpolarization of the sinoatrial node cells
(E) increased acetylcholine release at sinoatrial node nerve endings
48. A 62-year-old man presents with a long history of progressive exertional dyspnea. He states that he has an occasional dry cough and has been losing weight. You note that he has dyspnea with a relatively prolonged expiration. Chest x-ray reveals depressed diaphragms and a long narrow heart shadow. Microscopic examination of his lungs would most likely reveal which of the following?

(A) airspace enlargement and alveolar wall destruction
(B) airway dilation and scarring
(C) inflammatory scarring and obliteration of bronchioles
(D) mucous gland hyperplasia and hypersecretion
(E) smooth muscle hyperplasia and excess mucus production

49. A 59-year-old alcoholic man has a sudden onset of pneumonia with a sharp pleural pain and bloody sputum. The virulence of the etiologic microbe is associated with the presence of which of the following?

(A) cell wall teichoic acid
(B) M protein
(C) peptidoglycan
(D) pneumolysin
(E) polysaccharide capsule

50. A 17-year-old girl consults the doctor because she has not had her menses within the last 4 months. On questioning, she also describes being very sensitive to cold and being constipated. However, overall she feels well and does not see any need for treating these latter symptoms. Her weight is 34 kg (75lbs), her height 1.65 m (5 ft 4 in). A pregnancy test is negative. Results of a neurological examination are normal, and her axillary and pubic hair is normally developed. What is the most likely cause of her secondary amenorrhea?

(A) anorexia nervosa
(B) Celiac disease
(C) Crohn’s disease
(D) diabetes insipidus
(E) panhypopituitarism
1. (D) The medial segment of the globus pallidus projects to the ventral anterior as well as ventral lateral, dorsomedial, centromedian, and parafascicular nuclei of the thalamus. The medial segment also gives rise to pallidotegmental and pallidohabenular fibers. The caudate nucleus (choice A) and the putamen provide input to the globus pallidus and do not receive pallidal projections. The pars compacta of the substantia nigra (choice B) and subthalamic nucleus (of Luys; choice C) receive projections from the lateral segment of the globus pallidus. The ventral posterior lateral nucleus of the thalamus (choice E) receives projection fibers from the dorsal column-medial lemniscal system, as well as fibers from the anterolateral system. It does not receive fibers from the globus pallidus.

2. (B) The arrow points to an osteoblast at the surface of the bone matrix or osteoid (choice E). The osteoblast deposits additional matrix, mainly in the form of type I collagen and noncollagenous proteins. The chondroblast (choice A) is a cell of cartilage tissue and is not seen in this photomicrograph. The osteoclasts (choice C) are large, bone-resorbing cells that are also not present in this view. The osteocytes (choice D, arrow 2) are trapped within the osteoid.

3. (A) Family history of bipolar disorder is most relevant because it may indicate that the patient may be bipolar as well, and one should carefully look for evidence for bipolarity in this patient. Mood stabilizers may be needed if there is an indication that this patient may have bipolar disorder. Family history of all other conditions (choices B, C, D, and E) is important but perhaps not as immediately useful as that of bipolar disorder.

4. (C) Risperidone, atypical antipsychotic, is likely to be most helpful for positive and negative symptoms of schizophrenia. Valproic acid (choice E) is a mood stabilizer often used to treat bipolar disorder. Buspirone (choice A) is an antianxiety agent for generalized anxiety disorder. Fluoxetine (choice B) and transylcypromine (choice D) are antidepressants that may be useful in treating depression.

5. (C) Catatonia is a phenomenon in which the patient becomes mute and immobile. Waxy flexibility (cataplexy) may accompany this. Frontal lobe syndrome (choice D) is characterized by disinhibition and personality change. Cataplexy (choice B) is sudden loss of muscle tone as in narcolepsy. Hebephrenia (choice E) is a disorganized type of schizophrenia. Agitation (choice A) refers to a state of anxiety and increased motor activity.

6. (D) The Clinitest measures reducing substances so with the negative glucose test, the urinalysis indicates that a reducing substance other than glucose (for example galactose) is in this baby’s urine. As such, the Clinitest has lesser, not greater, sensitivity than a dipstick for glucose measurement (choice E). Choices A, B, and C do not result in false negatives on dipstick glucose tests.

7. (C) Conivaptan is a vasopressin antagonist recently approved for use in hyponatremia. Uncontrolled heart failure is often associated with increased ADH levels and hyponatremia as a compensatory response to the decrease in effective circulating blood volume. The V₂ receptor appears to be responsible for most of the renal effects of ADH and antagonism of ADH’s effects results in an increase in free water clearance and an increase in plasma sodium concentration. Hypertension (choice A) and hypokalemia (choice B) are caused by excess aldosterone, not ADH secretion in Cushing disease. Nephrogenic diabetes insipidus (choice D) causes hypernatremia if water intake is limited.
it is not associated with hyponatremia. Edema associated with cirrhosis (choice E) is caused by decreased plasma protein synthesis in the liver and elevated aldosterone levels, not ADH concentration.

8. (B) The clinical history and the gross and microscopic appearances of the lesion are compatible with those of a vocal cord polyp/nodule (called “singers’ nodules” if bilateral); these reactive lesions often arise as a result of excessive vocal cord strain, as may be the case with this elementary school teacher. Chronic inflammatory changes secondary to GERD (choice A) would not be expected, as reflux of material into the larynx/trachea is unusual. If reflux were to occur, it could result in local acute inflammation or progress to pneumonitis/pneumonia. Laryngeal squamous papillomas (choice C) would be expected to demonstrate cylindrical finger-like projections covered with well-differentiated, orderly squamous epithelium and supported by a fibrovascular core. Findings consistent with metastatic squamous cell carcinoma of the oral cavity (choice D) would include foci of pleomorphic squamous cells in the dermal and/or connective tissue layers with normal-appearing overlying mucosal epithelium. Similarly, squamous cell carcinoma of the larynx (choice E) would demonstrate invasion of a dysplastic or neoplastic mucosal epithelium, not simply a hyperplastic mucosa.

9. (B) Gas C does not reach equilibrium. This can be determined from Figure 14-2 since the pressure of gas C in the blood does not reach the 100% level, the level in alveolar air. Since it does not equilibrate, gas C is a diffusion-limited gas. For a diffusion-limited gas, uptake does not vary as a function of cardiac output. Answer B excludes answers A, C, D, and E.

10. (D) Respiratory syncytial virus is the major cause of bronchiolitis and pneumonia in infants less than a year old. Adenoviruses (choice A) can cause pneumonia with cough and fever, particularly among children >3 year old. Influenza virus (choice B) is not the most common cause of bronchiolitis in infants and is not associated with wheezing. Parainfluenza serotype 3 (choice C) in older individuals has mostly been associated with tracheobronchitis. Infections with rotaviruses (choice E) are especially common in children 1–24 months of age. However, these viruses cause diarrhea, not bronchiolitis.

11. (E) Pyruvate carboxylase is an enzyme of gluconeogenesis catalyzing the carboxylation of pyruvate to oxaloacetate. The major carbon substrate for gluconeogenesis is lactate produced by anaerobic glucose metabolism in skeletal muscle and red blood cells. Deficiencies in pyruvate carboxylase are the most common causes of lactic acidemia. Two primary forms of deficiency have been identified, simple and complex. The complex type presents shortly after birth with severe lactic acidemia accompanied by hyperammonemia, citrullinemia, and hyperlysinemia. Infants with this form of the disease rarely survive to 3 months of age. ACC (choice A) is the rate-limiting enzyme of fatty acid biosynthesis. It requires biotin as a cofactor thus, a deficiency in biotin will have a negative impact on the activity of the enzyme. Only a single case of an inherited deficiency in ACC has been reported. EFT-QO (choice B) is a protein through which electrons flow to ubiquinone in the respiratory chain. Glutaric acidemia type II, characterized by hypoketotic hypoglycemia and metabolic acidosis results from defects in EFT-QO. Neuronal GAD (choice C) is responsible for the synthesis of the neurotransmitter, GABA. However, the enzyme is present in numerous nonneuronal tissues. Clinical manifestations directly attributable to GAD deficiency have not been described. PEPCK (choice D) is an enzyme in the pathway of gluconeogenesis. Few cases of a deficiency in PEPCK have been reported. Although PEPCK is involved in the same pathway as pyruvate carboxylase, defects in the enzyme are rarely associated as a cause of lactic acidemia. Symptoms reported include hepatomegaly, hypotonia, hypoglycemia, and failure to thrive.

12. (D) Peutz–Jeghers syndrome is an autosomal dominant condition in which large numbers of hamartomatous polyps are found throughout the GI tract, particularly in the small intestine.
The hamartomatous polyps themselves are not premalignant, but these patients have an increased incidence of carcinomas at various sites, including the GI tract, breast, gonads, lung, and pancreas. Another characteristic finding in these patients is the appearance of pigmented macules in and around the mouth and over the genitalia and palmar surfaces of the hands. Familial polyposis coli (choice A) and Gardner syndrome (choice B) have the same genetic defect, are autosomal dominant, and are probably different expressions of the same disease process. Familial polyposis coli is associated with the occurrence of large numbers (hundreds to thousands) of adenomatous polyps throughout the large intestine and all of these patients eventually develop colon carcinoma unless a prophylactic colectomy is performed. Gardner syndrome in addition features extraintestinal lesions including osteomas of the skull, jaw, and long bones; epidermal cysts; fibromas of the skin; and fibromatosis of soft tissues. Juvenile retention polyps (choice C) are a fairly common finding in children and young adults. These hamartomas of the mucosa, typically found in the rectum, have no malignant potential. Turcot syndrome (choice E) is a very rare autosomal recessive condition in which there are multiple colonic adenomas that carry a high potential for malignant transformation. This condition is also associated with malignant brain tumors, in particular glioblastoma multiforme.

13. (A) Buspirone is not sedative, but it has anxiolytic effects that develop slowly over a week or more. All the other agents listed act through GABA modulation. Buspirone's action is not fully understood, but the drug has some affinity for 5-HT1A and dopamine D2 receptors. Buspirone lacks addiction liability and does not substitute for benzodiazepines or barbiturates in persons withdrawing from dependence on one of them.

14. (E) The cells shown here (Figure 14-3) are elongated (spindle) cells indicating a likely mesenchymal origin. Furthermore, the cells display vast pleomorphism and a few mitotic figures are present, making a malignant mesenchymal neoplasm the most likely choice. Of the tumors listed, the only one meeting these criteria is leiomyosarcoma of the uterus. Adenocarcinoma of the colon (choice A) is composed of malignant glandular cells. Basal cell carcinoma of the skin (choice B) is usually seen as islands of malignant basaloid cells attached to the epidermis and extending into the dermis. Around the periphery is a row of palisading cells with their nuclei parallel to one another. Fibroadenoma of the breast (choice C) and fibroma of the ovary (choice D) are benign tumors, not malignant. Undifferentiated small cell carcinoma of the lung (choice F) is a highly aggressive malignancy composed of round to oval cells with little cytoplasm that are derived from neuroendocrine cells of the lung.

15. (D) Congenital disorders of glycosylation (CDGs) represent a constellation of diseases that result from defects in the N-linked glycosylation pathway. To date there are 10 CDGs that have been classified. CDG-IIb is more commonly referred to as LAD II. LAD II belongs to the class of disorders referred to as primary immunodeficiency syndromes as the symptoms of the disease manifest due to defects in leukocyte function. Symptoms of LAD II are characterized by unique facial features, recurrent infections, persistent leukocytosis, defective neutrophil chemotaxis, and severe growth and mental retardation. The genetic defect resulting in LAD II is in the pathway of fucose usage, leading to loss of fucosylated glycans on the cell surface. An additional feature of LAD II is that individuals harbor the rare Bombay (hh) blood type at the ABO locus, as well as lack the Lewis blood group antigens. The defective neutrophil chemotaxis is due to the loss of a selectin ligand on these cells. This ligand is the sialylated Lewis^a antigen, another blood group antigen. The recurrent infections seen in LAD II patients are the result of the defective neutrophil function. Neutrophils are involved in innate immunity responses to bacterial infection. To carry out their role in host-defense mechanisms, neutrophils must adhere to the surface of the endothelium at the site of inflammation which is an event mediated by cell surface adhesion molecules. The selectin family (E-, L-, and P-selectins) of animal lectins are necessary to mediate the
The initial process of neutrophil adherence to the endothelium. The selectins recognize sialylated fucosylated lactosamines typified by the Lewisx antigen. Once neutrophils adhere and roll along the surface of the endothelium (due to vascular flow), the integrin family of adhesion molecules allow for firm adherence followed by tissue penetration. CDG-Ia (choice A) is the most commonly occurring CDG, with appearance in individuals of European ancestry being highest. Although there is considerable variability in the clinical phenotypes observed in CDG-Ia patients, there is always some level of psychomotor retardation. In addition, children are ataxic and have skeletal abnormalities consisting of long limbs and short torsos. Due to defective synthesis of coagulation factors by the liver (primarily factor XI, antithrombin III, protein C, and protein S), patients have severe coagulation defects. Adding to the situation is hepatomegaly with consequent liver dysfunction. CDG-Ia results from mutations in phosphomannomutase 2 (PMM2), the enzyme that is required to convert Man-6-P to Man-1-P used in the generation of GDP-Man. Fucosidosis (choice B) is caused by a deficiency in the lysosomal hydrolase alpha fucosidase. Originally, two classifications of fucosidosis were defined. Type I was the more severe with infantile onset and type II was the milder form. However, it has become apparent that individuals suffering from fucosidosis exhibit a continuum of symptoms with a wide spectrum of severity. The most severely afflicted individuals have psychomotor retardation, skeletal abnormalities, coarse facial features, and growth retardation. GM2 gangliosidosis (choice C) covers a constellation of diseases that result from defects in the degradation of GM2 gangliosides and related glycolipids. The degradation of GM2 gangliosides requires the complexing of the substrate with an activator protein (GM2 activator) and the enzyme, beta hexosaminidase, which itself consists of two distinct forms: alpha-beta and beta-beta. The alpha subunit is encoded by the HEXA gene and the beta subunit by the HEXB gene. The GM2 gangliosidoses include Tay-Sachs disease, Sandhoff disease, and GM2 activator deficiency. Tay-Sachs is caused by a defect in the HEXA gene and Sandhoff by a defect in HEXB. Schindler disease (choice E) is caused by a deficiency in the lysosomal hydrolase alpha-N-acetylgalactosaminidase. There are three forms of Schindler disease. Type I individuals appear normal for their first 9–12 months then a developmental delay sets in followed by increasing neurologic impairment and profound psychomotor retardation. The type II disease is an adult onset disorder characterized by mild intellectual impairment and angiokeratoma. Type III Schindler comprises an intermediate and a variable form, whose symptoms range from speech and language delay with autistic presentation to seizures and moderate psychomotor retardation.

16. **(B)** GLUT 2, a facilitated carrier, can only catalyze net glucose transport down a concentration gradient from a region of high to low concentration. On the other hand, SGLT 1, a secondary active transport protein, uses the sodium electrochemical gradient to move glucose against its concentration gradient. Neither transporter directly depends on ATP hydrolysis (choice A). GLUT 2 catalyzes passive transport that does not require energy. Though SGLT 1 does catalyze active transport, it is driven by an existing sodium electrochemical gradient, and does not directly catalyze ATP hydrolysis. Both of these transport mechanisms are carrier mediated (choice C) and as such both exhibit saturation (choice D) and in both glucose transport will be competitively inhibited by a related substrate (choice E).

17. **(E)** When transfusion with matching blood products is not possible, the best alternative is based on several factors, including immediate status of the patient, availability of blood products, potential incompatibility reactions based on the patient’s various blood group antigens, and so on. There are numerous red blood cell (RBC) blood group antigens (e.g., ABO, Rhesus [Rh], Kidd, Kell, P, etc.), as well as white blood cell and platelet antigens. Some antigens are commonly expressed on different cell types, while others are specific to a particular cell (e.g., platelet glycoproteins). The plasma component of whole blood contains a variety of antibodies, including ABO alloantibodies. The
two major blood group antigens of primary importance in transfusion therapy are ABO and Rh. Since this patient is a woman of reproductive age and is type B, Rh(−), she should not be given Rh(+) blood (choices C and D) as this would stimulate the production of anti-Rh antibodies. If this occurred and she subsequently were to become pregnant with an Rh(+) child, IgG anti-Rh antibodies could cross the placenta and destroy the baby’s RBCs, causing hemolytic disease of the newborn, or erythroblastosis fetalis. While ABO compatibility is critical, group O RBCs may be given to a group A, B, or AB patients if matching blood is not available as these red cells do not possess A, B, or AB membrane surface antigens against which a non-O patient’s immune system would react. Transfusing a group B patient with group A (choice A) or group AB RBCs is strictly forbidden in all but the most dire of cases as antibodies formed against A and AB antigens can bind complement and cause an acute hemolytic reaction. Transfusion with type O RBCs, rather than whole blood (choices B, D, and F), is optimal as anti-A, anti-B, and anti-AB alloantibodies are present in the plasma component of type O whole blood.

18. (E) Ropinirole is an orally active, nonergot D2-selective agonist. It has been used for parkinsonism and has recently been approved for restless legs syndrome. Amantadine (choice A) is a modulator of dopaminergic transmission but has no application in restless legs syndrome. Bromocriptine (choice B), a direct dopamine D2 agonist, entacapone (choice C), a catecholamine-O-methyltransferase inhibitor, and rasagiline (choice D), an MAO-B inhibitor, are all useful in parkinsonism but are of no value in restless legs syndrome.

19. (B) The time interval 0–6 h is called the eclipse period. During this period of viral growth cycle, the virus is absorbed to the host cell, enters the host cell, and the viral nucleic acid is separated from its capsid. The time period of 0–6 h is the eclipse period, and represents events that lead to loss, not retention, of viral infectivity (choice A). The time period of 6–8 hours represents a portion of the rise period, which marks the appearance of mature virus (choice C and D). The bacterial growth curve (choice E) is a bell-shaped curve composed of the lag phase (in which the cell population is constant), the logarithmic phase of growth (in which the number of cells increase in a geometric fashion, e.g., 1-2-4-8-16, etc.), the stationary phase (in which the cell population remains constant), and the phase of decline (in which the cells die in an exponential fashion).

20. (D) Differential diagnosis of neonatal hyperammonemia, as a consequence of a UCD can be accomplished by measurement of plasma citrulline and urinary orotic acid levels. Refer to Figure 3-6 which shows the standard differential diagnosis chart for determining which of four possible neonatal UCDs is the cause of the hyperammonemia. First the hyperammonemia appears in the absence of any significant acidosis or ketosis. If analysis of serum citrulline demonstrates undetectable levels then deficiencies in argininosuccinate lyase (choice B) and argininosuccinate synthetase (choice C) can be eliminated as causes of the symptoms. Assay for levels of urinary orotic acid will allow discrimination between carbamoylphosphate synthetase I and ornithine transcarbamoylase deficiency (choice E) deficiencies. Since the levels of orotic acid were found to be insignificant, the symptoms must be due to deficiency in carbamoylphosphate synthetase I. Deficiencies in arginase (choice A) do not lead to symptomatic hyperammonemia nor do symptoms manifest in the early postnatal period and so can be eliminated as a possibility.

21. (D) Patients with dramatizing, impressionistic (histrionic) personalities tend to respond better to generalities than specifics, unlike orderly, exacting (obsessive) personalities. Choice A will sound patronizing and choice B will tend to increase the level of distrust of the patient about the physician and the hospital, in addition to being patronizing. Choice C is likely to increase the patient’s anxiety to the point that she may not be able to hear or digest the information, unless she asks for it as in Choice D. Choice E will result in a mistrustful patient.
22. (C) The gross finding of a sharply demarcated, pale, and shrunken area of kidney is indicative of prior infarction with subsequent healing by scar formation. Renal infarcts are sharply demarcated, or wedge-shaped, due to the symmetric dichotomous branching distribution of the arcuate arteries that supply the renal pyramids. Following infarction, granulation tissue replaces necrotic parenchyma and the deposition of fibrous scar tissue is responsible for the pale appearance of the kidney, while scar contraction accounts for the shrunken appearance. Amorphous, eosinophilic material surrounded by giant cells and a rim of T-lymphocytes (choice A) describes the histological findings of a granuloma. Complex, branching papillomatous structures with numerous fronds projecting into a cystic space (choice B) is descriptive of a renal papillary adenoma, which would grossly appear as a small (<5 mm), pale yellow, encapsulated nodule. A mixture of neutrophils, extensive hemorrhage, and necrotic debris (choice D) is descriptive of morphological changes that would occur with an acute renal infarction; extensive hemorrhage particularly occurs in cases of renal vein thrombosis, which may arise in a variety of settings, most notably in patients with membranous glomerulopathy and accompanying nephrotic syndrome. Tubular necrosis with marked lymphocytic infiltration of the interstitium (choice E) is found in acute interstitial nephritis, which occurs secondary to drug-induced nephrotoxicity (e.g., penicillin derivatives [especially methicillin], sulfonamides, diuretics).

23. (D) The first major atypical breakthrough in neuroleptic therapy was with clozapine, a drug with a distinctly different receptor affinity profile and notably lower extrapyramidal toxicity than the older drugs, which were selected for their high affinity for D₂ receptors. Clozapine was followed by a series of dissimilar atypical agents with mixed receptor affinities and varied toxicities, but all of them show less extrapyramidal toxicity than the traditional agents.

24. (F) This man has the classical presentation of myocardial infarction. By 6 hours post-infarction, many substances have been released into the circulation from the injured cells. However, the only one that is relevant to myocardial cells (and has appropriate sensitivity and specificity) is troponin I. Amylase (choice A), creatinine (choice C), glucose (choice D), and lipase (choice E) are not increased following myocardial infarction. Increases in aspartate aminotransferase (choice B) can be seen but lack the necessary sensitivity and specificity to be of value.

25. (A) Enzyme inhibitors fall into two broad classes: those causing irreversible inactivation of enzymes and those the inhibitory effects of which can be reversed. Reversible inhibitors can be divided into two main categories; competitive inhibitors and noncompetitive inhibitors, with a third category, uncompetitive inhibitors, rarely encountered. Competitive inhibitors always bind at the catalytic or active site of the enzyme. Most drugs that alter enzyme activity are of this type. Since substrate and competitive inhibitors both bind at the same site, they compete with one another for binding. The greater the proportion of substrate, the greater the proportion of enzyme present in competent ES complexes, thus high concentrations of substrate can displace virtually all competitive inhibitor bound to active sites. Thus, it is apparent that Vmax should be unchanged by competitive inhibitors. This characteristic of competitive inhibitors is reflected in the identical vertical-axis intercepts of Lineweaver-Burk plots, with and without inhibitor (Figure 14-6). Since attaining Vmax requires appreciably higher substrate concentrations in the presence of competitive inhibitor, Km is also higher, as demonstrated by the differing negative intercepts on the horizontal axis in panel B. Analogously, panel C illustrates that noncompetitive inhibitors (choice B) appear to have no effect on the intercept at the x-axis, implying that noncompetitive inhibitors have no effect on the Km of the enzymes they inhibit. Since noncompetitive inhibitors do not interfere in the equilibration of enzyme, substrate and ES complexes, the Km is not expected to be affected by noncompetitive inhibitors, as demonstrated by x-axis intercepts in panel C. Noncompetitive inhibitors are expected to decrease Vmax, as illustrated by
the y-axis intercepts in panel C. A corresponding analysis of uncompetitive inhibition (choice D) leads to the expectation that these inhibitors should change the apparent values of \( K_m \) as well as \( V_{max} \). Changing both constants leads to double reciprocal plots, in which intercepts on the x and y axes are proportionately changed; this leads to the production of parallel lines in inhibited and uninhibited reactions (see panel D). Irreversible inhibitors, such as suicide inhibitors (choice C), usually cause an inactivating, covalent modification of enzyme structure. Irreversible inhibitors are usually considered to be poisons and are generally unsuitable for therapeutic purposes.

26. (D) Nephrogenic diabetes insipidus results from an insensitivity of the collecting duct cells to circulating antidiuretic hormone and thus the inability to concentrate the urine in response to increases in extracellular fluid osmolality. Since fluid is not conserved by the kidneys, polydipsia is necessary to maintain fluid balance. If drinking is prevented, the extracellular fluid osmolality will quickly rise, associated with an increased hematocrit, reflecting the dehydration. The increased extracellular fluid osmolality provides an osmotic gradient for water to leave the intracellular compartment and enter the extracellular fluid compartment, thus decreasing intracellular fluid volume. None of the other choices, A, B, C, or E, fit this pattern of changes.

27. (D) The clearance of inulin is used to calculate glomerular filtration rate (GFR) of plasma passing through the kidneys. The clearance formula involves multiplying the urine flow (1 mL/min) times the urine inulin concentration (100 mg/mL). Dividing this by the plasma inulin concentration (1 mg/mL) yields a GFR of 100 mL/min. Since renal plasma flowing through both kidneys is 500 mL/min, the 100 mL of plasma filtered at the glomerulus represents 100/500 or 20% of the total. Choice D excludes choices A, B, C, and E.

28. (E) The normal function of osteoclasts is removal of bone matrix, a process that is crucial both in regulation of circulating Ca\(^{2+}\) concentration and in modeling and remodeling of bones. Congenital failure of osteoclast function results
in development of thick, abnormally dense bones. The regulation of calcium concentration in plasma and tissue fluid depends on a dynamic system of hormone-mediated calcium removal and deposition in bone. Abnormal deposition of calcium in sites, such as the kidney and vessel walls (choice A), is a consequence of excessive calcium release from bone into circulation. This is a condition associated with inappropriately high activity of osteoclasts as a result of their stimulation by excessive PTH. Low levels of circulating calcium stimulate release of PTH, which stimulates calcium release from bone by osteoclasts. Osteoclast activity is an important component of the system, and failure of osteoclast function tends to reduce rather than increase (choice B) calcium in circulation. During bone development, osteoclasts are required for replacement of the initial spongy core of the bone by a marrow cavity. Thus, failure of osteoclast function results in reduced, not enlarged (choice C), marrow cavities. The consequences of this include deficient hematopoietic capacity. Individuals with osteopetrosis typically suffer from anemia and increased susceptibility to infections. Failure of osteoclasts to respond and the consequent failure of circulating calcium levels to return to normal would more likely result in increased, rather than decreased, PTH levels (choice D).

29. (D) The early articular symptoms of rheumatoid arthritis often appear in the hands, that is, the metacarpophalangeal and proximal interphalangeal joints. There is bilateral stiffness in the morning and following other periods of prolonged immobility, but this decreases with joint activity. The joints may be warm, tender, and painful with motion. Histological examination of an affected joint would most likely demonstrate a chronically inflamed synovium that is hyperplastic and edematous. Choice A is the histological appearance of gout; choice B describes acute bacterial arthritis; choice C refers to osteoarthritis; and choice E refers to hemochromatosis-associated arthropathy.

30. (D) Lepirudin is a recombinant form of hirudin, a direct thrombin inhibitor derived from the saliva of the leech. Clopidogrel (choice A) is an inhibitor that blocks the ADP receptor of platelets. Eptifibatide (choice B) is another platelet inhibitor and blocks the glycoprotein IIb/IIIa receptor, preventing fibrinogen binding. Heparin (choice C) is an indirect thrombin inhibitor that activates antithrombin III and increases its antithrombin action. Reteplase (choice E) is a recombinant form of human tissue plasminogen activator that is used for lysing preformed clots.

31. (A) The accessory nerve emerges from the posterior border of the sternocleidomastoid muscle and passes posteriorly across the posterior triangle to supply the trapezius muscle. The superior thyroid artery (choice B) arises from the external carotid artery in the carotid triangle and descends through the neck in the anterior triangle. The thoracic duct (choice C) enters the root of the neck on the left side under cover of the sternocleidomastoid muscle and empties at the junction of the internal jugular and subclavian veins. The vertebral artery (choice E) arises from the first part of the subclavian artery in the root of the neck and under cover of the sternocleidomastoid muscle. It is not related to the posterior triangle of the neck. The vagus nerve (choice D) descends in the neck within the carotid sheath. Superiorly it lies in the carotid triangle, and inferiorly it lies under cover of the sternocleidomastoid muscle.

32. (D) Because being in control is important to this orderly, controlling personality, PCA is especially effective for this type of patient (it is effective in almost all types of patients). As needed medication (prn) schedule (choice A) will tend to be troublesome since the patient may become dissatisfied with the lag time between the request and delivery. General anesthesia (choice B) may be seen by the patient as loss of control, as would hypnosis (choice C). Use of a placebo (choice E) with this type of patient is likely to be discovered, increasing his level of suspicion.

33. (A) Serological tests, such as agglutination reactions, are of little, if any value, for the diagnosis of dermatophytes because they tend to have common antigens and they grow in clumps.
Thus, homogeneous fungal cell suspensions are extremely difficult to produce and use in proper agglutination reactions.

34. (A) As an organ transplant recipient, this patient would have been receiving immunosuppressive therapy, thus making him susceptible to opportunistic infections—particularly of the lung. A number of different agents could have been responsible for this patient’s pneumonia; however, the microscopic image in Figure 14-5 reveals septate hyphae with narrow-angle branching that is typical of aspergillosis. Candidiasis (choice B) is identified by the formation of pseudohyphae with yeast forms. Cryptococcus (choice C) is caused by encapsulated yeast that display narrow-based budding. Histoplasmosis (choice D) is produced by small yeast that are parasitic within macrophages. The organism causing pneumocystosis (choice E) is a cup-shaped yeast that is identified by silver staining.

35. (A) The middle nasal concha is supplied by branches from the anterior and posterior ethmoidal arteries and branches from the sphenopalatine artery, on the lateral wall of the nose. The facial artery (choice B) contributes branches to the internal aspect of the nostrils. The greater palatine artery (choice C) supplies the hard palate and sends a branch through the incisive foramen to anastomose in the nasal septum. The superior labial artery (choice D) supplies anterior aspect of the nasal septum. The maxillary artery (choice E) does not directly supply the lateral wall of the nose.

36. (B) Three enzymes of the heme biosynthesis pathway are targets of the toxic effects of lead. These include ferrochelatase, ALA dehydratase (choice A), and ALA synthase with ferrochelatase sensitivity to lead being greatest and thus the most significant in lead poisoning. The ability to distinguish between inhibition of ferrochelatase and ALA dehydratase is the fact that high levels of coproporphyrinogen III were found in the urine. Since this heme biosynthetic intermediate is downstream of the ALA dehydratase-catalyzed reaction, inhibition of this enzyme would not result in the observed urine analysis result. Lead does not inhibit the activities of PBG deaminase (choice C), protoporphyrinogen III cosynthase (choice D) nor uroporphyrinogen decarboxylase (choice E).

37. (E) These are the typical symptoms and signs of meningitis and the CSF findings of decreased glucose, cloudiness, increased protein, and mostly PMNs indicate a bacterial etiology. Thus, of the six choices, this must be meningococcal meningitis. Amecic meningoencephalitis (choice A) could have clinical and laboratory findings similar to those of bacterial meningitis with the exception that the CSF has many red cells and may have identifiable trophozoites. However, this is much less common and therefore much less likely than bacterial meningitis. Cryptococcus (choice B) would follow a chronic course of weeks to months and would have predominantly lymphocytes in the CSF. Herpetic meningoencephalitis (choice C) would be expected to follow a more slowly evolving or subacute course and would demonstrate lymphocytes in the CSF with normal glucose levels. Intracerebral hemorrhage (choice D) and subarachnoid hemorrhage (choice F) act as space-occupying lesions increasing intracranial pressure, but are not associated with inflammation as seen in this case.

38. (D) Ezetimibe is the first member of a new class of antilipemic drugs that act on a transporter in the intestinal epithelium to inhibit absorption of cholesterol and related sterols. Unlike resins, ezetimibe is active in small doses and produces little gastrointestinal upset while more effectively lowering plasma cholesterol. Reduction in VLDL secretion from the liver (choice E) is an effect of niacin. Inhibition of HMG-CoA reductase (choice B) is the mechanism of action of the statins. Fibric acid derivatives (e.g., fenofibrate, gemfibrozil) bind PPAR-alpha (choice A) and are believed to cause decreased lipolysis in adipose tissue (choice C). They reduce triglycerides as well as cholesterol.

39. (E) Massage of the carotid sinus activates the pressure-sensitive baroreceptor nerve fibers, which is interpreted by the brainstem control centers as an increase in arterial blood pressure.
The baroreflex response to increased arterial pressure is an increase in vagal tone to the heart (choice B) and a decrease in cardiac sympathetic nerve activity (choice C). Together, these autonomic influences may slow the heart and thus increase the electrocardiographic R-R interval (choice A). Carotid artery blood flow will not increase (choice D) and if anything, will decrease in response to baroreflex maneuvers that decrease heart rate and blood pressure.

40. (A) AMPK is a central component of the cellular-signaling system responsible for monitoring the energy status of the cell. As its name implies, the enzyme is activated by AMP, which rises within cells as energy is consumed. One of the many targets of AMPK is ACC, the rate-limiting enzyme of fatty acid biosynthesis. When activated, AMPK will phosphorylate and thus inhibit the activity of ACC, thereby conserving ATP energy. In hepatocytes mildly poisoned with cyanide, the level of ATP production via the oxidative phosphorylation machinery will be compromised leading to increases in AMP and an activation of AMPK. This will occur even in the presence of glucose and insulin. Glucose oxidation would yield ATP, but not at levels sufficient to overcome the block to oxidative phosphorylation. Insulin-mediated responses normally would lead to an increase in ACC activity, but the phosphorylation by AMPK will counter any activation. Although changes in energy status can lead to changes in the overall rate of activity of the other enzymes (choices B–D), none would be as dramatically influenced as that of AMPK.

41. (A) This boy has nephritic syndrome and since he recently had a sore throat but was otherwise in good health, the most likely diagnosis is postinfectious (poststreptococcal) glomerulonephritis. Acute pyelonephritis (choice B) is unusual in a young healthy boy. Also it is usually accompanied by changes in urination (frequency, burning, nocturia), fever, and malaise not seen in this patient. Focal segmental glomerulosclerosis (choice C) is associated with the nephrotic syndrome, not the nephritic syndrome. Patients with lupus nephritis (choice D) can present with either nephritic or nephrotic syndrome but this boy, already an unlikely candidate for this disease, has no signs or symptoms of having lupus. Minimal change disease (choice E) is the most common cause of nephrotic syndrome in children and does not cause the nephritic syndrome.

42. (C) G. vaginalis is a gram-negative or gram-variable (older cultures) coccobacillus that can be routinely isolated from the normal female genitourinary tract. It is associated with vaginosis (inflammatory cells are absent), called bacterial vaginosis to distinguish it from candidiasis. G. vaginalis infections yield “clue cells,” vaginal epithelial cells covered with many gram-variable bacilli. Usually, an absence of other common causes of vaginitis (yeasts or trichomonas) would be determined. Such infections with G. gardinella are often asymptomatic or present with occasional abdominal pain and a moderate white-grey discharge, which may have a “fishy” odor. Metronidazole will usually control these infections. None of the other choices (A, B, C, and E) have been reported as having “clue” cells present as part of their infections.

43. (D) Levofloxacin, like other fluoroquinolones, selectively blocks bacterial topoisomerase II and IV and are active against both gram-negative and gram-positive organisms. Because of this relatively broad spectrum of action, they have been overused and resistance to the group is becoming more common. Azithromycin (choice A) is a macrolide and inhibits bacterial RNA polymerase by binding the 50S moiety. Clindamycin (choice B) also binds to the 50S subunit of bacterial ribosomes; cross resistance with macrolides is common. Etoposide (choice C) is not antibacterial but blocks topoisomerase in rapidly dividing mammalian cells; it is used in cancer chemotherapy. Linezolid (choice E) is a newer antibacterial RNA polymerase inhibitor that binds the 50S subunit and prevents formation of initiation complexes. Cross resistance with macrolides is not common.

44. (D) The pancreatic duct joins with the common bile duct at the ampulla of Vater and opens by way of the sphincter of Oddi into the second part of the duodenum. All other segments of the
duodenum (choices A, B, and E) and the pylorus of the stomach (choice C) are incorrect.

45. (B) Measles is a highly contagious childhood disease, which is associated with a maculopapular rash, fever, and respiratory symptoms. Measles virus is an enveloped, single-stranded RNA, linear, nonsegmented, negative-polarity virus. Some types of herpes virus (type 1, 3, 6) (choice A) and variola (choice E) are associated with production of rash. However, both variola and herpesvirus are double-stranded DNA viruses. Molluscum contagiosum virus (choice C) is an enveloped double-stranded DNA virus that causes small, pink, papular wart-like benign skin tumors. Papovaviruses (choice D) are double-stranded DNA viruses that cause lytic and transforming infections, warts, and cervical carcinoma.

46. (C) Imatinib (Gleevec) is a small molecule inhibitor of the tyrosine kinase associated with the Bcr-Abl oncoprotein found in the Philadelphia chromosome translocation and is remarkably effective in chronic myelogenous leukemia, a neoplasm heretofore resistant to most chemotherapeutic drugs. It has produced full remissions in many patients and apparent cures in some. Anastrozole is an inhibitor of the aromatase that converts precursors to estrogens in the body. It is used in advanced breast cancer. Fludarabine (choice B) is a purine antagonist effective in non-Hodgkin’s lymphoma and chronic lymphocytic leukemia. Paclitaxel (choice D) is a natural product that inhibits microtubule disassembly and blocks mitosis. It is useful in breast and ovarian cancer and some other solid tumors. Trastuzumab (choice E) is a human antibody to the HER-2/neu receptor, which is overexpressed in a significant number of breast cancers.

47. (C) The autonomic response to an inability to maintain cardiac output during exercise includes increasing sympathetic autonomic tone to the heart. Norepinephrine release at the atrioventricular node cells results in depolarization and thus more rapid conduction of excitatory impulses to the ventricles. At the same time, norepinephrine release increases, not decreases contractility of the atrial muscle (choice A) as well as ventricular muscle (choice B). Sympathetic nerves also release norepinephrine at sinoatrial node nerve ending (not acetylcholine, choice E) and increase heart rate via depolarization, not hyperpolarization (choice D) of the sinoatrial node cells.

48. (A) Dyspnea, cough, weight loss, and prolonged expiration are usual findings in emphysema. Further evidence is provided by the chest x-ray findings where the overinflation of the lungs has led to depression of the diaphragms and elongation of the heart shadow. The histological findings in emphysema are airspace enlargement and alveolar wall destruction. Airway dilation and scarring (choice B) or irregular emphysema is a fairly common finding at autopsy but in most cases is not of clinical significance. Inflammatory scarring and obliteration of bronchioles (choice C) describes bronchiolitis obliterans, which may be seen in several different conditions including inhalation of irritant gases and chronic bronchitis. Mucous gland hyperplasia and hypersecretion (choice C) are found in chronic bronchitis and smooth muscle hyperplasia and excess mucus production (choice E) are found in asthma.

49. (E) The importance of the capsule in the virulence of the pneumococcus is apparent from the observations that only encapsulated strains are virulent, and vaccine efficacy is type specific (the organisms are divided into more than 80 types on the basis of antigenic differences in the capsular carbohydrate composition). Cell wall teichoic acids (choice A) and peptidoglycan (choice C) are found in pneumococci, and are not involved in the pathogenesis of pneumonia. M protein (choice B) is a potent anti-phagocytic cell wall component of group A streptococci, not pneumococci. Pneumolysin (choice D) is a cytolytic enzyme for pneumococci not human cells, and plays no important documented role in the pathogenesis of pneumonia.

50. (A) Anorexia nervosa is a neurological problem, which predominantly, but not exclusively, affects adolescent girls and young adult women. Patients refuse to maintain minimum lean body
mass levels, which would for this woman be about 90 lbs at a height of 5 ft 4 in. In 90% of the cases, anorexia nervosa leads to secondary amenorrhea, defined as the lack of at least three consecutive menses. People with anorexia nervosa feel cold or are sensitive to cold due to a lowered body temperature as a result of the loss of healthy insulating layers of fat. Cramps, bloating, and constipation are common symptoms due to decreased bowel activity. Although anorexia nervosa is a serious, life-threatening disorder, patients rarely acknowledge having an eating disorder until starvation leads to organ failures. Celiac disease (choice B) presents with diarrhea, not constipation due to the fact that unabsorbed food binds water. Malabsorption is a result of immune-induced damage to the mucosal surface of the small intestine. Diarrhea, together with abdominal pain, is also one of the most common symptoms of Crohn’s disease (choice C), a chronic inflammatory disease of the intestines. For diabetes insipidus (choice D), excessive urination (polyuria) would be expected. Panhypopituitarism (choice E) is defined as the lack of all anterior pituitary hormones. Although the lack of FSH and LH could explain her amenorrhea, her normal body hair does not support this diagnosis.
Index

A
A and B cells, 12, 38
“A wave,” 61, 86
Abdominal aorta, 4, 19, 32, 44
Abdominal aortic aneurysm, 246, 275
Abdominal cavity, 9, 35
Abdominal hernia, 25, 50
Abducens nerve, 2
Abnormal gene mutation, 27, 52
Abnormal involuntary movement scale (AIMS), 463, 472
Abscess, healing of, 237, 264–265
Absence seizures, 291, 308–309, 380, 393
Abstract thinking, 338, 345
ACC (acetyl-CoA carboxylase), 443, 455
Accessory nerves, 487, 498
Accident trauma, 67, 92
ACE (See Angiotensin-converting enzyme)
ACE inhibitor treatment
fetal agenesis, 304, 328
cardiac malformation, 304, 328
doing heart failure, 302, 325
of hypertension, 302, 325
Acetabulum, 29, 54
Acetylcholine, 289, 307
Acetylcholine esterase inhibitors, 78, 104
Acetyl-CoA, 111, 112, 137, 139
Acetyl-CoA carboxylase (ACC), 443, 455
Acid distribution, 117, 148
Acidemia, 65, 89
Acidophil secretion, 15, 41
Acidosis (See also Metabolic acidosis)
acute respiratory, 420
renal tubular, 73
respiratory, 417, 426
Acid-peptic disease, 304, 328
Acquired immune deficiency syndrome (AIDS)
C. parvum, 176, 199
and candida, 237, 264, 357, 369
fungal infections, 237, 264
M. avium-intracellulare, 186–187, 211–212
P. carinii, 178, 201
Acromegaly, 69, 94, 124, 160
ACTH (See Adrenocorticotropic hormone)
Actin, and dystrophin, 30
Action potentials
of cardiac nodal cells, 63, 88
and potassium conductance, 76, 101–102
Acute dyspnea, 489, 501
Acute frontal sinusitis, 469, 479
Acute glomerulonephritis, 62, 87, 444, 457–458
Acute heart failure, 294
Acute hemorrhagic pancreatitis, 16, 41–42
Acute infectious mononucleosis, 380, 393
Acute intermittent porphyria (AIP), 110, 135
Acute meningitis, 462–463, 471–472
Acute pancreatitis, 246–247, 276
Acute postinfectious
glomerulonephritis, 489, 500
Acute psychosis, 340, 346
Acute respiratory acidosis, 420, 431
AD (See Alzheimer’s disease)
ADA, 123, 157
Adaptive response, 70, 95
Addison disease, 58, 82
Adductor muscles, 26, 52
Adema, adrenal, 76, 101
Adenocarcinoma, 237, 264, 401, 412–413
Adenocarcinoma, pancreatic, 242, 270
Adenoma, pleomorphic, 352, 362
Adenosine, 129, 166
Adenosine deaminase deficiency, 123, 157
Adenosine diphosphate deficiency, 354, 365–366
Adenovirus, 191, 195, 217, 224
ADHD (See Attention deficit hyperactivity disorder)
ADH (See Antidiuretic hormone)
ADHD, 337, 347
Adipocytes, 130, 168
Adolescence, 337, 343
ADP, 354, 365–366
Adrenal cortical adenoma, 239, 267
Adrenal enzyme 21-β-hydroxylase, 66, 91
Adrenal neuroendocrine axis suppression, 62, 87
Adrenocorticotropic hormone (ACTH), 60, 66, 85, 91
Adrenogenital syndrome, 66, 91
Adult respiratory distress syndrome, 239, 267
Advanced renal failure, 244, 274
Agnammaglobulinemia, congenital, 179, 201
Agenesis, fetal, 304, 328
Agglutination assays, 487, 498–499
AGN, 444, 457–458
Agoraphobia, with panic attack, 336, 342
AIDS (See Acquired immuno deficiency syndrome)
AIMS, 463
AIP (See Acute intermittent porphyria)
Airway obstruction, 65, 89
ALA (See Delta-aminolevulinic acid)
ALA synthase, 462, 471
Albumin concentration, 62, 86–87
Alcohol abuse
and macrovesicular fatty change, 238, 265
and naltrexone, 292, 310
and pneumonia, 186, 210–211
and porphyria cutanea tarda, 110, 134
squamous cell carcinoma of the esophagus, 241, 269–270
Alcoholic hepatitis, 398, 410
Alcoholic liver cirrhosis, 442, 454
Aldosterone
and ACE, 110, 134–135
Conn’s disease, 122, 155
deficiency in, 73, 98
kidney sodium reabsorption, 113, 139
and potassium clearance, 76, 102
primary aldosteronism, 122, 155
and primary aldosteronism, 122, 155
and RTA, 73, 98
and sodium reabsorption, 113, 139
Aldosteronism, primary (See Primary aldosteronism)
Aldinization, urinary, 295, 314
Alkalosis, respiratory, 74, 99
Allergic asthma, 62–63, 87
Allergic rhinitis, 466, 476
Alpha blocker, 298, 320
Alpha motoneurons, 21, 46
Alpha-adrenergic agonist, 466, 476
Alpha-adrenergic receptors, 58, 83
Alpha-collagen gene defect, 116, 144–145
Alpha-galactosidase A deficiency, 109, 133
Alprazolam withdrawal, 336, 342
Alveolar air, 65, 89
Alveoli, in lungs, 378, 391
Alzheimer’s disease (AD), 78, 104
dementia, 254–255, 285
and Down syndrome, 337
Amadori rearrangement, 150
Amantadine, 176, 199
Ambiguous nucleus, 25, 51
Amenorrhea, and dopamine, 439, 449
Aminopyridines, 72, 97
Amiodarone, 423, 435, 469, 480
Amnestic syndrome, 374, 383
Amoebic dysentery, 194
AMP-activated protein kinase (AMPK)
and ATP/ADP ratio, 376, 386
and metformin, 444, 456
and phosphorylation, 488, 500
AMPK (See AMP-activated protein kinase)
Amprenavir, 398, 409
Amygdala, 7, 33–34
Amyloidosis, 454
Amyotrophic lateral sclerosis, 444, 456
Anaphylaxis, by penicillin, 187, 212–213
Anaplasia, 252–253, 283
Anastomosis procedure, 20, 45
And microcytic anemia, 143
Andersen disease, 111, 138
Anemia
and folic acid deficiency, 126, 163
hypoproliferative, 231, 258
macrocytic, 71, 97, 126, 163
megakaryoblastic, 129, 168
microangiopathic hemolytic, 237, 264
microcytic, 75, 100, 115, 143
pernicious, 247, 277, 294, 312
Anencephaly, 7, 34
Anesthesics, inhaled, 299, 321
Anurism, abdominal aortic, 64, 88
Angina pectoris, 290, 307–308
Angioedema, 183, 206–207
Angiob fibroma, juvenile, 230, 257
Angiotensin II, 294, 313
Angiotensin-converting enzyme (ACE), 110, 134–135, 294, 313
Animal bite infections, 187, 212
Anorexia nervosa
and excessive vomiting, 58, 83
and secondary amenorrhea, 490, 501–502
Antacids, 301
Anterior cruciate ligament, 16, 41–42
Anterior inferior cerebellar artery, 463, 472
Anterior pituitary lactotrophs, 116, 146
Anterior spinal artery, 3, 31
Antidepressants, 305, 328–329
cardiotoxic effects of, 291, 309
sedative effects, 298, 318
sedative effects of, 298, 318
SSRIs, 305, 328–329
Antidiabetic agents, 293, 311
Antidiuretic hormone (ADH), 386
and extracellular fluid osmolality, 57, 67, 68, 82, 92, 93
and lung cancer, 69, 94
neurogenic diabetes insipidus, 78, 104
and neurogenic diabetes insipidus, 78, 104
production of, 69, 94
and water deprivation, 67, 92
Antiemetic drugs, 303, 327
Antifungal drugs, 292, 310
Antigen-IgE complexes, 127, 164
Anti-insulin antibodies, 59, 84
Anti-mold immunoglobulin, 186, 210
Antipsychotic drugs
autonomic toxicity, 304, 328
chlorpromazine, 69, 95
and dopamine receptors, 379, 392
extrapyramidal effects, 304, 328
Antipsychotic neuroleptic agents, 485, 496
Antithrombin III, 396, 405–406
Antitubercular agents, 297, 316
Antiviral protein (AVP), 176, 199
Antral gastritis, 183, 206
Anxiety, 340, 341, 346
Aortic arch, double, 25, 51
Aortic blood pressure, 64
Aortic valve sclerosis, 71, 96–97
Aortic valve stenosis, 73, 98
Aortic valvular sclerosis, 71, 96–97
Apasia conduction, 15, 40
Apical ectodermal ridge, 16, 41
Apo B<sub>48</sub>, 124, 159
Apo B<sub>100</sub> 439, 449–450
Apolipoproteins, 116, 146
Apparent volume of distribution, 349, 359–360
Appendicitis, acute, 19
Aquocous humor synthesis, 304, 327
Arcuate fasciculus, 15, 40
Arginine, 122, 155, 424, 436
Argininosuccinate synthetase, 109, 132, 446, 458
Arrhythmias, 298, 320, 354, 365
Arsenic poisoning, 403, 415
Arterial clot, 296, 316
Arterial pressure
and carotid sinus nerves, 63, 88
and Ohm’s Law, 66, 91
pulse, 68, 93
Arthritis
gouty, 464
osteoarthritis, 236
rheumatoid (See Rheumatoid arthritis)
Arytenoids cartilages, bulky, 2
AS (argininosuccinate synthetase), 446
ASD, 109, 132
Aseptic meningitis, 196, 226
Aspartate transcarbamoylase, 122, 155
Aspartic acid, 121, 154
Aspergillosis, 403, 416, 487, 499
Aspirin
anticoagulant effect of, 111, 137
and body temperature, 445, 457
bronchoconstriction due to, 379, 391
and myocardial infarct, 295, 314–315
Asthma
allergic, 62–63, 87
bronchoconstriction, 298, 318–319
mast cell stabilization, 290, 308
and mast cell stabilization, 290, 308
treatment, 467, 477
Astrocytoma, 254, 284–285
Astroglioma, 28, 54
Asynery, 12, 38
Ataxia, 12, 38
ATC, 122, 155
Atenolol, 353, 364
Atmospheric pressure, decreased, 70, 95
ATP/ADP ratio, 376, 386
Atrial contraction, 61, 86
Atrial fibrillation, 300, 323
and P-waves, 73, 98
thromboemboli, 229, 256
Atrial septal defects, 356, 367–368
Atrial stretch receptors, 62, 87
Attention deficit hyperactivity disorder, 337, 347
Atypical antipsychotic drugs, 485, 496
Autoimmune disorders (See specific types, e.g.: Myasthenia gravis)
Autoimmune thyroiditis, 69, 94
Autonomic toxicity, 304, 328
AVP (antiviral protein), 176, 199
saw palmetto, 300, 322–323
AZT (azidothymidine), 189, 215
B
B. anthracis, 178, 201
B. coccus, 196, 225
B. dermatitidis, 375, 384–385
B. pertussis, 191, 196, 217–218, 226
B. recurrentis, 182, 205
Babinski’s sign, 21, 46
Bacteria
aerobic, 193, 220–221
anaerobic, 185, 190, 193, 209, 220–221
Bacterial growth rate, 186, 211
Barrett esophagitis, 250, 279–280
Basal cell carcinoma, 244, 273, 379, 392
Basilar artery, 7, 33, 463, 472
B-cell immunodeficiency disorder, 182, 188, 205, 213
Bell’s palsy, 17, 43
Benedikt’s syndrome, 4, 32
Benzodiazepine withdrawal, 336, 342
Benzodiazepines, 378, 391
Beta-adrenergic agonist, 58, 84
Beta-globin gene promoter defect, 115, 143
Beta-lactam antibiotics, 292, 310
Beta-lactamase-producing organisms, 290, 308
Beta-migrating VLDL, 120, 152
B₄₈, 128, 165
Bicarbonate ions, 376, 386
Biceps brachii, 8, 15, 34, 41
Bicornuate uterus, 19
Bilateral adrenal cortical hyperplasia, 246, 276
Bile acid, malabsorption of, 75, 101
Bilirubin, 67, 93
Bilirubin-UDP-glucuronyltransferase, 124, 159
Bipolar disorder, 440, 450, 481, 491
Bisphosphonate drugs, 289, 307
Bithermal caloric test, 58, 83
Bleomycin, 461, 469–471, 480
Blindness, functional, 59
Blood
carbon dioxide in, 62, 87
and carbon monoxide, 67, 92
flow of, from kidneys, 77, 103
loss of, 61, 86
Blood coagulation, 126, 131, 162, 170
Blood cultures, contamination of, 232, 259
Blood glucose control, 73, 81, 98–99, 107
Blood pressure, 64, 88
Blood testing (See Serological testing)
Blood transfusion, 484, 494–495
Blood-gas partition coefficient, 299, 321
Bone marrow
cellular changes in, 10, 36
and hematopoiesis, 464, 474
and sargramostim, 299, 321
transplantation, 177, 200
Botulinum toxin, 291, 309
Botulism, 193, 220
Bradycardia, reflex, 298, 319
Brachial arch, 1
Branchial cleft cyst, 246, 276
Breast cancer, 19, 44, 303, 327
Breast enlargement, 122, 156
Bromocriptine, 421, 432–433
Brucellosis, 176, 199–200
Bromochloride, chronic, 234, 261
Bronchoconstriction
and allergic asthma, 62–63, 87
asthma, 298, 318–319
Bromocholism, 290, 308
Brucella melitensis, 176, 199–200
Brucellosis, 176, 199–200
Brunchet disease, 179, 182, 201, 205
Buccal nerve, 8, 35
Buccinator muscle, 17, 43
Burkitt lymphoma, 250–251, 281
Burn infections, 185, 209
Bupivacaine, 441, 451–452, 483, 493
Butterfly tumor, 254, 284–285
C
C. albicans, 422, 434
C. botulinum, 419, 429
C. jejuni, 444, 456
C. parvum, 176, 199
C. perfringens, 196, 225, 448, 460
Calcitonin, 27, 52, 230, 257
Calcitrol, 122, 155
Calcium, 61, 86, 293, 312
Calcium channel blockers, 290, 307–308
Calcium load, filtered, 62, 87
Calcium-dependent molecules, 26, 52
Calmodulin, 125, 161
Camptothecins, 422, 434
Cancer chemotherapy, 303, 327
Candida infections, 180–181, 203–204, 237, 264, 357, 369
Carbon dioxide, 62, 69, 87, 94
Carbon monoxide absorption in blood, 67, 92
diffusion-limited gas, 67, 92
and heme oxygenase, 110, 136
poisoning, 353, 363
Carbuncles, 402, 414–415
Carcinoma of the pancreas, 338, 344
Cardiac decompensation, 294, 313
Cardiac output
and heart rate, 60, 85
and stroke volume, 60, 85
and sympathetic nerves, 70, 96
Cardioactive steroids, 78, 105
Cardiogenic shock, 296, 315
Cardiomyopathy, hypertrophic, 245, 275
Carnitine, 128, 165–166
Carnitine palmitoyltransferase (CPTI), 113, 140
Carotid artery, 7, 29, 33, 54
Carotid sinus, 63, 88, 488, 499–500
Catabolic enzyme defect, 233, 260
Cataract location, 9, 36
Catatonia, 450, 482, 491
Catecholamine release, 67, 92
Caudal neuropore, malclosure of, 7, 34
CCK (See Cholecystokinin)
CD4+ T lymphocytes, 464, 474
Celiac disease, 61, 86, 234, 261
Cell adhesion molecules, 26, 52
Cell-cycle arrest, 123, 157
“Central seven” symptoms, 46
Centroacinar cells, 16, 41–42
Cerebral arteries
and basilar artery, 7, 33
and lateral medullary syndrome, 4, 32
strokes in, 18, 43
Cervical carotid dissection, 6, 33
CF (See Cystic fibrosis)
C-fibers, 338, 344
CGD (See Chronic granulomatous disease)
Chancroid, 185, 210
Charcot-Marie-Tooth disease, 27, 52
Chemotherapy
antiemetic drugs for, 303, 327
and cyclophosphamide, 417, 426
and T-cell deficiency, 356, 367
Chickenpox, 189, 215
Chief (peptic, zymogenic) cells, 4, 32
Chlamydae, 176, 199
Chlorine, as microbial disinfectant, 180, 203
Chlorpromazine, 69, 95
Cholangitis, 369–370
Cholecystokinin, 66, 90, 441, 452–453
Cholecystomy, 28, 53–54
Cholesteatoma, 241, 269
Cholesterol
and hypercholesterolemia, 111, 137
inhibition of, 294, 312
reduction of, 302, 324–325
Cholinesterase inhibitor poisoning, 293, 312
Chondromas, 373, 382
Chorda tympani, 441, 451
Chordoma, 377, 388
Choriocarcinoma, 294, 312
Chromaffin cells, 398, 410
Chromatin remodeling, 112, 138–139
Chronic adrenal insufficiency, 57, 82
Chronic autoimmune thyroiditis, 251, 281
Chronic bronchitis, 234
Chronic granulomatous disease, 253, 283
cause of, 461, 470
and S. aureus, 356, 367
Chronic myelogenous leukemia, 489, 501
Chronic myeloid leukemia, 417, 426–427
Chronic obstructive pulmonary disease (COPD), 196, 225
Chronic otitis media, 241, 269
Chronic pyelonephritis, 369, 383–384
Chronic renal disease, 57, 82–83
Chronic renal failure, 72, 97, 485, 496
Chronic renal insufficiency, 65, 90
Chronic rheumatic heart disease, 443, 455
Chronic salpingitis, 439, 450
Chronic sinopulmonary disease, 126, 163–164
Chvostek sign, 79, 105
Chyle, 14, 40
Chylophilic, 124, 159
Ciliary muscles, 65, 89
Circadian rhythms, 374–375, 384
Cirrhosis, 385
alcoholic liver, 442, 454
and hemochromatosis, 396, 407
hepatic, 375, 385
liver, 20
Citalopram, 357, 368
Citric acid cycle, 119, 140
Citrolycine, 119, 140
Citronella, 180, 203
Clindamycin, 369, 379
Clostridia infection, 180, 202–203
Clots
arterial, 296, 316
formation of, 76, 102
platelet aggregation, 296, 316
Clotting factors, 130, 169, 293, 311–312
“Clue cells,” 489
Coagulation cascade, 240, 268
Coagulativ necrosis, 234, 262
Cocaine, 291, 309, 338, 344
Cochlea, 59, 84
Cochlear nuclei, 14, 40
Codeine, and μ-type opioid receptors, 301, 324
Colchicine, and gouty arthritus, 464, 474
Cold virus, 187, 213
Colestipol, 357, 369
Colon obstruction, 229, 257
Color obesity, 74, 99–100
Coma, and hyponatremia, 66, 91
Comatose patients, 467, 476–477
Communicating (gap) junction, 27, 52
Complement-fixation procedures, 183, 206–207
Component of complement, 183, 206–207
Components of complement deficiency, 184, 207
Concomitant stress, 340, 346
Conduction aphasia, 15, 40
C1 (See Component of complement)
C1 nerve, 375, 385
Confirmatory tests, 397, 409
Congenital adrenal hyperlasia, 246, 276
Congenital coartation of the aorta, 350, 361
Congo Red staining method, 442, 454
Conjugate base, and acid distribution, 117, 148
Conjugate base distribution, 117, 148
Conn syndrome, 235, 262–263
aldosterone, 122, 155
Connexins, in communicating junction, 27, 52
Conscious proprioceptive information, 75, 100–101
Constipation, 377, 388
Contact dermatitis, 191, 218–219
Contraceptives, oral, 243, 272
Contraction (of heart), 61, 86
Convection currents in endolymph, 58, 83
COPD, 196, 225
Copper absorption defect, 113, 140–141
Copper metabolism disorder, 232, 260
Cord factor, 179, 202
Cornea innervation, 25, 50
Corona-associated virus, 178, 201
Coronary vasospasm, 440, 450
Cortical collecting duct, 77, 103
Corticobulbar system, 46
Cortical spinal injury, 21, 46
Corticosteroids, 293, 311
Cough reflex, 70, 95
Coxsackie group B virus, 176–177, 200
CPS-1, 111, 131
CPTI, 113, 140
Cranial nerve IX, 23, 48
Cranial nerve V (trigeminal nerve), 25, 50
Cranial nerve VII, 20, 46
Creatine phosphate, 424, 436
Creatinine
glomerular filtration rate, 74–75, 100
organ transplant rejection, 292–293, 311
and skeletal muscles, 129, 166–167
Cretinism, 241, 269
Creutzfeld-Jacob disease (CJD), 183, 207, 244, 273
Cricothyroid muscle, 26, 51
Crigler-Najjar syndrome, type I, 124, 159
Crohn’s disease, 376, 387
Culdocentesis, 9, 35
Cutaneous anthrax, 178, 201
Cutaneous vasculature, 70, 96
Cyanotic heart disease, 3
Cyclooxygenase, 111, 137
Cyclosporine, 464, 473
Cystic acne, 396, 406–407
Cystic fibrosis (CF), 126, 163–164, 252, 282
Cytoplasmic steroid receptor, 289, 307
D
De novo pyrimidine biosynthesis, 122, 155
Death, proximate cause of, 236, 263
Deep peroneal (fibular) nerve, 14, 39
Deep pressure, 421, 432
Defense mechanisms, 447, 459
Degenerative central nervous system diseases, 183, 207
Dehydration, 376, 386
acute, 73, 98
and baroreceptor firing rate, 73, 98
and delirium, 336, 343
and extracellular fluid osmolality, 68, 93
and serum electrolyte levels, 335, 342
and tubular fluid osmolality, 68, 93
Delayed-type hypersensitivity, 177, 200
Delirium, 335, 336, 342, 343
Delta cells, 423, 435
Delta-aminolevulinic acid (ALA), 110, 115, 135, 143
Delta-aminolevulinic acid synthase, 462, 471
Dementia
Alzheimer’s disease, 254–255, 285
Lewy body dementia, 463, 472
multi-infarct dementia, 335, 342
Demyelination disease, 72, 97
Depression, 337, 343–344
and carcinoma of the pancreas, 338, 344
and pancreatic cancer, 417, 427
Dermatitis, 442, 453–454
Dermoid cysts, 357, 368–369
Desmin, 17, 30
Desmoid tumor, 238, 265
Dextroamphetamine, 337, 344
DHPR, 401, 413–414
Diabetes insipidus, nephrogenic
(See Nephrogenic diabetes insipidus)
Diabetes mellitus, 65
and diabetic retinopathy, 70–71, 96
glomerular filtration rate, 77, 102–103
and glucose, 64, 88, 102–103
glucose excretion, 77, 102–103
and glycated hemoglobin, 380, 393
and glycosylated hemoglobin, 118–119, 150
and hemorrhages, 70–71, 96
Diabetes mellitus, type I, 78, 104
and fasting hyperglycemia, 64, 88
and MHC, 126, 163
Diabetes mellitus, type II, 128, 166, 462, 471
and cortisol levels, 468, 478
diabetic malignant external otitis, 301, 324
injected insulin, 301, 324
insulin, 116, 144–145
and insulin, 301, 324
and otitis, 301, 324
sulfonylurea drugs for, 353, 364
Diabetic retinopathy, 70–71, 96
Diarrhea, and E. coli, 196, 225–226, 464, 472–473
Diazepam, 356, 367
DIC (See Disseminated intravascular coagulation)
Didanosine treatment, 296, 316, 444, 457
Diethylstilbestrol, 468, 478–479
diabetic malignant external otitis, 301, 324
injected insulin, 301, 324
insulin, 116, 144–145
and insulin, 301, 324
and otitis, 301, 324
sulfonylurea drugs for, 353, 364
Diabetic retinopathy, 70–71, 96
Diarrhea, and E. coli, 196, 225–226, 464, 472–473
Diazepam, 356, 367
DIC (See Disseminated intravascular coagulation)
Didanosine treatment, 296, 316, 444, 457
Diethylstilbestrol, 468, 478–479
diffusion-limited gas, 67, 92
diffusion-limited gases, 482, 492
DiGeorge syndrome, 3, 31, 242, 270
Dihydrofolate reductase, 419, 430
Dihydropyridine reductase, 401, 413–414
Dimeric caprol, 403, 415
Dinitrophenol, 127, 164
<table>
<thead>
<tr>
<th>Term</th>
<th>Page Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fabry disease</td>
<td>109, 133</td>
</tr>
<tr>
<td>Facial (seventh cranial) nerve</td>
<td>17, 42, 43</td>
</tr>
<tr>
<td>Facilitate glucose carrier</td>
<td>484, 494</td>
</tr>
<tr>
<td>Factitious disorder</td>
<td>338–340, 345–346</td>
</tr>
<tr>
<td>Factor VII</td>
<td>130, 169, 379, 391–392</td>
</tr>
<tr>
<td>Fainting spells</td>
<td>302, 325–326</td>
</tr>
<tr>
<td>Falx cerebri</td>
<td>11, 37</td>
</tr>
<tr>
<td>Familial dysbetalipoproteinemia</td>
<td>120, 152</td>
</tr>
<tr>
<td>Familial lecithin-cholesterol acyltransferase deficiency</td>
<td>120, 152</td>
</tr>
<tr>
<td>Farber lipogranulomatosis</td>
<td>110, 134</td>
</tr>
<tr>
<td>Fasciculus of Foville (See Stria terminalis)</td>
<td></td>
</tr>
<tr>
<td>Fasting hyperglycemia</td>
<td>64, 88</td>
</tr>
<tr>
<td>FD (fibrous dysplasia)</td>
<td>244</td>
</tr>
<tr>
<td>Femoral canal</td>
<td>25, 50</td>
</tr>
<tr>
<td>Femoral head and neck injury</td>
<td>23, 48</td>
</tr>
<tr>
<td>Femoral nerve</td>
<td>400, 412</td>
</tr>
<tr>
<td>Ferrochelatase</td>
<td>488, 499</td>
</tr>
<tr>
<td>FEV (forced expiratory volume)</td>
<td>65, 90</td>
</tr>
<tr>
<td>Fibrinogen</td>
<td>380, 392–393</td>
</tr>
<tr>
<td>Fibroadenoma</td>
<td>251, 282, 443, 454–455</td>
</tr>
<tr>
<td>Fibrous dysplasia (FD)</td>
<td>244, 273</td>
</tr>
<tr>
<td>Fibular (deep peroneal) nerve</td>
<td>14, 39</td>
</tr>
<tr>
<td>53-kDa protein</td>
<td>17</td>
</tr>
<tr>
<td>Fingerprinting, DNA</td>
<td>123, 157</td>
</tr>
<tr>
<td>5-azacytidine (5-azaC)</td>
<td>349, 359</td>
</tr>
<tr>
<td>Flumazenil</td>
<td>356, 367, 420, 431</td>
</tr>
<tr>
<td>Fluorescent treponemal antibody absorption test (FTA-ABS)</td>
<td>190, 217</td>
</tr>
<tr>
<td>Folic acid</td>
<td>126, 163, 396, 406</td>
</tr>
<tr>
<td>Follicle-stimulating hormone (FSH)</td>
<td>111, 136</td>
</tr>
<tr>
<td>Food poisoning</td>
<td>196, 225–226</td>
</tr>
<tr>
<td>Food poisoning, staphylococcal</td>
<td>192, 219</td>
</tr>
<tr>
<td>Foramen ovale</td>
<td>350, 360</td>
</tr>
<tr>
<td>Foramina of Monro</td>
<td>10, 36</td>
</tr>
<tr>
<td>Forced expiratory volume (FEV)</td>
<td>65, 90</td>
</tr>
<tr>
<td>Forced vital capacity (FVC)</td>
<td>65, 90</td>
</tr>
<tr>
<td>Forearm supination</td>
<td>8, 15, 34, 41</td>
</tr>
<tr>
<td>Fragile X syndrome</td>
<td>114, 142</td>
</tr>
<tr>
<td>FRC (functional residual capacity)</td>
<td>69, 94</td>
</tr>
<tr>
<td>Frey’s syndrome</td>
<td>24, 50</td>
</tr>
<tr>
<td>Friedreich’s ataxia</td>
<td>1</td>
</tr>
<tr>
<td>Fructokinase</td>
<td>111, 137</td>
</tr>
<tr>
<td>Fructose absorption</td>
<td>59, 84–85</td>
</tr>
<tr>
<td>Fructose intolerance, hereditary</td>
<td>125, 161–162</td>
</tr>
<tr>
<td>FSH, 111, 136</td>
<td></td>
</tr>
<tr>
<td>FTA-ABS, 190, 217</td>
<td></td>
</tr>
<tr>
<td>Fuel partitioning disorder</td>
<td>113, 140</td>
</tr>
<tr>
<td>Functional blindness</td>
<td>59, 84</td>
</tr>
<tr>
<td>Functional dyspepsia</td>
<td>59, 85</td>
</tr>
<tr>
<td>Functional residual capacity (FRC)</td>
<td>69, 94</td>
</tr>
<tr>
<td>Fungal infections</td>
<td>185, 209–210</td>
</tr>
<tr>
<td>AIDS, 237, 264</td>
<td></td>
</tr>
<tr>
<td>FVC (forced vital capacity)</td>
<td>65, 90</td>
</tr>
<tr>
<td>G. lamblia</td>
<td>418, 427</td>
</tr>
<tr>
<td>G. vaginalis</td>
<td>489, 500</td>
</tr>
<tr>
<td>G cells</td>
<td>73, 98</td>
</tr>
<tr>
<td>GABA (See Gamma-aminobutyric acid)</td>
<td></td>
</tr>
<tr>
<td>GAG accumulation</td>
<td>121, 153</td>
</tr>
<tr>
<td>Gall bladder</td>
<td></td>
</tr>
<tr>
<td>Gag reflex</td>
<td>25, 51</td>
</tr>
<tr>
<td>Galactosemia</td>
<td>113, 139–140, 235, 262</td>
</tr>
<tr>
<td>Galectins (S-type lectins)</td>
<td>467, 476</td>
</tr>
<tr>
<td>Gall bladder</td>
<td></td>
</tr>
<tr>
<td>cholceystomy</td>
<td>28, 53–54</td>
</tr>
<tr>
<td>simple columnar epithelium in</td>
<td>12, 38</td>
</tr>
<tr>
<td>Gamma-aminobutyric acid</td>
<td>299, 320</td>
</tr>
<tr>
<td>inhibitory postsynaptic potential</td>
<td>74, 99</td>
</tr>
<tr>
<td>receptors</td>
<td>303, 327</td>
</tr>
<tr>
<td>Gamma-carboxylation</td>
<td>126, 162</td>
</tr>
<tr>
<td>Ganglionic GM&lt;sub&gt;2&lt;/sub&gt;</td>
<td>114, 142</td>
</tr>
<tr>
<td>Gap (communicating) junction</td>
<td>27, 52</td>
</tr>
<tr>
<td>Gas composition</td>
<td>65, 89</td>
</tr>
<tr>
<td>Gas exchange</td>
<td>65, 89</td>
</tr>
<tr>
<td>Gasserian (trigeminal) ganglion</td>
<td>463, 472</td>
</tr>
<tr>
<td>Glomerular filtration rate (GFR)</td>
<td>57, 82–83</td>
</tr>
<tr>
<td>and chronic renal disease</td>
<td>57, 82–83</td>
</tr>
<tr>
<td>creatine clearance</td>
<td>74–75, 100</td>
</tr>
<tr>
<td>diabetes mellitus</td>
<td>77, 102–103</td>
</tr>
<tr>
<td>and sodium excretion</td>
<td>65, 90</td>
</tr>
<tr>
<td>Starling forces</td>
<td>80, 106–107</td>
</tr>
<tr>
<td>Glomerular ultrafiltration</td>
<td>62, 86–87</td>
</tr>
<tr>
<td>Glomerulonephritis</td>
<td>178, 201, 233, 261</td>
</tr>
<tr>
<td>filtered calcium load</td>
<td>62, 87</td>
</tr>
<tr>
<td>streptococcus pyogenes</td>
<td>178, 201</td>
</tr>
<tr>
<td>Glomus tumor</td>
<td>377, 387</td>
</tr>
<tr>
<td>Glossopharyngeal</td>
<td>357</td>
</tr>
<tr>
<td>Glossopharyngeal nerve</td>
<td>23, 48, 369</td>
</tr>
<tr>
<td>GLP-1 (See Glucagon-like peptide-1)</td>
<td></td>
</tr>
<tr>
<td>Glucagon, in pancreas</td>
<td>12, 38</td>
</tr>
<tr>
<td>Glucagon-like peptide-1 (GLP-1)</td>
<td>109, 133–134, 351, 362</td>
</tr>
<tr>
<td>Glucocerebrosidase activity defect</td>
<td>117, 148</td>
</tr>
<tr>
<td>Glucocorticoids</td>
<td>77, 103, 293, 311</td>
</tr>
<tr>
<td>Glucocorticosteroid toxicity</td>
<td>297, 318</td>
</tr>
<tr>
<td>Gluconeogenesis</td>
<td>127, 164</td>
</tr>
<tr>
<td>acetoacoenzyme A</td>
<td>111, 137</td>
</tr>
<tr>
<td>pyruvate carboxylase</td>
<td>127, 164</td>
</tr>
<tr>
<td>tricarboxylic acid cycle</td>
<td>118, 149</td>
</tr>
</tbody>
</table>
Glucose, and diabetes, 64, 88, 102–103
Glucose-6-phosphatase, 112, 139
Glucuronyl transferase, 67, 93
GLUT 2 (facilitate glucose carrier), 484
Glutamate dehydrogenase, 354, 365–366
Glutamic acid, 121, 154
Gluten hypersensitivity, 234, 261
Glycated hemoglobin, 73, 98–99
Glycogen metabolism, 117, 148
Glycogen storage disease
type I, 117, 147–148
type Ia, 112, 139
type II, 418, 428
type IV, 111, 138
type VII, 109, 132–133
Glycogen synthesis, 141
Glycolysis, 111, 124, 136, 160
Glycosaminoglycan accumulation, 121, 153
Glycogen homeostasis, 378, 389–390
GM-CSF, 299, 321
GnRH secretion, 66, 91
Golfer’s elbow (See Medial epicondylitis)
Golgi tendon organs, 57, 82
Gonadal arteries, 19, 44
Gonadotropes, pituitary, 111, 136
Gonorrhea, 179, 202
Goodpasture syndrome, 255, 285
Gout, 121, 155, 206, 375, 385
Gouty arthritis, 464, 474
Graft-versus-host disease (GVHD), 397, 407
Granulocyte development, 15, 41
Granulocyte-macrophage colony stimulating factor (GM-CSF, sargramostim), 299, 321
Granulomatous disease, chronic, 194, 222–223
Granulomatous thyroiditis, 351, 361–362
Granulosa cell tumor, 263, 257
Greater alveolar cells, 26, 51
Growth hormones, and acromegaly, 69, 94, 124, 160
Guilt, and superego, 339, 346
Gums, 8, 35
GVA fibers, 25, 50
GVHD, 397, 407
Gynecomastia (See Breast enlargement)

H
H. ducreyi, 185, 210
H. influenzae, 186, 211
H. pylori, 183, 206, 375, 385
HA (hemagglutination) assay, 188, 214
Half-life, 350, 360–361, 446, 458
Half-life, elimination, 295, 314
Hallucination, 398, 410–411
Hallucinogens, 292, 310
Haloperidol, 291, 309, 462, 471
Haptens, 183, 207
Hashimoto thyroiditis, 69, 94
HBV (See Hepatitis B virus)
HD (See Huntington’s disease)
H&E (hematoxylin-eosin) stain, 6–7, 33
Heart murmur, 71, 96–97
Heart pressure-volume curve, 61, 86
Heart rate
and beta-adrenergic agonist, 58, 84
and cardiac output, 60, 85
and parasympathetic nerves, 62, 87
Heart transplants, 299, 320
Heartbeat, 23
Heart failure
progressive, 290, 308
treatment of, 302, 325
Heart murmur, 71, 96–97
HEV (Hepatitis E virus), 186, 211
Hemagglutination (HA) assay, 188, 214
Hemagglutination inhibition (HI), 468, 479
Hematemesis, 14, 39
Hematocrit, 71, 96
Hemoglobin, 113, 139–140
Hemiballismus, 9, 35
Hemolysis, and jaundice, 59, 84
Hemolytic disease of the newborn, 187, 212
Hemophilia A, 242, 270
Hemorrhages, dot, 70–71, 96
Heparin, 76, 102, 418, 427
Hepatic angiosarcoma, 229, 256
Hepatic cholesterol synthesis, 294–295, 313
Hepatic cirrhosis, 375, 385
Hepatic metabolism, 300–301, 323
Hepatic reaction, during metabolic acidosis, 128, 166
Hepatic synthesis of coagulation factors, 304, 328
Hepatitis A, 194, 222, 238, 265
Hepatitis B surface antigen, 177, 200
Hepatitis B virus (HBV), 190, 217
recombinant vaccine, 200
and viral surface antigen, 400, 412
Hepatitis E virus (HEV), 186, 211
Hepatocellular carcinoma, 253, 284, 399, 411
Hepatomegaly, 117, 148
Hepatosplenomegaly, 111, 116, 138, 145–146
Hepcidin, 121, 153–154
Hereditary fructose intolerance, 125, 161–162
Hereditary galactosemia, 113, 139–140
Hernia
abdominal, 25, 50
inguinal, 22, 47
Herpes infection, disseminated, 243, 272–273
Herpes simplex virus, 182, 205
Herpetic meningencephalitis, 249, 279
HEV (Hepatitis E virus), 186, 211
HGPR deficiency, 118, 149
HI (hemagglutination inhibition), 468, 479
High endothelial postcapillary venules, 27, 53
High-dose glucocorticoid therapy, 62, 87
High-pitched sound sensitivity, 59, 84
Hirschsprung disease, 68, 93, 229, 257
Histamine, 231, 259
and vascular permeability, 175, 198
vasodilation, 299, 320
Histone acetylation, 112, 138–139
Histrionic personalities, 485, 495
HIV (See Human immunodeficiency virus)
HIV virus, 188–189, 214–215
HL (Hodgkin lymphoma), 461
HMD (hyaline membrane disease), 13, 38
Hodgkin lymphoma (HL), 461, 470–471
Homicide, 420, 430
Horner syndrome
indirectly acting
sympathomimetics, 289, 307
and lateral medullary syndrome, 20
and red and dry skin, 20, 45
skin in, 20, 45
sympathomimetics, 289, 307
and tunica intima, 6, 33
HPT, 419, 429–430
Human immunodeficiency virus (HIV)
safe practices, 423, 435
statistics on infection with, 403, 416
Human leukocyte antigen complex iron protein, 115, 143–144
Human papillomavirus infection, 353, 364
Human prion disease, 244, 273
Humeral immune system, 176, 199
Hunter syndrome, 440–441, 451
Huntington’s disease (HD), 238–239, 266
and RNA interference, 375, 384
and trinucleotide repeat expansion, 122–123, 156
Hurler syndrome, 121, 153
Hyaline membrane disease (HMD), 13, 38
Hydrocephalus, 10, 23, 48–49
Hydrochlorothiazide, 290, 304, 307, 328
Hydrochlorothiazide, potassium wasting, 290, 304, 307, 328
Hydrolyzing initiation factor eIF-2, 114, 142
Hydroxocobalamin, 294, 312
Hypatic gluconeogenesis, 420
Hyperammonemia, 290, 308
Hypercholesterolemia, 111, 137
Hyperglycemia
fasting, 64, 88
and liver glucose output, 116, 146
Hyperinsulinemia, 128, 166
Hyperkalemia, 65, 66, 89, 90
Hyperlipoproteinemia, 120, 152, 464, 473
Hyperolorization, 429
Hyperparathyroidism, secondary, 396, 406
Hyperpigmentation, 57, 82
Hypersensitivity reaction, 175, 198
Hypertension, 297, 317
and ACE inhibitor, 302, 325
angiotensin II, 294, 313
diuretic treatment of, 302, 325
and renal artery stenosis, 65, 89
secondary, 65, 89
Hypertensive intracerebral hemorrhage, 233, 260–261
Hyperthermia, malignant, 79, 106
Hyperthyroidism, 341, 346–347
Hypertrophic cardiomyopathy, 245, 275
Hyperventilation, 70, 74, 95, 99
as adaptive response, 70, 95
decreased atmospheric pressure, 70, 95
respiratory alkalosis, 74, 99
Hypocalcemia
and celiac disease, 61, 86
and chronic kidney insuffiency, 395, 404–405
and parathyroid hormone, 443, 455–456
Trousseau sign, 79, 105
Hypocortisolism, 57, 82
Hypoglycemia, 128, 166
Hypokalemia, 81, 107
Hypoketotic hypoglycemia, episodic, 120, 151–152
Hypomethylation, 349, 359
Hypornatremia
and coma, 66, 91
due to heart failure, 482, 491–492
Hypoplasia, pulmonary, 19, 44–45
Hypotension, 290, 307
Hypothalamic dopamine, 68, 93
Hypothalamic set point, 70, 95, 422, 433–434
Hypothalamic suppression
Hyperthyroidism (myxedema), 299, 321–322
autoimmune thyroiditis, 69, 94
Hashimoto thyroiditis, 69, 94
testing for, 354, 365
Hypotonic overhydration, 74, 99
Hypoxia, 62, 87, 398, 409–410
I
Iatrogenic Cushing syndrome, 297, 318
IBS (irritable bowel syndrome), 20
Ibutilide, 354, 365
I-cell disease, 120, 153
Id function, 335, 342
Identity formation, 337, 343
IgG (See Immunoglobulin G)
Igm (See Immunoglobulin M)
Ileum, terminal, 67, 92
Ileus, 21, 46
Iliac nodes, 401, 414
Ilioinguinal nerve, 19, 44
Ilium, and acetabulum, 29, 54
IL-1 synthesis deficiency, 183, 206
Imatinib (Gleevec), 489
Imipramine, 425, 437
Immunoglobulin E antibodies, 175, 198
Immunoglobulin G (IgG)
anti-mold, 186, 210
and hemolytic disease of the newborn, 187, 212
and spleen, 176, 199
Immunoglobulin M (Igm), 423, 435
and J chain production, 175, 198
and spleen, 176, 199
Imprinting, 339, 345
Incretins, 126, 162
Infant mortality, 336, 343
Infectious disease, laboratory tests, 243, 272
Infective endocarditis, 419, 428–429
Inferior alternating hemiplegia, 465, 474
Inferior epiagastric artery, 9, 35
Inferior epiagastric vessels, 22, 47
Inferior laryngeal nerve, 24, 49
Inferior olivary nucleus, 26, 51
Inferior sagittal sinus, 16, 41
Inferior thyroid artery, 16, 41
Influenza, 191, 195, 218, 224
amantadine, 176, 199
humeral immune system, 176, 199
Influenza virus, 467, 478
Influenza virus groups, 180, 203
Infraorbital nerve, 12, 38
Inguinal hernia, 22, 47
Inhaled anesthetics, 299, 312
Inhibitory postsynaptic potential, 74, 99, 429
Insulin
actions of, 350, 360
and anti-insulin antibodies, 59, 84
concentration of, 66–67, 92
diabetes mellitus Type II, 301, 324
hypokalemia, 81, 107
muscle resistance to, 116, 144–145
and protein targeting glycogen,
397, 408–409
secretion of, 378
and translation, 403, 415–416
Insulin-induced signaling cascade,
110, 135–136
Integumentary system, 3, 31–21
Intelligent thinking, 337, 343
Intention tremor, 4, 12, 32, 38
Intercalated disks, 10, 36
Intercranial primary neoplasm,
254, 284–285
Interferons, 176, 199
Interleukin-1 synthesis deficiency,
183, 206
Intermediate filament disease, 26, 52
Intermediate filament proteins,
17, 42
Internuclear ophthalmoplegia, 18, 43
Intervertebral disks, 24, 49–50
Intestinal obstruction, 21, 46
Intoxication
parathion, 293, 312
water, 58, 83
Intracellular processes, 126, 162–163
Inulin, 486, 497
Iodine organification, 293, 311
Ion channel receptors, 289, 307
Ion conductance, 76, 101
Ion distribution, 75, 101
IPSP (See Inhibitory postsynaptic
potential)
IRBP, 131, 170
Iron, and transfusion therapy,
397, 409
Iron homeostasis, 124–125, 131,
160, 170
Iron regulation, 121, 153–154
Iron response element-binding
protein (IRBP), 131, 170
Iron sulfate, 376, 386
Irrigation, of ears, 395, 405
Irritable bowel syndrome (IBS), 20
IRS-1, 110, 135–136
Ischium, 29, 54
Isoproterenol, 468, 479
Isotretinoin, 396, 406–407
J
J chain production, 175, 198
Jaundice, 59, 67, 84, 93, 442, 454
Jaw-jerk reflex, 21, 46
Jock itch, 192, 219
Jugular foramen, 11, 37
Jugular vein pressure curve, 61, 86
K
Kartagener syndrome, 255, 286–287
Kava, 295, 314
Keratin K5 and K14, 26, 52
Kernicterus, 124, 159
Ketoconazole, 292, 310
Ketogenesis, 115, 143
Kidneys
development of, 27
and mesonephroi, 27, 52
and metanephroi, 380–381, 394
sodium reabsorption by, 113, 139
specific blood flow, 77, 103
transplantation of, 353, 364
Kleinfelter syndrome, 241, 270
L
L. interrogans, 197, 226
L. monocytogenes, 181, 204
Lac operon in bacteria, 127, 165
Lactate dehydrogenase, 124, 160
Lactation, 122, 156
Lactic acidemia, 483, 492
Lactiferous ducts, 19, 44
LAD II, 484, 493–494
Lambert-Eaton myasthenic
syndrome, 72, 97
Lamotrigine, 442, 453–454
Laryngeal muscle, 24, 49
Laryngeal nodule, 482, 492
Laryngomalacia, 2
Lateral medullary syndrome, 4,
20, 32
Laxative, osmotic, 294, 312
Laxatives, 388
LCAT deficiency, 120, 152
Leiomyosarcoma of the uterus,
483, 493
LEMS, 72, 97
Lens substance, 9, 36
Lepirudin, 486, 498
Leptospirosis, 197, 226
Lesch-Nyhan disease, 118, 149
Leukocyte adhesion deficiency
syndrome II, 484, 493–494
Leukotrienes, 62–63, 87
Levator labii superioris, 17, 43
Levator labii superioris alaeque nasi,
17, 43
Levofloxacin, 489, 500
Lewy body dementia, 463, 472
Leydig cell, 11, 37
LFS (See Li-Fraumeni syndrome)
LH (See Luteinizing hormone)
Libman-Sacks endocarditis, 405
Liddle syndrome, 300, 321–322
Li-Fraumeni syndrome (LFS), 129,
130, 167, 168
Lineweaver-Burk plot, 402, 415
Lingual artery, 441, 451
Lipid storage diseases, 109, 133
Lipoprotein lipase (LPL), 116, 146
Lipoprotein-associated coagulation
factor, 131, 170
Lipoprotein-associated disorder,
120, 152
Lithium carbonate, 292, 309
Liver
cirrhosis of, 20
and embryonic foregut, 8, 35
and glucocorticoids, 77, 103
Liver cell adenomas, 243, 272
Liver glucose output, 116, 146
Liver glycogen content, 77, 103
Lockjaw, 188, 214
Locus ceruleus, 338
LOH (loss of heterozygosity),
129, 167
Lorazepam, 440, 450
Losartan, 297, 317
Loss of heterozygosity (LOH),
129, 167
Lou Gehrig disease, 444, 446
LPL (lipoprotein lipase),
116, 146
Lung cancer, 69, 94, 441, 452
Lung capacity, 62–63, 87
Lung compliance, 72, 97
Lung maturation, 293, 311
Lung surfactant, 13, 38
Lungs
compliance, 72
and glucocorticoids, 293, 311
reflex vasoconstriction in, 62, 87
squamous cell carcinoma of, 467,
477–478
volume of, 72, 97
Luteinizing hormone (LH)
and metastatic prostate carcinoma,
296, 315
and ovulation, 72, 97–98
Lyme disease
B. burgdorferi, 189, 197, 215, 226,
242–243, 271–272
erythema chronicum migrans,
189, 215
hard-bodied tick, 197, 226
Lymphatic trunk rupture, 14, 40
Lymphatic vessels, 3, 31
Lymphatics, drainage, 401, 414
Lymphocytes
delayed-type hypersensitivity,
177, 200
and high endothelial postcapillary
venules, 27, 53
Lymphoid follicles, 15, 40
Lymphoma
malignant, 355, 366
and Sjögren syndrome, 231,
258–259
Lymphoma, malignant, 231, 258–259
Lysosomal acid lipase enzymes, 116,
145–146
Lysosomal enzymes
and I-cell disease, 120, 153
mannose-6-phosphate, 123,
156–157
mannose-6-phosphate, 123,
156–157
and mucolipidosis type II,
120, 153
Lysosomal storage diseases
(See Gaucher disease)

M
M. avium-intracellulare, 186–187, 211–212
M. pneumoniae, 177, 200
M protein, 195, 223–224
Macroversicular fatty change,
238, 265
Macula densa, 14, 40
Mad cow disease, 244, 273
Magnesium hydroxide, 294, 312
Magnetic resonance image (MRI), 1
Major histocompatibility locus,
126, 163
Malarial infection, 282, 296, 316
Malignant melanoma, 244, 273
Malignancy, pain of, 302–303, 326
Malignant hyperthermia, 79, 106
Malignant lymphoma, 231, 258–259,
355, 366
Malonyl-CoA, 113, 140
Macrophage activation, 294, 313
Macrovesicular fatty change,
238, 265
Medium-chain acyl-CoA dehydrogenase (MCAD) deficiency, 119, 120, 150–152
Medullary carcinoma, 230, 257
Medullary sponge kidney, 239,
266
Medulloblastoma, 373, 382
Megaloblastic anemia, 129, 168
Meiotic division, 24, 49
Melanoma, 442, 453
malignant, 240, 244, 267, 273
ultraviolet radiation, 244, 273
Melatonin, 417, 427
Meningitis, 181, 196, 204, 225, 226
Meningococcal meningitis, 488, 499
Menkes disease, 113, 140–141
Mental retardation, inherited,
114, 142
Mesencephalic trigeminal nucleus,
21, 46
Mesenchymal cells, 16, 41
Mesenchymal tumors, 238, 265
Mesonephros, 27, 52–53
Metabolic acid excretion, 69, 94
Metabolic acidosis, 128, 166, 290,
308, 401, 414
Metanephric diverticulum, 26, 52
Metastatic prostate carcinoma,
296, 315
Metformin, 444, 456
Methadone, 292, 309–310
Methanol, 424, 436
Methotrexate, 375, 385–386
Methylmalonic acidemia, 120, 151
Methylmalonyl-CoA mutase, 120,
151, 468, 479
Metoprolol, 373, 382
MHC (major histocompatibility
locus), 126
MI (See Myocardial infarct)
Microbial flora, commensal, 195, 223
Microcytic anemia, 75, 100, 115
Microsomal glucose-6-phosphate
transporter defect, 117, 147–148
Microtubule disassembly, 294, 313
Microtubules
and cilia motility, 21, 46
growth of, 122, 156
Micturition reflex, 18, 44
Mifepristone, 289, 307
Milk, cow’s, 113, 139–140
Mineralocorticoids, 113, 139, 293, 311
Mitral stenosis, 421, 432, 443, 455
Mitral valve blood flow, 60–61,
85–86
Mitral valve prolapse, 379, 391
MLF (medial longitudinal fasciculus), 18, 43
MODY, 425, 437–438
MODY2, 425, 437–438
Motor impairment, 4, 32
Movement disorders
and antipsychotic drugs, 463, 472
and subthalamic nucleus of Luys,
9, 35
MPS disease (See Mucopolysacharidotic diseases)
MRI (magnetic resonance image), 1
MSUD, 115, 144
Mucolipidosis type II, 120, 153
Mucopolysacharidotic (MPS) diseases
Hunter syndrome, 440–441, 451
Hurler syndrome, 121, 153
Multiaxal system, 336, 342
Multi-infact dementia, 335, 342
Multiple myeloma, 247, 276–277, 442, 454
Multiple personality disorder (dissociated identity disorder), 335–337, 342, 343
Multiple sclerosis, 18, 43, 72, 97
Mumps virus, 196, 226
Muscarinic receptors, 303, 326–327
Muscle cell energy production, 118, 149
Muscle phosphofructokinase deficiency, 109, 132–133
Muscle spindles, 21, 46
Muscular dystrophy, Duchenne, 253, 284
Musculocutaneous nerve, 8, 34
Musculotaneous nerves, 421, 433
Mutism, 450, 482, 491
N-type opioid receptors, 301, 324
Myasthenia gravis (MG), 247, 277, 302
N. meningitides, 462–463, 471–472
N-acetylglutamate, 111, 136
NADH-coenzyme Q reductase, 125, 160–161
Naloxone, 340, 346
Naltrexone, 292, 310
Narcotic drug addiction, 338, 344
Nasal polyps, 236, 263
Nausea, postoperative, 291, 309
Nearsightedness, 65, 89
Neocerebellum lesion, 12, 38
Neoplasm, malignant, 232–233, 260
Neoplastic changes to skin, 5, 32
Nephroblastoma (See Wilms’ tumor)
Nephrogenic diabetes insipidus, 292, 309, 486, 497
and excreted glucose, 64, 88
and lithium carbonate, 292, 309
Nephrotic syndrome, 244, 273–274, 489, 500
NEU oncogene, 248–249, 278
Neuroblastoma, 230–231, 258
Neurogenic diabetes insipidus, 78, 104
Neuroleptic antipsychotic drugs, 379, 392
Neuromuscular irritability, 79, 105
Neuron identification, 6–7, 33
Neuronal action potential, 72, 97
Nicotine craving, reduction of, 292, 310
Niemann-Pick disease (NPD)
type 1A, 377, 387–388
type 1B, 469, 480
Nitrile oxide (NO)
arginine, 122, 155
dependence of factor, 78, 104–105
inhaled anesthetics, 299, 321
penile artery dilation, 78, 104–105
Nitrovasodilators, 301, 323–324
NO (See Nitric oxide)

O
Obesity, 113, 140
Obliquus capitus superior muscle, 23, 49
Obsessive personality, 461, 470, 487, 498
Obstruction of the intestine, 21, 46
Obturating nerve, 16, 26, 42, 52
Occipital bone, 23, 49
Occulsive embolus, 230, 257
Oculomotor nerve, 2
Odorant-binding protein, 376, 386–387
Ohm’s Law, 66, 91
olfactory gland of Bowman, 376, 386–387
Oncogenes, 354, 366
Ondansetron, 397, 408
Oocytes, maturation of, 24, 49
Opioid mu receptors, 292, 309–310
Opioid peptides, 77, 103
Opioid use, 302–303, 326
Optic chiasma, 399, 411
Orad stomach, 78, 103–104
Oral anticoagulants, 304, 328
Oribacularis oculi, 17, 43
Organ transplant and creatinine clearance, 292–293, 311
and cytomegalovirus, 192, 219
immunologic suppression for, 191, 218
Ornithine transcarbamoylase (OTC) deficiency, 117, 146–147
Ornithosis, 193, 221
Orotic acid concentration, 109, 132
Osmotic diuresis, 78, 104
Osmotic laxative, 294, 312
Osteoarthritis, degenerative, 236, 263
Osteoblasts, 481, 491
Osteoclastic activity, 289, 307
Osteoclasts, 27, 52, 486, 497–498
Osteocytes, 17, 42–43
Osteogenesis imperfecta, 116, 144–145
Norwalk virus, 184, 208
Notochord, 377, 388
NPD (See Niemann-Pick disease)
NSAIDs (See Nonsteroidal anti-inflammatory drugs)
Nuclear morphology, 6–7, 33
Nucleus raphe magnus, 21, 47
<table>
<thead>
<tr>
<th>Page</th>
<th>Index 515</th>
</tr>
</thead>
<tbody>
<tr>
<td>247</td>
<td>Osteogenesis imperfecta type I, 248, 278</td>
</tr>
<tr>
<td>248</td>
<td>Osteogenic sarcoma, 464–465, 474</td>
</tr>
<tr>
<td>254</td>
<td>Osteomalacia, 27, 53</td>
</tr>
<tr>
<td>258</td>
<td>Osteomyelitis, 232, 260</td>
</tr>
<tr>
<td>258</td>
<td>Osteoporosis and osteoclasts, 486, 497–498</td>
</tr>
<tr>
<td>260</td>
<td>senile or post-menopausal, 254, 284</td>
</tr>
<tr>
<td>278</td>
<td>Osteosarcoma, 244, 249, 274, 278–279</td>
</tr>
<tr>
<td>278</td>
<td>Ostium secundum atrial septal defect, 17, 42</td>
</tr>
<tr>
<td>278</td>
<td>OTC deficiency (See Ornithine transcarbamoylase)</td>
</tr>
<tr>
<td>278</td>
<td>Otitis media, 241, 269, 350, 360</td>
</tr>
<tr>
<td>278</td>
<td>Ovary activity, 80, 106</td>
</tr>
<tr>
<td>278</td>
<td>Outer hair cells, 374, 383</td>
</tr>
<tr>
<td>278</td>
<td>Pain transmission, modulation of, 21, 47</td>
</tr>
<tr>
<td>278</td>
<td>Palatoglossus muscle, 10, 36</td>
</tr>
<tr>
<td>278</td>
<td>Pancreas A and B cells in, 12, 38</td>
</tr>
<tr>
<td>278</td>
<td>carcinoma of, 338, 344</td>
</tr>
<tr>
<td>278</td>
<td>glucagon in, 12, 38</td>
</tr>
<tr>
<td>278</td>
<td>and insulin, 421, 433</td>
</tr>
<tr>
<td>278</td>
<td>insulin in, 12, 38</td>
</tr>
<tr>
<td>278</td>
<td>secretions of, 12, 38</td>
</tr>
<tr>
<td>278</td>
<td>Pancreatic adenocarcinomas, 247, 276</td>
</tr>
<tr>
<td>278</td>
<td>Pancreatic duct, 489, 500–501</td>
</tr>
<tr>
<td>278</td>
<td>Pancreatic secretion, 59, 85</td>
</tr>
<tr>
<td>278</td>
<td>Pancreatitis, acute, 236, 263</td>
</tr>
<tr>
<td>278</td>
<td>Pancreatitis, acute hemorrhagic, 16, 41–42</td>
</tr>
<tr>
<td>278</td>
<td>Pancreatitis, and didanosine, 296, 316, 444, 457</td>
</tr>
<tr>
<td>278</td>
<td>Panic disorders, 338, 345 and hyperthyroidism, 341</td>
</tr>
<tr>
<td>278</td>
<td>patient history of, 341, 346</td>
</tr>
<tr>
<td>278</td>
<td>sertraline for, 338, 345</td>
</tr>
<tr>
<td>278</td>
<td>Papex circuit, 18, 42</td>
</tr>
<tr>
<td>278</td>
<td>Paracrine hormones, 400, 412</td>
</tr>
<tr>
<td>278</td>
<td>Parainfluenza viruses, 350, 360</td>
</tr>
<tr>
<td>278</td>
<td>Paralysis, transient, 335, 342</td>
</tr>
<tr>
<td>279</td>
<td>Paramyxovirus, 189, 215–216</td>
</tr>
<tr>
<td>279</td>
<td>Parathyroid gland development, 18, 43</td>
</tr>
<tr>
<td>279</td>
<td>Parathyroid hormone (PTH) and hypocalcemia, 443, 455–456</td>
</tr>
<tr>
<td>279</td>
<td>and squamous cell carcinoma of lung, 467, 477–478</td>
</tr>
<tr>
<td>279</td>
<td>Parenchyma of the kidney, 424, 437</td>
</tr>
<tr>
<td>279</td>
<td>Parsimony, 339, 345</td>
</tr>
<tr>
<td>279</td>
<td>Patient-controlled analgesia, 487, 498</td>
</tr>
<tr>
<td>279</td>
<td>PC (paramytonia congenita), 444, 456</td>
</tr>
<tr>
<td>279</td>
<td>Penicillins, 424, 436</td>
</tr>
<tr>
<td>279</td>
<td>phenytoin toxicity, 300, 322</td>
</tr>
<tr>
<td>279</td>
<td>Philadelphia chromosome, 417</td>
</tr>
<tr>
<td>279</td>
<td>Phenytoin, 300, 322</td>
</tr>
<tr>
<td>279</td>
<td>Peptic ulcer disease, 73, 98, 235, 262</td>
</tr>
<tr>
<td>279</td>
<td>Peptide elongation process, 118, 149–150</td>
</tr>
<tr>
<td>279</td>
<td>Perfusion-limited gas, 444, 457</td>
</tr>
<tr>
<td>279</td>
<td>Perinatal fracture dislocation, 11, 37</td>
</tr>
<tr>
<td>279</td>
<td>Peripheral nervous system, 11, 37</td>
</tr>
<tr>
<td>279</td>
<td>Pernicious anemia, 247, 277, 294, 312</td>
</tr>
<tr>
<td>279</td>
<td>Peroxisome proliferator-activated receptor-gamma nuclear receptor, 293, 311</td>
</tr>
<tr>
<td>279</td>
<td>Peroxisomes, defective assembly of, 124, 159</td>
</tr>
<tr>
<td>279</td>
<td>Personality, 425, 437</td>
</tr>
<tr>
<td>279</td>
<td>Perspiration, 24, 50</td>
</tr>
<tr>
<td>279</td>
<td>Pertussis (See Whooping cough)</td>
</tr>
<tr>
<td>279</td>
<td>Peutz-Jeghers syndrome, 483, 492–493</td>
</tr>
<tr>
<td>279</td>
<td>P53 protein, 130, 168</td>
</tr>
<tr>
<td>279</td>
<td>cell-cycle arrest, 123, 157</td>
</tr>
<tr>
<td>279</td>
<td>Li-Fraumeni syndrome, 130, 168</td>
</tr>
<tr>
<td>279</td>
<td>tumor suppressor, 123, 157</td>
</tr>
<tr>
<td>279</td>
<td>Pharyngeal arch, 467, 477</td>
</tr>
<tr>
<td>279</td>
<td>Pharyngeal arches, 23, 48</td>
</tr>
<tr>
<td>279</td>
<td>Pharyngeal pouch, 18, 43</td>
</tr>
<tr>
<td>279</td>
<td>Phencyclidine, 292, 310</td>
</tr>
<tr>
<td>279</td>
<td>Phenotype differences, 127, 165</td>
</tr>
<tr>
<td>279</td>
<td>Phenotypic variation, 130–131, 170</td>
</tr>
<tr>
<td>279</td>
<td>Phenylcyclidine, 292, 310</td>
</tr>
<tr>
<td>279</td>
<td>Phenylephrine, 300, 322</td>
</tr>
<tr>
<td>279</td>
<td>Philadelphia chromosome, 417</td>
</tr>
<tr>
<td>279</td>
<td>Phosphate concentration, 57, 82–83</td>
</tr>
<tr>
<td>279</td>
<td>Phosphorylase kinase, 125, 161</td>
</tr>
<tr>
<td>279</td>
<td>Phosphorylation, 126, 162</td>
</tr>
<tr>
<td>279</td>
<td>Phosphorylation, oxidative, 127, 164</td>
</tr>
<tr>
<td>279</td>
<td>Photoreceptors, 2, 119, 150</td>
</tr>
<tr>
<td>279</td>
<td>Phrenic nerve, 12–13, 38</td>
</tr>
<tr>
<td>279</td>
<td>Phytanic acid, serum, 129, 166</td>
</tr>
<tr>
<td>279</td>
<td>Piaget, 337, 338, 343, 345</td>
</tr>
<tr>
<td>279</td>
<td>PID, 238, 266</td>
</tr>
<tr>
<td>279</td>
<td>Pinworms, 427</td>
</tr>
<tr>
<td>279</td>
<td>Pituitary adenotropes, 111, 136</td>
</tr>
<tr>
<td>279</td>
<td>Pituitary hormones, 68, 93</td>
</tr>
<tr>
<td>279</td>
<td>PKC, 117, 148</td>
</tr>
<tr>
<td>279</td>
<td>Plasma clearance of drugs, 300–301, 323</td>
</tr>
<tr>
<td>279</td>
<td>Plasma renin level, 76, 101</td>
</tr>
<tr>
<td>279</td>
<td>Platelet aggregation, 296, 316</td>
</tr>
<tr>
<td>279</td>
<td>Platelet crosslinking, 113, 141</td>
</tr>
<tr>
<td>279</td>
<td>Platelet membrane protein complex GPIb-GPIIIa, 113, 141</td>
</tr>
<tr>
<td>279</td>
<td>Platelet-activating factor (PAF), 127, 164</td>
</tr>
<tr>
<td>279</td>
<td>Pleomorphic adenoma, 352, 362</td>
</tr>
<tr>
<td>279</td>
<td>Pleuroperitoneal membrane defect, 19, 44–45</td>
</tr>
<tr>
<td>Pneumocystis carinii, 178, 201</td>
<td></td>
</tr>
<tr>
<td>Pneumocytes, type II, 26, 51</td>
<td></td>
</tr>
<tr>
<td>Pneumonia</td>
<td></td>
</tr>
<tr>
<td>and alcoholism, 186, 210–211</td>
<td></td>
</tr>
<tr>
<td>and antibody activity, 175, 198</td>
<td></td>
</tr>
<tr>
<td>cord factor, 179, 202</td>
<td></td>
</tr>
<tr>
<td>fungal, 184, 208</td>
<td></td>
</tr>
<tr>
<td>and polysaccharide capsule, 490, 501</td>
<td></td>
</tr>
<tr>
<td>“walking” primary atypical, 177, 200</td>
<td></td>
</tr>
<tr>
<td>Pneumotaxic center, 15, 40</td>
<td></td>
</tr>
<tr>
<td>Poliovirus, types of, 184, 207–208</td>
<td></td>
</tr>
<tr>
<td>Poliovirus, wild-type, 192, 219–220</td>
<td></td>
</tr>
<tr>
<td>Polyarteritis nodosa, 240, 268</td>
<td></td>
</tr>
<tr>
<td>Polycystic ovarian syndrome, 128, 166</td>
<td></td>
</tr>
<tr>
<td>Polymerase chain reaction, 119, 150</td>
<td></td>
</tr>
<tr>
<td>Polymorphic repeat sequences, 123, 157</td>
<td></td>
</tr>
<tr>
<td>Polypeptide hormone, 69, 94</td>
<td></td>
</tr>
<tr>
<td>Poly-ubiquitination of proteins, 121, 154</td>
<td></td>
</tr>
<tr>
<td>Polyuria, 78, 104</td>
<td></td>
</tr>
<tr>
<td>Pompe disease, 418, 428</td>
<td></td>
</tr>
<tr>
<td>Pons, 15, 40</td>
<td></td>
</tr>
<tr>
<td>Porphyria cutanea tarda (PCT), 110, 134</td>
<td></td>
</tr>
<tr>
<td>Portocaval shunt, end-to-side, 20, 45</td>
<td></td>
</tr>
<tr>
<td>Posterior cricoarytenoid muscle, 24, 49</td>
<td></td>
</tr>
<tr>
<td>Post-menopausal osteoporosis, 254</td>
<td></td>
</tr>
<tr>
<td>Postoperative nausea, 291, 309</td>
<td></td>
</tr>
<tr>
<td>Postrenal obstruction, 245, 275</td>
<td></td>
</tr>
<tr>
<td>Potassium, 462, 471</td>
<td></td>
</tr>
<tr>
<td>conductance, 76, 101–102</td>
<td></td>
</tr>
<tr>
<td>serum, 293, 312</td>
<td></td>
</tr>
<tr>
<td>wasting, 290, 304, 307, 328</td>
<td></td>
</tr>
<tr>
<td>Potassium channel blocking, 296, 315</td>
<td></td>
</tr>
<tr>
<td>Potassium clearance, 76, 102</td>
<td></td>
</tr>
<tr>
<td>Potassium wasting</td>
<td></td>
</tr>
<tr>
<td>hydrochlorothiazide, 290, 304, 307, 328</td>
<td></td>
</tr>
<tr>
<td>Potassium-sparing diuretics, 300, 321–322</td>
<td></td>
</tr>
<tr>
<td>PPAR-gamma nuclear receptor, 293, 311</td>
<td></td>
</tr>
<tr>
<td>PPD (purified protein derivative), 191, 218</td>
<td></td>
</tr>
<tr>
<td>Precocious (early onset) puberty, 66, 91</td>
<td></td>
</tr>
<tr>
<td>Predictive value positive, 422, 434</td>
<td></td>
</tr>
<tr>
<td>Prednisone, 293, 311</td>
<td></td>
</tr>
<tr>
<td>Prenatal testing, 444, 456–457</td>
<td></td>
</tr>
<tr>
<td>Primary aldosteronism, 76, 101, 235, 262–263</td>
<td></td>
</tr>
<tr>
<td>adrenal adema, 76, 101</td>
<td></td>
</tr>
<tr>
<td>aldosterone, 122, 155</td>
<td></td>
</tr>
<tr>
<td>plasma renin level, 76, 101</td>
<td></td>
</tr>
<tr>
<td>Primary hyperparathyroidism (HPT), 419, 429–430</td>
<td></td>
</tr>
<tr>
<td>Primary sclerosing cholangitis, 369–370</td>
<td></td>
</tr>
<tr>
<td>Primary syphilis, 190, 217</td>
<td></td>
</tr>
<tr>
<td>Proconvertin (See Factor VII)</td>
<td></td>
</tr>
<tr>
<td>Progesterone receptors, 289, 307</td>
<td></td>
</tr>
<tr>
<td>Proinflamation, secretion of, 15, 41</td>
<td></td>
</tr>
<tr>
<td>breast enlargement, 122, 156</td>
<td></td>
</tr>
<tr>
<td>lactation, 122, 156</td>
<td></td>
</tr>
<tr>
<td>Prolactin secretion, 68, 93</td>
<td></td>
</tr>
<tr>
<td>Prolactin-releasing factor, 116, 146</td>
<td></td>
</tr>
<tr>
<td>Propofol, 291, 309</td>
<td></td>
</tr>
<tr>
<td>Proprioception, conscious, 5, 32–33</td>
<td></td>
</tr>
<tr>
<td>Prostaglandin, 70, 95</td>
<td></td>
</tr>
<tr>
<td>Plastic surgery, 121, 154</td>
<td></td>
</tr>
<tr>
<td>Protein targeting glycogen, 397, 408–409</td>
<td></td>
</tr>
<tr>
<td>Protein zero (P0), 11, 37</td>
<td></td>
</tr>
<tr>
<td>Proteins</td>
<td></td>
</tr>
<tr>
<td>intermediate filament, 17, 42</td>
<td></td>
</tr>
<tr>
<td>muscle cell contraction, 17</td>
<td></td>
</tr>
<tr>
<td>poly-ubiquitination of, 121, 154</td>
<td></td>
</tr>
<tr>
<td>synthesis, 119, 151</td>
<td></td>
</tr>
<tr>
<td>Proximal tubule, 78, 104</td>
<td></td>
</tr>
<tr>
<td>Proximate cause of death, 236, 263</td>
<td></td>
</tr>
<tr>
<td>Psuedomonad aeruginosa, 197, 226–227</td>
<td></td>
</tr>
<tr>
<td>Psittacosis, 193, 221</td>
<td></td>
</tr>
<tr>
<td>Psychomotor retardation, 354, 365</td>
<td></td>
</tr>
<tr>
<td>Purine nucleotide cycle, 118, 149</td>
<td></td>
</tr>
<tr>
<td>Purine nucleotide salvage enzyme (HGPRT) deficiency, 118, 149</td>
<td></td>
</tr>
<tr>
<td>Q-waves, 73, 98</td>
<td></td>
</tr>
<tr>
<td>Pylonephritis, 178, 201</td>
<td></td>
</tr>
<tr>
<td>Pyruvate carboxylase, 127, 164, 483</td>
<td></td>
</tr>
<tr>
<td>Psychomotor retardation, 354, 365</td>
<td></td>
</tr>
<tr>
<td>P0 (protein zero), 11, 37</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td></td>
</tr>
<tr>
<td>RA (See Rheumatoid arthritis)</td>
<td></td>
</tr>
<tr>
<td>Rabies virus, 179, 202</td>
<td></td>
</tr>
<tr>
<td>Radial nerve lesion, 15, 40–41</td>
<td></td>
</tr>
<tr>
<td>Radiation, exposure to, 467, 477</td>
<td></td>
</tr>
<tr>
<td>Radioallergosorbent test (RAST), 185, 210</td>
<td></td>
</tr>
<tr>
<td>Rate limiting step glycolysis, 111, 136</td>
<td></td>
</tr>
<tr>
<td>Receptive relaxation reflex, 78, 103–104</td>
<td></td>
</tr>
<tr>
<td>Rectocutaneous pouch, 9, 35</td>
<td></td>
</tr>
<tr>
<td>Renal cell carcinoma, 254, 284</td>
<td></td>
</tr>
<tr>
<td>Renal clearance, 76, 102</td>
<td></td>
</tr>
<tr>
<td>Renal disease, chronic, 57, 82–83</td>
<td></td>
</tr>
<tr>
<td>Renal failure, 72, 97, 234, 261, 396</td>
<td></td>
</tr>
<tr>
<td>Renal infarct, 238, 265</td>
<td></td>
</tr>
<tr>
<td>Renal insufficiency, 122, 155</td>
<td></td>
</tr>
<tr>
<td>Renal malformation, fetal, 304, 328</td>
<td></td>
</tr>
<tr>
<td>Renal toxicity, 297, 317</td>
<td></td>
</tr>
<tr>
<td>Renal tubular acidosis (RTA), 73, 98</td>
<td></td>
</tr>
<tr>
<td>Renal urate stones, 298, 319</td>
<td></td>
</tr>
</tbody>
</table>
Renal vascular disease, 65, 90
Renin secretion, 64, 88–89
Repaglinide, 378, 389
Repression, 447, 459
Resolution, 250, 280
Respiration, noisy, 2
Respiratory acidosis, 417, 426
Respiratory alkalosis, 74, 99
Respiratory distress syndrome (See Hyaline membrane disease) Respiratory syncytial virus, 483, 492
Response time, 289, 307
Restriction endonuclease BamHI, 119, 150
Reticuloendothelial system, 176, 199–200
Retina ganglion cell, 74, 99–100
Retinal detachment, 13, 38
Retinal pigment epithelium, 13, 38
Retinitis pigmentosa, 2
Rh (—) blood type, 484, 494–495
Rheumatoid arthritis (RA), 62, 87, 486, 498
choriocarcinoma, 294, 312
methotrexate for, 375, 385–386
and NSAIDs, 298, 319
tumor necrosis factor-alpha, 292, 310–311
Rh (-) blood type, 484, 494–495
Rheumatoid arthritis (RA), 62, 87, 486, 498
chooriocarcinoma, 294, 312
methotrexate for, 375, 385–386
and NSAIDs, 298, 319
tumor necrosis factor-alpha, 292, 310–311
Rhinitis, allergic, 185, 210
Virus, 187, 213
Rickettsia rickettsii, 193, 221
Rifampin, 399, 411–412
Right coronary artery, 23, 48
Risperidone, 484, 495
RNA editing, 128, 165
RNA interference (RNAi), 375, 384
RNA translation, 130, 168
Rocky Mountain spotted fever, 193, 221
Rod cells, 119, 150
Romberg’s sign, 440, 450
Ropinirole, 484, 495
Rotavirus, 231, 259
RTA (renal tubular acidosis), 73, 98
Rubella virus, 184, 208–209
Rubeola (See Measles virus)
Running, difficulty, 1

S
S. pyogenes, 446, 459
SA (sinoatrial) node, 23, 48
Salivary glands, 16, 41, 303, 326–327
Salt wasting, 353, 363–364
Sarcoidosis, 418, 428
Sarcolemma, 30
Sarcoplasma, 28, 53, 423, 435
Sarcomplasm reticulum, 79, 106
Sargramostim, 299, 321
SARS, 178, 201
Scatchard plot, 60, 85
Schistosomiasis, 79, 105
Schizophrenia
chlorpromazine for, 69, 95
risperidone for, 481, 491
treatment of, 298, 318
Schwann cells, 11, 37
SCID (See Severe combined immunodeficiency disease)
Sclerosing cholangitis, primary, 369–370
Scotopsin, 119, 150
Scrotum, innervation of skin of the, 19, 44
Second branchial arch, anomalies of, 1
Second pharyngeal arch, 467, 477
Secondary hyperparathyroidism, 396, 406
Secondary hypertension, 65, 89
Secondary syphilis, 190, 216
Secretin, 59, 85, 352, 362
Sedation
and absence seizures, 291, 308–309
antidepressants, 298, 318
kava, 295, 314
Seminoma, 469, 479–480
Senile osteoporosis, 254
Sensitivity testing, 464, 473–474
Sensorimotor period, 337, 343
Sensory relay thalamic nuclei, 13, 39
Sensory (neural) retina, 13, 38
Separation anxiety disorder, 340, 346
Septum primum, 17, 42
Septum secundum, 350, 360
Serological testing, 186, 211
Serotonin (5-HT), 290, 308
Serous secretory cells, 16, 41
Sertraline, 338, 345
Serum hormone-binding globulin, 128, 166
Serum sodium concentration, 66, 91
Seventh cranial (facial) nerve, 17, 43
Severe acute respiratory syndrome, 178, 201
Severe combined immunodeficiency disease
stem differentiation defect, 177, 200
Severe combined immunodeficiency disease (SCID), 123, 157
Severe non-hemolytic icterus, 124, 159
SGLT 1 (See Sodium-dependent secondary active transporter)
SGLT-1 protein, 80, 107
SHBG, 128, 166
Sheathed arteriole, 21, 47
Shingles, 442, 454
SIADH, 74, 99
Sickle trait, 252, 282
Sildenafil (Viagra), 301, 323–324
and hypotension, 290, 307
and nitrovasodilators, 301, 323–324
Sinoatrial nodal tissue, 352, 362
Sinoatrial (SA) node, 23, 48
Sinopulmonary disease, chronic, 126, 163–164
Sjögren syndrome, 231, 258–259
Skeletal muscle contraction, 57, 82
and creatinine, 129, 166–167
tension, 70, 95
Skin and Horner syndrome, 20, 45
perspiration of the, 24, 50
sensation loss, 12, 38
SLE (See Systemic lupus erythematosus)
Sleeping pills, 291, 308
Sliding filament theory, 435
Slow calcium channels, 58, 83
Smoking and porphyria cutanea tarda, 110, 134
squamous cell carcinoma of the esophagus, 241, 269–270
Sodium electrochemical gradient, 80, 107
Sodium excretion, 65, 90
Sodium reabsorption, by kidney, 113, 139
Sodium-dependent secondary active transporter, 80, 107, 484, 494
Solute clearance, 401, 413
Somatogenic deficits, 5, 33
Somatostatin, 79, 106
Somatostatin-analogue treatment, 69, 94
Somatotropin release inhibiting factor, 69, 94
Sonic hedgehog gene, 41
Spastic neurogenic urinary bladder, 18, 43–44
Special visceral afferent fibers, 25, 50
Spinal accessory nerve, 11, 37
Spinal cord lesion, 18, 43–44
Spinal nerves, 24, 49–50
Spironolactone, 465, 474
and diuresis, 375, 385
and heart failure, 401, 413
and hepatic cirrhosis, 375, 385
Spleen, 9, 35
arterial circulation of, 21, 47
arterial circulation of the, 21, 47
and immunoglobulins, 176, 199
Splenic (left colic) flexure, 20, 45
Sporotrichosis, 190, 216
Squamous cell carcinoma (SCC),
248, 277
of esophagus, 241, 269–270
of lung, 467, 477–478
on middle nasal concha, 487, 499
ultraviolet radiation, 244, 273
SRIF, 69, 94
SSRIs, 305
Standing, difficulty with, 1
Stapedius, 467, 477
Staphylococcal scalded skin
syndrome, 189, 215
Starling forces, 80, 106–107
Status asthmaticus, 245, 274
Steady-state concentration, 446, 458
Steely hair disease, 141
Stem differentiation defect, 177, 200
Sterility, 66, 91
Steroid-receptor complexes, 126,
162–163
Stimulus generalization, 424, 437
Straight sinus, 28, 53
Stratified squamous epithelium,
24, 50
Streptococci, group D, 183, 206
Streptococcus pyogenes, 178, 201
Streptokinase, 301, 323
Streptomyacin use, 301, 323
Stretch receptors, atrial, 62, 87
Stria terminalis, 7, 33–34
Stridor, 2
Stroke volume (of heart), 60, 61,
85, 86
Stylohyoid muscle, 17, 42
S-type lectins (galectins), 467, 476
Suboccipital triangle, 375, 385
Substantia nigra, 357, 368
Subthalamic nucleus of Luys, 9, 35
Succinyl-CoA-acetoacetate-CoA-
transferase, 115, 143
Suicide, 354, 365
Sun, long-term exposure to, 5, 32
Superego, and guilt, 339, 346
Superficial flexor muscles, 8, 34
Superior alternating hemiplegia,
19, 45
Superior alveolar nerves, 20, 45
Superior ganglion of ninth cranial
nerve, 357, 369
Superior mesenteric artery, 21, 46
Superior sagittal sinus, 11, 37
Superior vena cava, 22, 47
Supraorbital nerve, 5, 32
Suprascapular artery, 12–13, 38
SVA fibers (See Special visceral
afferent fibers)
Sweating, thermoregulatory, 289
Sympathetic nerves, 63, 70, 88, 96
Syndrome of inappropriate
hypersecretion of antidiuretic
hormone, 74, 99
Syphilis, 190, 216, 217
Systemic lupus erythematosus
(SLE), 181, 195, 204, 224, 356,
367, 395, 405
Systemic vasculitis, 240, 268
T
T. pallidum, 190, 216
T. spiralis, 439, 449
T. vaginalis, 377, 388
Tachycardia
acute AV nodal reentrant, 302,
325–326
and isoproterenol, 468, 479
Taeniae coli muscles, 19, 45
Tardive dyskinesia, 298, 318
and AIMS, 463, 472
extrapyramidal dystonia, 298, 318
Thrombin, 422, 434–435
clot formation, 76, 102
inhibitor, 486, 498
Thromboplastin, 349, 359
Thrombotic thrombocytopenic
purpura, 237, 264
Thymic hypoplasia, 242, 270–271
Thymidine kinase, viral, 296, 316
Thymidylate synthase inhibition,
297, 317
Thymus, 15, 40
Thyroid peroxidase, 293, 311
Thyroiditis, 69, 94
Thyrotoxicosis, 241, 269
Thyroxine deficiency, 241, 269
Tic douloureux (See Trigeminal
neuralgia)
Tick, hard-bodied, 197, 226
Tidal volume, 74, 99
Tight junction (zonula occludens),
14, 39
Tinea cruris, 192, 219
Titin, 30
TNF-alpha (See Tumor necrosis
factor-alpha)
Tobacco, 337, 344, 376, 387
Tongue development, 23, 48
Tongue innervation, 23, 48
Topoisomerase II
DNA strand breakage, 297, 318
and doxorubicin, 130, 169–170
Toxoplasmosis, 466, 475
Transferrin, 124–125, 160
Transient paralysis, 335, 342
Tetanus, 188, 189, 214, 215
Tetracycline antimicrobials, 181, 204,
301, 323
Tetracycline resistance, 297, 316
Tetralogy of Fallot, 469, 480
TGA (See Transposition of the great
arteries)
Thalamic motor nucleus, 21, 46
Thalamic nuclei, 13, 39
Thalamus, 481, 491
Therapeutic index of drugs, 302, 325
Thermoregulatory sweating,
289, 307
Thiazide diuretic chlorothiazide,
78–79, 105
Thiazolidinediones (TZDs),
442, 453
Thoracentesis, 23, 48
Thought blocking, 399, 411
Thrombin, 422, 434–435
Thromboplatin, 349, 359
Thrombotic thrombocytopenic
purpura, 237, 264
Thyrotropic hormone, 242, 270–271
Thymidine kinase, viral, 296, 316
Thymidylate synthase inhibition,
297, 317
Thymus, 15, 40
Tobacco, 337, 344, 376, 387
Tongue development, 23, 48
Tongue innervation, 23, 48
Topoisomerase II
DNA strand breakage, 297, 318
and doxorubicin, 130, 169–170
Toxoplasmosis, 466, 475
Transferrin, 124–125, 160
Transient paralysis, 335, 342
Transitional epithelium, 22, 47
Transitional objects, 339, 345
Translation factor eEF-2, 118, 149–150
Transmissible spongiform encephalopathies, 183, 207
Transposition of the great arteries (TGA)
and cyanotic heart disease, 3
and right ventricle, 3, 31
and truncoconal septum, 22, 47
Transverse cervical artery, 12–13, 38
Treadmill stress test, 68, 93–94
Tremors, 1
Tricarboxylic acid cycle, 112, 118, 139, 149–150
Trichinosis infections, 439, 449
Trigeminal (gasserian) ganglion, 463, 472
Trigeminal nerve (cranial nerve V), 25, 50
Trigeminal neuralgia, 29, 54, 463
Trinucleotide repeat expansion, 114, 122–123, 142, 156
Troponin I, 30, 253, 283
Trousseau sign, 79, 105
Truncoconal septum, 22, 47–48
Tryptophan, 417, 427
Tuberculosis, 235, 262
and hypogonadism, 175, 198
and hypopituitarism, 57
pulmonary, 57, 82
Tuberculosis, secondary, 255, 286
Tubular fluid osmolality, 68, 93
Tumor necrosis factor, 424, 279
Tumor necrosis factor-alpha, 292, 310–311
Tumor suppression
Li-Fraumeni syndrome, 130, 168
p53 protein, 123, 157
Tumors, pathological staging of, 244, 436
Tunica intima, 6, 33
Turner syndrome, 125, 161
21-beta hydroxylase deficiency, 353, 363–364
Type III hyperlipoproteinemia, 120, 152
Type IV glycogen storage disease, 111, 138
Typhoid fever, 252, 282–283
TZDs (thiazolidinediones), 442, 453

U
U. urealyticum, 440, 450–451
UCD (See Urea cycle defect)
UGT, 124, 159
Ulcerative colitis, 230, 242, 257–258, 271
Ulcers, 339, 345
Ulnar nerve, 448, 460
Ultraviolet radiation, 244, 273
Umbilical vein, 11, 37, 465, 474–475
Urea cycle, 110–111, 136
Urea cycle defect, 109, 132, 485, 495 neonatal, 396, 407
and OTC deficiency, 117, 146–147
Urease, 375, 385
Ureter development, 26, 52
Uric acid, 121, 155
Uridine, 129, 168
Urinary system, 22, 47
Urinary tract infection (UTI), 187, 213
Urination, and micturition reflex, 18, 44
Uterus, embryonic development of, 19, 44
Uterus development, 19, 44
Uterus didelphys, 19, 44

V
V. vulnificus, 379, 392
“V wave,” 62, 87
Vagus (tenth cranial) nerve, 5, 20, 33, 45
Valproic acid, 440, 450
Valsava maneuver, 22
Vancomycin, 399, 411
Varicella, 189, 215
Vasa recta of jejunum, 21, 46
Vascular permeability, 175, 198
Vasculitis, 229, 240, 256–257, 268
Vasoactive intestinal peptide, 79, 106
Vasoconstruction, 409–410
Vein of Galen, 16, 28, 41, 53
Ventral lateral nucleus, 21, 46
Ventral posterior lateral nuclei, 13, 39
Ventral posterior medial nuclei, 13, 39
Ventricular action potential, 58, 83
Ventricular arrhythmia, 251, 281
Ventricular blood pressure, 64, 88
Ventricular depolarization, 402, 414
Ventricular load, 294, 313

W
Walking, slow and clumsy, 1
Wallenberg syndrome (See Lateral medullary syndrome)
Wallerian degeneration, 299, 320
Warthin degeneration, 445, 457
Wasp sting, 356–357, 368
Ventricular systole, 62, 87
Ventriculopertoneal shunts, 337, 343
Verapamil, 381, 394
Vertebral artery, 3, 31
Vertigo, 77, 102
Vestibular sensitivity, 58, 83
Vestibular system, 398, 409
Viagra (See Sildenafil)
Vibration sensation, 18, 43
Vinyl chloride exposure, 229, 256
VIP (vasoactive intestinal peptide), 79, 106
Viral DNA synthesis, 190, 216
Viral mRNA activity, 176, 199
Viral multiplication curve, 484
Viral myocarditis, 351, 361
Virulence factor
encapsulated bacteria, 187, 213
for gonorrhea, 179, 202
M protein, 195, 223–224
Visual impairment, 59, 84
Vitamin A, 126, 162
Vitamin B_{12} deficiency, 67, 92
Vitamin C deficiency, 233, 261, 441, 451
Vitamin D, 293, 312
Vitamin K, 126, 162
Vocal cord polyp/nodules, 482, 492
Vocal fold, abduction of the, 24, 49
Vocal folds, covering, 24, 50
Volume of distribution, apparent, 295, 314
Vomiting, excessive, 58, 83
von Gierke disease, 112, 117, 139, 147–148
von Recklinghausen disease, 130–131, 170
von Willebrand disease, 420, 431–432
von Willebrand factor, 124, 158–59
VPL nuclei, 13, 39
VPM nuclei, 13, 39

W
Walking, slow and clumsy, 1
Wallenberg syndrome (See Lateral medullary syndrome)
Wallerian degeneration, 299, 320
Warthin degeneration, 445, 457
Wasp sting, 356–357, 368
Water deprivation, 67, 92
Water ingestion, 63, 88
Water intoxication, 58, 83
Water secretion, 63, 88
Weakness, progressive generalized, 1
Wernicke syndrome, 337, 344
Western blot test, 185, 210
Wheezing respiration, 25, 51

Whooping cough, 191, 196,
   217–218, 226
Wilms’ tumor, 255,
   275, 286
Wilson disease, 232, 260
Wolman disease, 116,
   145–146
Wrist injury, 11, 37

Z
   lines, 28, 53
Zellweger syndrome, 124, 159
Zollinger-Ellison syndrome, 235, 262
Zone of equivalence, 181, 204
Zonula occludens (tight junction),
   14, 39
Zymogenic (chief, chief) cells, 4, 32