CHAPTER

1

Health Occupations Entrance Exam Planner

CHAPTER SUMMARY

In this chapter, you will learn about what you can expect on a health occupations entrance exam as well as how to use this book to your best advantage. You will learn tips about how to prepare for the exam and develop a study plan that meets your specific needs. After conducting a self-evaluation, you can choose from among four customized test-preparation schedules.

YOU HAVE CHOSEN this book because you want to pursue a rewarding career in healthcare. The healthcare field encompasses a wide range of exciting career choices, and the employment prospects for jobs in the next decade are excellent. Healthcare services make up the largest industry today and include occupations that are projected to be some of the fastest growing jobs in the United States.

There are plenty of good reasons to pursue training in healthcare:

- The largest U.S. industry, healthcare services, employed 12.9 million people in 2002.
- Ten of the 20 hottest jobs—projected to grow the fastest—are in healthcare services.
- Healthcare services will likely create 3.5 million new wage and salary jobs in the next decade.
- Many healthcare service jobs require less than four years of college education.

Healthcare occupations are composed of professionals and paraprofessionals, assistants and aides, technologists and technicians. You may be preparing for a job as a medical records technician, a physical therapist, respiratory therapist, a speech-language pathologist, or one of the other professions under the broad umbrella of health services.

But to begin your career, you need to get into a training program, and most likely, you will face a health occupations entrance exam. Because there is no one standard test that applies to all training programs, this book is not test-specific, but rather encompasses the core knowledge and skills you will need to pass *any* health occupations entrance exam. Developed from real tests commonly used in the field today, this book offers a study planner, valuable practice tests, and a review of the subjects tested—in short, everything you need to succeed.

▶ Test Overview

To begin preparing for the test, you need an overview of the type of exam you are facing and some tips about how to use this book to achieve your best test score. Again, there is no single test required by all health occupations training programs. Schools have different requirements for admission, depending on the institution, your choice of study, and whether you are applying for a certification course, a one-, two-, or four-year degree, or a graduate program. Many accredited health education programs ask candidates to pass one of these two tests: the Health Occupations Aptitude Exam (HOAE) or the Health Occupations Basic Entrance Test (HOBET). However, even if the school of your choice uses another exam, you will most likely need to demonstrate the essential skills covered in this book. You must show that you can communicate effectively, read and understand college-level materials, and that you have basic math skills. You may be also asked to demonstrate that you have fundamental knowledge about biology, chemistry, natural science, anatomy, and physiology.

Contact the school of your choice immediately to find out exactly which tests you will need to pass. Many institutions offer a test guide or sample questions from the entrance exam that they use—be sure to take advantage of any information that the school provides about the test.

If you have not done so already, find out about test dates and sites in your area. The dates when the test is offered in your area may determine when you take the exam. However, if you have a choice of test dates, and if you have not already applied to take the exam, do not apply until you have conducted the self-evaluation outlined in this chapter. The results of that self-evaluation can help you decide when to take the exam.

In this chapter, you will find contact information and an overview of two common health occupations entrance exams, the HOAE and the HOBET. If you know you will need to take one of these tests, contact the following testing agencies for more information about registration, testing locations, and dates.

▶ Health Occupations Aptitude Exam (HOAE)

Educational programs that offer degrees ranging from the associate level to a master's degree may require that applicants take the HOAE. Developed by the Psychological Services Bureau, Inc., this exam consists of five parts and takes about $2\frac{1}{2}$ hours to complete. The first section is divided into three subsections.

- Academic Aptitude
  1. Verbal, 30 questions
  2. Math, 30 questions
  3. Analytical Reasoning, 30 questions
- Spelling, 60 questions
- Reading Comprehension, 45 questions
- Natural Science, 65 questions
- Vocational Adjustment, 90 questions

To register for this test or learn about testing sites, contact the school of your choice or:

Psychological Services Bureau, Inc.
Health Careers Aptitude Tests
2246 Ivy Road, Suite 7
Charlottesville, VA 22903
877-932-8378
www.psbtests.com

▶ Health Occupations Basic Entrance Test (HOBET)

Many healthcare training programs require the HOBET. This approximately $2\frac{1}{2}$-hour test measures your ability in two general academic areas—your critical reading ability and your knowledge of basic math. The test includes two academic sections:

- Mathematics, 60 questions
- Reading Comprehension, 33 questions

Some schools require a different version of this test that includes a written expression section. Find out from the training program of your choice whether this is required. If it is, you will have an additional hour to complete this section.

In addition to reading comprehension and math questions, the basic HOBET includes questions that evaluate your learning style, stress, and social skills. These nonacademic sections include the following: Test-Taking Skills (30 questions); Stress Level (45 questions); Social Interaction Profile (30 questions); and Learning Style (50 questions). These sections are *not* used to determine whether or not you will be accepted into a training program. The purpose of these sections is to help learning institutions *after* a student has been accepted to the program—it aids the school in considering how a student will best learn and to increase the likelihood that a student will complete the program successfully.

If you know you need to take the HOBET, contact the school you are applying to or the testing agency for the exam:

Educational Resources, Inc.
8910 West 62nd Terrace
P.O. Box 29160
Shawnee Mission, KS 66201
800-292-2273
www.eriworld.com/hobet.htm

▶ How to Use This Book

This book contains three practice exams (in Chapters 3, 10, and 11) that combine what you need to know on the health occupations entrance exam that you will face. You may be tempted to start right in with a practice exam—but before you do, read on in this chapter. You will learn how to use the first practice exam as a self-evaluation to diagnose your strengths and the areas in which you need more preparation. This chapter will also show you how to customize your study plan so that you can achieve a top score.

In Chapter 2, "LearningExpress Test Preparation System," you will learn strategies to manage your study time as well as practical test-taking tips, such as how to pace yourself during the exam, when to guess, and how to combat test anxiety. Be sure to review the helpful strategies in this chapter before you begin the self-evaluation process.

Chapters 4–9 cover the subject areas found on most health occupations entrance exams: Verbal Ability, Reading Comprehension, Math, Biology, Chemistry, and General Science. Each of these chapters will provide an overview of the kinds of questions you will encounter on the exam and how to tackle them. And you will find practice questions throughout—so you can hone your test-taking skills while you review each topic.

▶ Self-Evaluation

Your first step is to evaluate your level of preparedness. Begin by taking the practice test in Chapter 3 to highlight areas in which you are strongest and those in which you need more work. You do not have to time yourself—just make sure you have allotted enough time (approximately four hours) so that you can complete the test in one sitting. When you have finished, score your exam using the answer key at the end. Then match your percentages on each section with the following analysis.

SECTION SCORE	ANALYSIS
under 50%	You need concentrated work in this area. Your best bet is to take an additional course. If that is not possible, contact your school's guidance or academic counseling office to arrange for a tutor. Turn to the chapter of this book pertaining to this section of the test only after you have taken a review course or spent at least two months in tutoring; at that point, you will be ready to get maximum benefit from the tips and practice questions in the chapter.
51–70%	This area may not be your strong suit, which is why you should not only work through the relevant chapter that follows, but also use the additional resources listed at the end of that chapter. You might want to find a tutor or form a study group with other students preparing for a health occupations entrance exam.
71–85%	You can probably get all the additional help you need from the chapter of this book pertaining to this section of the test—unless science falls into this category, in which case you should also refer to a biology, chemistry, natural science, or anatomy and physiology textbook.
over 85%	Congratulations! You do not need a lot of work in this area. Turn to the relevant chapter of this book to pick up vital tips and practice that can give you extra points in this area.

Most people do better on some sections of the exam than on others, but most also find that the variation is within a certain range; that is, it is rare to score under 50% in one section and over 90% in another. If you are one of those rare types, do not worry; it just shows you where most of your preparation time should go.

But if you are more typical, where your section scores tend to cluster on the chart should tell you something about when you should take the exam, if you have a choice, and how much time you will have to put in to prepare. If your scores cluster in the "under 50%" category, you should really consider postponing taking the exam until you have had some time for serious study. If your scores tend to be in the middle ranges, then you can go ahead and take the exam, but you should plan to put aside a fair amount of time for study between now and exam day. And if most or all of your scores are in the "over 85%" category, you can still benefit from the practice tests and review chapters in this book—your study time will most likely ensure a high score on the entrance exam.

▶ Planning for Success

There are four customized schedules on the following pages, based on the amount of time you have before the exam. If you are the kind of person who needs deadlines and assignments to motivate you for a project, here they are. If you prefer to design your own study timeline, use the suggested schedules here to help you create an effective plan.

Be sure to research the content of the specific entrance test you will be taking in order to adapt the given schedules for your exam. For example, if you are taking the HOBET, you may plan to spend less time on the science chapter, realizing that this topic is not covered with as much depth as the HOAE. (However, because the reading comprehension section of the HOBET focuses on science material, do not skip this chapter altogether!)

In constructing your plan, you should take into account how much work you need to do. If your scores on the first practice exam were not what you hoped,

you should take some of the steps from Schedule A and get them into Schedule D somehow, even if you do have only two weeks before the exam. Similarly, your scores on the practice exam should help determine how much time you have to spend each week. If you scored low, you might need to devote several hours a day to test preparation. If you scored high, a few hours a week will probably be enough.

Even more important than making a plan is making a commitment. You cannot get ready overnight for a health occupations entrance exam. Set aside some time every day—every other day, if your scores were high and you have months until the exam—for study and practice. An hour every day or every other day will do you much more good than a day or two of cramming right before the exam.

▶ Schedule A: Six Months to Exam

You have taken the first practice test in Chapter 3 and know that you have at least six months in which to build on your strengths and improve in areas where you are weak. Do not put off your preparation. In six months, five hours a week can make a significant difference in your score.

TIME	PREPARATION
Exam minus 6 months	Pick the one section in which your percentage score on the practice exam was lowest to concentrate on this month. Read the relevant chapters from among Chapters 4–9 and work through the exercises. Use the additional resources listed in that chapter. When you get to that chapter in the plan below, review it.
Exam minus 5 months	Read Chapter 5, "Reading Comprehension," and work through the exercises. Practice reading textbooks and professional journal articles about healthcare, and quiz yourself on each chapter or article you read. Read Chapter 9, "General Science Review," using your reading comprehension skills. Find other people who are preparing for the exam and form a study group.
Exam minus 4 months	Read Chapter 7, "Biology Review," and work through the sample questions. Use the resources listed at the end of the chapter for a comprehensive review. All this reading is a good time to practice your reading comprehension skills, too.
Exam minus 3 months	Read Chapter 8, "Chemistry Review," and work through the exercises. Use the resources listed at the end of the chapter, or your old textbooks, to review topics you are shaky on.
Exam minus 2 months	Read Chapter 6, "Math Review," and work through the exercises. Give yourself additional practice by making up your own test questions in the areas that give you the most trouble.
Exam minus 4 weeks	Read Chapter 4, "Verbal Ability," and work through the exercises. Use at least one additional resource listed here.

TIME	PREPARATION
Exam minus 2 weeks	Take the practice exam in Chapter 10. Use your scores to help you decide your focus for this week. Go back to the relevant chapters, and get the help of a teacher or your study group.
Exam minus 1 week	Review the first two sample tests, especially the answer explanations. Then, take the practice exam in Chapter 11 for extra practice. As you study this week, concentrate on the areas you're strongest in and decide not to let any areas where you still feel uncertain bother you. Go to bed early every night this week so you can be at your best by test time.
Exam minus 1 day	Relax. Do something unrelated to your health occupations entrance exam. Eat a good meal and go to bed at your new early bedtime.

▶ Schedule B: Three to Six Months to Exam

If you have three to six months until the exam, you have just enough time to prepare, as long as you put in at least seven or eight hours a week. This schedule assumes you have four months; stretch it out or compress it if you have more or less time.

TIME	PREPARATION
Exam minus 4 months	Read Chapter 5, "Reading Comprehension," and work through the exercises. Practice your reading comprehension skills as you work through Chapter 9, "General Science Review," and the resources listed at the end of that chapter. Find other people who are preparing for the exam and form a study group.
Exam minus 3 months	Read Chapters 7 and 8, "Biology Review" and "Chemistry Review," and work through the exercises. Use the resources listed at the end of the chapters, or your old textbooks, to review topics you're shaky on.
Exam minus 2 months	Read Chapter 6, "Math Review," and work through the exercises. Give yourself additional practice by making up your own test questions in the areas that give you the most trouble.
Exam minus 4 weeks	Read Chapter 4, "Verbal Ability," and work through the exercises. Use at least one of the additional resources listed there.
Exam minus 2 weeks	Take the practice test in Chapter 10. Use your scores to help you decide where to concentrate your efforts this week. Go back to the relevant chapters, and get help from a teacher or your study group.

TIME	PREPARATION
Exam minus 1 week	Review the first two sample tests, especially the answer explanations. Read over the test-taking strategies in Chapter 2. Then, take the sample test in Chapter 11 for extra practice. Choose the one area in which your scores are lowest to review this week. Go to bed early every night this week so you can be at your peak by test time.
Exam minus 1 day	Relax. Do something unrelated to your health occupations entrance exam. Eat a good meal and go to bed at your new early bedtime.

▶ Schedule C: One to Three Months to Exam

If you have one to three months until the exam, you still have time to get ready, but you should plan to put in ten hours a week. This schedule is built around a two-month time frame. If you have only one month, spend a couple of extra hours a week so you can get all the steps in. If you have three months, include some of the steps from Schedule B.

TIME	PREPARATION
Exam minus 8 weeks	Read Chapter 5, "Reading Comprehension," and work through the exercises. Use your reading comprehension skills as you review Chapter 9, "General Science Review."
Exam minus 6 weeks	Read Chapters 7 and 8, "Biology Review" and "Chemistry Review," and work through the exercises. Use the resources listed at the end of the chapters, or your old textbooks, to review topics you're shaky on.
Exam minus 4 weeks	Read Chapter 6, "Math Review," and work through the exercises.
Exam minus 2 weeks	Read Chapter 4, "Verbal Ability," and work through the exercises.
Exam minus 1 week	Take the practice test in Chapter 10. Use your scores to help you decide where to concentrate your efforts this week. Go back to the relevant chapters, and get the help of a teacher or friend. Go to bed early every night this week so you can be at your peak by test time.
Exam minus 4 days	Take the practice exam in Chapter 11 for extra practice.
Exam minus 1 day	Relax. Do something unrelated to your health occupations entrance exam. Eat a good meal and go to bed at your new early bedtime.

▶ Schedule D: Two to Four Weeks to Exam

If you have just two to four weeks until the exam, you really have your work cut out for you. Carve two hours out of your day, every day, for study. This schedule shows you how to make the most of your time if you have just two weeks. If you have an extra week or two, spend more time with the resources listed at the end of Chapters 4–9.

TIME	PREPARATION
Exam minus 14 days	Read Chapter 5, "Reading Comprehension," and work through the exercises. Use your reading comprehension skills as you review Chapter 9, "General Science Review." Work through the exercises in that chapter.
Exam minus 12 days	Read Chapters 7 and 8, "Biology Review" and "Chemistry Review," and work through the exercises. Use the resources listed at the end of the chapters, or your old textbooks, to review topics you're shaky on.
Exam minus 10 days	Read Chapter 6, "Math Review," and work through the exercises.
Exam minus 8 days	Read Chapter 4, "Verbal Ability," and work through the exercises. Go to bed early every night this week so you can be at your peak by test time.
Exam minus 6 days	Take the practice test in Chapter 10. Choose one or two areas to review until the day before the exam, based on your scores. Go back to the relevant instructional chapters, and get the help of a teacher or friend.
Exam minus 4 days	Take the practice exam in Chapter 11 for extra practice.
Exam minus 1 day	Relax. Do something unrelated to your health occupations entrance exam. Eat a good meal and go to bed at your new early bedtime.

▶ Score Your Best

The final step in your study plan is to plan to succeed on exam day. Preparation is the key to building your confidence and giving you the edge you will need to do your best on the exam. If you use this book to customize and follow a study plan, learn the secrets of test success, study the kinds of questions on the exam, and take the practice tests, you *will* score your best—because you will be prepared.

CHAPTER

2

The LearningExpress Test Preparation System

CHAPTER SUMMARY

Taking a health occupations entrance exam can be tough, and your career in healthcare depends on your passing the exam. The LearningExpress Test Preparation System, developed exclusively for LearningExpress by leading test experts, gives you the discipline and attitude you need to succeed.

First, the bad news: Taking the health occupations entrance exam is no picnic, and neither is getting ready for it. Your future career in healthcare depends on passing the test, but there are all sorts of pitfalls that can keep you from doing your best on this all-important exam. Here are some of the obstacles that can stand in the way of your success:

- Being unfamiliar with the format of the exam
- Being paralyzed by test anxiety
- Leaving your preparation to the last minute
- Not preparing at all!
- Not knowing vital test-taking skills: how to pace yourself through the exam, how to use the process of elimination, and when to guess
- Not being in tip-top mental and physical shape
- Arriving late at the test site, having to work on an empty stomach, or shivering through the exam because the room is cold

What's the common denominator in all these test-taking pitfalls? One word: control. Who's in control, you or the exam?

Now the good news: The LearningExpress Test Preparation System puts you in control. In just nine easy-to-follow steps, you will learn everything you need to know to make sure that you are in charge of your preparation and your performance on the exam. Other test takers may let the test get the better of them; other test takers may be unprepared or out of shape—but not you. You will have taken all the steps you need to take to get a high score on the health occupations entrance exam.

Here's how the LearningExpress Test Preparation System works: Nine easy steps lead you through everything you need to know and do to get ready to master your exam. Each of the steps listed below includes both reading about the step and one or more activities. It is important that you do the activities along with the reading, or you won't be getting the full benefit of the system.

Step 1. Get Information
Step 2. Conquer Test Anxiety
Step 3. Make a Plan
Step 4. Learn to Manage Your Time
Step 5. Learn to Use the Process of Elimination
Step 6. Know When to Guess
Step 7. Reach Your Peak Performance Zone
Step 8. Get Your Act Together
Step 9. Do It!

If you have several hours, you can work through the whole LearningExpress Test Preparation System in one sitting. Otherwise, you can break it up and do just one or two steps a day for the next several days. It is up to you—remember, you are in control.

▶ Step 1: Get Information

Activities: Read Chapter 1, "The Health Occupations Entrance Exam Planner," and use the suggestions there to find out about your requirements.

Knowledge is power. Therefore, first, you have to find out everything you can about the health occupations entrance exam. Once you have your information, the next steps will show you what to do about it.

Part A: Straight Talk about the Health Occupations Entrance Exam

Why do you have to take this exam, anyway? Because an increasing number of people, particularly elderly people, need to be cared for. And, since more and more people need these services, there is growing concern about the quality of care the patients get. One way to try to ensure quality of care is to test the people who give that care to find out if they have been well trained. And that's why your state or the agency you want to work for may require you to take a written exam.

It is important for you to remember that your score on the written exam does not determine how smart you are or even whether you will make a good healthcare professional. There are all kinds of things a written exam like this can't test: whether you are likely to show up late or call in sick a lot, whether you can be patient with a trying client, or whether you can be trusted with confidential information about people's health. Those kinds of things are hard to evaluate on a written exam. Meanwhile, it is easy to evaluate whether you can correctly answer questions about your job duties.

This is not to say that correctly answering the questions on the written exam is not important! The knowledge tested on the exam is knowledge you will need to do your job, and your ability to enter the profession you have trained for depends on your passing this exam. And that's why you are here—to achieve control over the exam.

Part B: What's on the Test

If you haven't already done so, stop here and read Chapter 1 of this book, which gives you an overview of the written exam. Later, you will have the opportunity to take the sample practice exams in Chapters 3, 10, and 11.

▶ Step 2: Conquer Test Anxiety

Activity: Take the Test Anxiety Quiz on page 12.

Having complete information about the exam is the first step in getting control of the exam. Next, you have to overcome one of the biggest obstacles to test success: test anxiety. Test anxiety cannot only impair your performance on the exam itself; it can even keep you from preparing! In this step, you will learn stress management techniques that will help you succeed on your exam. Learn these strategies now, and practice them as you complete the exams in this book so that they will be second nature to you by exam day.

Combating Test Anxiety

The first thing you need to know is that a little test anxiety is a good thing. Everyone gets nervous before a big exam—and if that nervousness motivates you to prepare thoroughly, so much the better. Many well-known people throughout history have experienced anxiety or nervousness—from performers such as actor Sir Laurence Olivier and singer Aretha Franklin to writers such as Charlotte Brontë and Alfred Lord Tennyson. In fact, anxiety probably gave them a little extra edge—just the kind of edge you need to do well, whether on a stage or in an examination room.

Stop here and complete the *Test Anxiety Quiz* on the next page to find out whether your level of test anxiety is something you should worry about.

Stress Management before the Test

If you feel your level of anxiety getting the best of you in the weeks before the test, here is what you need to do to bring the level down again:

- **Get prepared**. There's nothing like knowing what to expect and being prepared for it to put you in control of test anxiety. That's why you are reading this book. Use it faithfully, and remind yourself that you are better prepared than most of the people taking the test.
- **Practice self-confidence**. A positive attitude is a great way to combat test anxiety. This is no time to be humble or shy. Stand in front of the mirror and say to your reflection, "I'm prepared. I'm full of self-confidence. I'm going to ace this test. I know I can do it." If you hear it often enough, you will come to believe it.
- **Fight negative messages**. Every time someone starts telling you how hard the exam is or how it is almost impossible to get a high score, start telling them your self-confidence messages above. If the someone with the negative messages is you telling yourself you don't do well on exams or you just can't do this, don't listen.
- **Visualize**. Imagine yourself reporting for duty on your first day as a healthcare professional. Think of yourself helping patients and making them more comfortable. Imagine coming home with your first paycheck. Visualizing success can help make it happen—and it reminds you of why you are working so hard to pass the exam.
- **Exercise**. Physical activity helps calm down your body and focus your mind. Besides, being in good physical shape can actually help you do well on the exam. Go for a run, lift weights, go swimming—and do it regularly.

Test Anxiety Quiz

You only need to worry about test anxiety if it is extreme enough to impair your performance. The following questionnaire will provide a diagnosis of your level of test anxiety. In the blank before each statement, write the number that most accurately describes your experience.

0 = Never
1 = Once or twice
2 = Sometimes
3 = Often

___ I have gotten so nervous before an exam that I simply put down the books and didn't study for it.
___ I have experienced disabling physical symptoms such as vomiting and severe headaches because I was nervous about an exam.
___ I have simply not showed up for an exam because I was scared to take it.
___ I have experienced dizziness and disorientation while taking an exam.
___ I have had trouble filling in the little circles because my hands were shaking too hard.
___ I have failed an exam because I was too nervous to complete it.
___ **Total:** Add up the numbers in the blanks above.

Your Test Anxiety Score

Here are the steps you should take, depending on your score. If you scored:

- **Below 3**, your level of test anxiety is nothing to worry about; it is probably just enough to give you that little extra edge.
- **Between 3 and 6**, your test anxiety may be enough to impair your performance, and you should practice the stress management techniques listed in this section to try to bring your test anxiety down to manageable levels.
- **Above 6**, your level of test anxiety is a serious concern. In addition to practicing the stress management techniques listed in this section, you may want to seek additional, personal help. Call your local high school or community college and ask for the academic counselor. Tell the counselor that you have a level of test anxiety that sometimes keeps you from being able to take an exam. The counselor may be willing to help you or may suggest someone else you should talk to.

Stress Management on Test Day

There are several ways you can bring down your level of test anxiety on test day. They will work best if you practice them in the weeks before the test, so you know which ones work best for you.

- **Deep breathing**. Take a deep breath while you count to five. Hold it for a count of one, then let it out for a count of five. Repeat several times.
- **Move your body**. Try rolling your head in a circle. Rotate your shoulders. Shake your hands from the wrist. Many people find these movements very relaxing.
- **Visualize again**. Think of the place where you are most relaxed: lying on the beach in the sun, walking through the park, or whatever makes you feel good. Now close your eyes and imagine you are actually there. If you practice in advance, you will find that you only need a few seconds of this exercise to experience a significant increase in your sense of well-being.

When anxiety threatens to overwhelm you right there during the exam, there are still things you can do to manage the stress level.

- **Repeat your self-confidence messages**. You should have them memorized by now. Say them quietly to yourself, and believe them!
- **Visualize one more time**. This time, visualize yourself moving smoothly and quickly through the test answering every question correctly and finishing just before time is up. Like most visualization techniques, this one works best if you have practiced it ahead of time.
- **Find an easy question**. Skim over the test until you find an easy question, and answer it. Getting even one circle filled in gets you into the test-taking groove.
- **Take a mental break**. Everyone loses concentration once in a while during a long test. It is normal, so you shouldn't worry about it. Instead, accept what has happened. Say to yourself, "Hey, I lost it there for a minute. My brain is taking a break." Put down your pencil, close your eyes, and do some deep breathing for a few seconds. Then you will be ready to go back to work.

Try these techniques ahead of time, and see if they don't work for you!

▶ Step 3: Make a Plan

Activity: Construct a study plan.

Maybe the most important thing you can do to get control of yourself and your exam is to make a study plan. Too many people fail to prepare simply because they fail to plan. Spending hours poring over sample test questions the day before the exam not only raises your level of test anxiety, but it also will not replace careful preparation and practice over time.

Don't fall into the cram trap. Take control of your preparation time by mapping out a study schedule. On the following pages are two sample schedules, based on the amount of time you have before you take the written exam. If you are the kind of person who needs deadlines and assignments to motivate you for a project, here they are. If you are the kind of person who doesn't like to follow other people's plans, you can use the suggested schedules here to construct your own.

Even more important than making a plan is making a commitment. You can't review everything you learned in your healthcare courses in one night. You need to set aside some time every day for study and practice. Try for at least 20 minutes a day. Twenty minutes daily will do you much more good than two hours on Saturday—divide your test preparation into smaller pieces of the larger work. In addition, making study notes, creating visual aids, and memorizing can be quite useful as you prepare. Each time you begin to study, quickly review your last lesson. This act will help you retain all you have learned and help you assess if you are studying effectively. You may realize you are not

remembering some of the material you studied earlier. Approximately one week before your exam, try to determine the areas that are still most difficult for you.

Don't put off your study until the day before the exam. Start now. A few minutes a day, with half an hour or more on weekends, can make a big difference in your score.

Learning Styles

Each of us absorbs information differently. Whichever way works best for you is called your dominant learning method. If someone asks you to help them construct a bookcase they just bought, which may be in many pieces, how do you begin? Do you need to read the directions and see the diagram? Would you rather hear someone read the directions to you—telling you which part connects to another? Or do you draw your own diagram?

The three main learning methods are visual, auditory, and kinesthetic. Determining which type of learner you are will help you create tools for studying.

1. **Visual Learners** need to see the information in the form of maps, pictures, text, words, or math examples. Outlining notes and important points in colorful highlighters and taking note of diagrams and pictures may be key in helping you study.
2. **Auditory Learners** retain information when they can hear directions, the spelling of a word, a math theorem, or poem. Repeating information aloud or listening to your notes on a tape recorder may help. Many auditory learners also find working in study groups or having someone quiz them is beneficial.
3. **Kinesthetic Learners** must *do!* They need to draw diagrams, write directions, etc. Rewriting notes on index cards or making margin notes in your textbooks also helps kinesthetic learners to retain information.

Mnemonics

Mnemonics are memory tricks that help you remember what you need to know. The three basic principles in the use of mnemonics are imagination, association, and location. Acronyms (words created from the first letters in a series of words) are common mnemonics. One acronym you may already know is **HOMES**, for the names of the Great Lakes (**H**uron, **O**ntario, **M**ichigan, **E**rie, and **S**uperior). **ROY G. BIV** reminds people of the colors in the spectrum (**R**ed, **O**range, **Y**ellow, **G**reen, **B**lue, **I**ndigo, and **V**iolet). Depending on the type of learner you are, mnemonics can also be colorful or vivid images, stories, word associations, or catchy rhymes such as "Thirty days hath September . . . " created in your mind. Any type of learner, whether visual, auditory, or kinesthetic, can use mnemonics to help the brain store and interpret information.

▶ Step 4: Learn to Manage Your Time

Activities: Practice these strategies as you take the sample tests in this book.

Steps 4, 5, and 6 of the LearningExpress Test Preparation System put you in charge of your exam by showing you test-taking strategies that work. Practice these strategies as you take the sample tests in this book, and then you will be ready to use them on test day.

First, you will take control of your time on the exam. Most health occupations entrance exams have a time limit, which may give you more than enough time to complete all the questions—or may not. It is a terrible feeling to hear the examiner say, "Five minutes left," when you are only three-quarters of the way through the test. Here are some tips to keep that from happening to you.

- **Follow directions**. If the directions are given orally, listen to them. If they are written on the exam booklet, read them carefully. Ask questions before the exam begins if there's anything you don't understand. If you are allowed to write in your exam booklet, write down the beginning time and the ending time of the exam.

- **Pace yourself**. Glance at your watch every few minutes, and compare the time to how far you have gotten in the test. When one-quarter of the time has elapsed, you should be a quarter of the way through the test, and so on. If you are falling behind, pick up the pace a bit.
- **Keep moving**. Don't dither around on one question. If you don't know the answer, skip the question and move on. Circle the number of the question in your test booklet in case you have time to come back to it later.
- **Keep track of your place on the answer sheet**. If you skip a question, make sure that you also skip the question on the answer sheet. Check yourself every 5–10 questions to make sure that the number of the question still corresponds with the number on the answer sheet.
- **Don't rush**. Though you should keep moving, rushing won't help. Try to keep calm and work methodically and quickly.

▶ Step 5: Learn to Use the Process of Elimination

Activity: Complete worksheet on Using the Process of Elimination (see page 17).

After time management, your next most important tool for taking control of your exam is using the process of elimination wisely. It is standard test-taking wisdom that you should always read all the answer choices before choosing your answer. This helps you find the right answer by eliminating wrong answer choices. And, sure enough, that standard wisdom applies to your health occupations entrance exam, too.

Let's say you are facing a question that goes like this:

Which of the following lists of signs and symptoms indicates a possible heart attack?

a. headache, dizziness, nausea, confusion
b. dull chest pain, sudden sweating, difficulty breathing
c. wheezing, labored breathing, chest pain
d. difficulty breathing, high fever, rapid pulse

You should always use the process of elimination on a question like this, even if the right answer jumps out at you. Sometimes, the answer that jumps out isn't right after all. Let's assume, for the purpose of this exercise, that you are a little rusty on your signs and symptoms of a heart attack, so you need to use a little intuition to make up for what you don't remember. Proceed through the answer choices in order.

- **Start with choice a.** This one is pretty easy to eliminate; none of these signs and symptoms is likely to indicate a heart attack. Mark an **X** next to choice **a** so you never have to look at it again.
- **On to choice b.** "Dull chest pain" looks good, though if you are not up on your cardiac signs and symptoms you might wonder if it should be "acute chest pain" instead. "Sudden sweating" and "difficulty breathing"? Check. And that's what you write next to answer **b**—a check mark, meaning "good answer, I might use this one."
- **Choice c is a possibility.** Maybe you don't really expect wheezing in a heart attack victim, but you know "chest pain" is right, and let's say you are not sure whether "labored breathing" is a sign of cardiac difficulty. Put a question mark next to **c**, meaning "well, maybe."
- **Choice d is also a possibility.** "Difficulty breathing" is a good sign of a heart attack. But wait a minute. "High fever?" Not really. "Rapid pulse?" Well, maybe. This doesn't really sound like a heart attack, and you have already got a better answer picked out in choice **b**. If you are feeling sure of yourself, put an **X** next to this one. If you want to

be careful, put a question mark. Now your question looks like this:

Which of the following lists of signs and symptoms indicates a possible heart attack?
X a. headache, dizziness, nausea, confusion
✓ b. dull chest pain, sudden sweating, difficulty breathing
? c. wheezing, labored breathing, chest pain
? d. difficulty breathing, high fever, rapid pulse

You have got just one check mark, for a good answer. If you are pressed for time, you should simply mark answer **b** on your answer sheet. If you have got the time to be extra careful, you could compare your check mark answer to your question-mark answers to make sure that it is better.

It is good to have a system for marking good, bad, and maybe answers. We recommend this one:

X = bad
✓ = good
? = maybe

If you don't like these marks, devise your own system. Just make sure you do it long before test day—while you are working through the practice exams in this book—so you won't have to worry about it during the test.

Key Words

Often, identifying key words in a question will help you in the process of elimination. Words such as *always, never, all, only, must,* and *will* often make statements incorrect. Here is an example of an incorrect statement:

When a nursing assistant is preparing to ambulate a client, making sure the client is wearing proper footwear will always prevent them from falling.

The word *always* in this statement makes it incorrect. Nursing assistants must also take other measures, in addition to providing proper footwear, when ambulating a resident, such as proper body mechanics and providing support to the client.

Words like *usually, may, sometimes,* and *most* may make a statement correct. Here is an example of a correct statement:

Clients of healthcare facilities and hospitals may need help with tasks such as being fed and bathed.

The word *may* makes this statement correct. There are clients in facilities who may be too ill or weak to perform daily tasks such as feeding and bathing themselves.

Even when you think you are absolutely clueless about a question, you can often use the process of elimination to get rid of at least one answer choice. If so, you are better prepared to make an educated guess, as you will see in Step 6. More often, you can eliminate answers until you have only two possible answers. Then you are in a strong position to guess.

Try using your powers of elimination on the questions in the following worksheet, *Using the Process of Elimination*. The questions are not about healthcare work; they are just designed to show you how the process of elimination works. The answer explanations for this worksheet show one possible way you might use the process to arrive at the right answer.

▶ Step 6: Know When to Guess

Activity: Complete worksheet on Your Guessing Ability (see page 18).

Armed with the process of elimination, you are ready to take control of one of the big questions in test taking: Should I guess? The first and main answer is *Yes*. Some exams have what's called a "guessing penalty," in which a fraction of your wrong answers is subtracted from your right answers—but health occupations

Using the Process of Elimination

Use the process of elimination to answer the following questions.

1. Ilsa is as old as Meghan will be in five years. The difference between Ed's age and Meghan's age is twice the difference between Ilsa's age and Meghan's age. Ed is 29. How old is Ilsa?
- **a.** 4
- **b.** 10
- **c.** 19
- **d.** 24

2. "All drivers of commercial vehicles must carry a valid commercial driver's license whenever operating a commercial vehicle."

According to this sentence, which of the following people need NOT carry a commercial driver's license?
- **a.** a truck driver idling his engine while waiting to be directed to a loading dock
- **b.** a bus operator backing her bus out of the way of another bus in the bus lot
- **c.** a taxi driver driving his personal car to the grocery store
- **d.** a limousine driver taking the limousine to her home after dropping off her last passenger of the evening

3. Smoking tobacco has been linked to
- **a.** increased risk of stroke and heart attack.
- **b.** all forms of respiratory disease.
- **c.** increasing mortality rates over the past ten years.
- **d.** juvenile delinquency.

4. Which of the following words is spelled correctly?
- **a.** incorrigible
- **b.** outragous
- **c.** domestickated
- **d.** understandible

Answers

Here are the answers, as well as some suggestions as to how you might have used the process of elimination to find them.

1. d. You should have eliminated answer **a** off the bat. Ilsa can't be four years old if Meghan is going to be Ilsa's age in five years. The best way to eliminate other answer choices is to try plugging them in to the information given in the problem. For instance, for answer **b**, if Ilsa is 10, then Meghan must be 5. The difference in their ages is 5. The difference between Ed's age, 29, and Meghan's age, 5, is 24. Is 24 two times 5? No. Then answer **b** is wrong. You could eliminate answer **c** in the same way and be left with answer **d**.

2. c. Note the word *not* in the question, and go through the answers one by one. Is the truck driver in choice **a** "operating a commercial vehicle"? Yes, idling counts as "operating," so he needs to have a commercial driver's license. Likewise, the bus operator in answer **b** is operating a commercial vehicle; the question doesn't say the operator has to be on the street. The limo driver in choice **d** is operating a commercial vehicle, even if it doesn't have a passenger in it. However, the cabbie in answer **c** is not operating a commercial vehicle, but his own private car.

Using the Process of Elimination (continued)

3. a. You could eliminate answer **b** simply because of the presence of the word *all*. Such absolutes hardly ever appear in correct answer choices. Choice **c** looks attractive until you think a little about what you know—aren't fewer people smoking these days, rather than more? So how could smoking be responsible for a higher mortality rate? (If you didn't know that mortality rate means the rate at which people die, you might keep this choice as a possibility, but you would still be able to eliminate two answers and have only two to choose from.) And choice **d** is plain silly, so you could eliminate that one, too. You are left with the correct choice, **a**.

4. a. How you used the process of elimination here depends on which words you recognized as being spelled incorrectly. If you knew that the correct spellings were outrageous, domesticated, and understandable, then you were home free.

Your Guessing Ability

The following are ten really hard questions. You are not supposed to know the answers. Rather, this is an assessment of your ability to guess when you don't have a clue. Read each question carefully, just as if you did expect to answer it. If you have any knowledge of the subject, use that knowledge to help you eliminate wrong answer choices.

1. September 7 is Independence Day in
- **a.** India.
- **b.** Costa Rica.
- **c.** Brazil.
- **d.** Australia.

2. Which of the following is the formula for determining the momentum of an object?
- **a.** $p = MV$
- **b.** $F = ma$
- **c.** $P = IV$
- **d.** $E = mc^2$

3. Because of the expansion of the universe, the stars and other celestial bodies are all moving away from each other. This phenomenon is known as
- **a.** Newton's first law.
- **b.** the big bang.
- **c.** gravitational collapse.
- **d.** Hubble flow.

4. American author Gertrude Stein was born in
- **a.** 1713.
- **b.** 1830.
- **c.** 1874.
- **d.** 1901.

5. Which of the following is NOT one of the Five Classics attributed to Confucius?
- **a.** the *I Ching*
- **b.** the *Book of Holiness*
- **c.** the *Spring and Autumn Annals*
- **d.** the *Book of History*

6. The religious and philosophical doctrine that holds that the universe is constantly in a struggle between good and evil is known as
- **a.** Pelagianism.
- **b.** Manichaeanism.
- **c.** neo-Hegelianism.
- **d.** Epicureanism.

7. The third Chief Justice of the U.S. Supreme Court was
- **a.** John Blair.
- **b.** William Cushing.
- **c.** James Wilson.
- **d.** John Jay.

8. Which of the following is the poisonous portion of a daffodil?
- **a.** the bulb
- **b.** the leaves
- **c.** the stem
- **d.** the flowers

9. The winner of the Masters golf tournament in 1953 was
- **a.** Sam Snead.
- **b.** Cary Middlecoff.
- **c.** Arnold Palmer.
- **d.** Ben Hogan.

10. The state with the highest per capita personal income in 1980 was
- **a.** Alaska.
- **b.** Connecticut.
- **c.** New York.
- **d.** Texas.

Answers

Check your answers against the correct answers below.

1. c.
2. a.
3. d.
4. c.
5. b.
6. b.
7. b.
8. a.
9. d.
10. a.

How Did You Do?

You may have simply gotten lucky and actually known the answer to one or two questions. In addition, your guessing was probably more successful if you were able to use the process of elimination on any of the questions. Maybe you didn't know who the third Chief Justice was (question 7), but you knew that John Jay was the first. In that case, you would have eliminated answer **d** and therefore improved your odds of guessing right from one in four to one in three.

According to probability, you should get two and a half answers correct, so getting either two or three right would be average. If you got four or more right, you may be a really terrific guesser. If you got one or none right, you may be a really bad guesser.

Keep in mind, though, that this is only a small sample. You should continue to keep track of your guessing ability as you work through the sample questions in this book. Circle the numbers of questions you guess on as you make your guess; or, if you don't have time while you take the practice tests, go back afterward and try to remember which questions you guessed at. Remember, on a test with four answer choices, your chance of guessing correctly is one in four. So keep a separate "guessing" score for each exam. How many questions did you guess on? How many did you get right? If the number you got right is at least one-fourth of the number of questions you guessed on, you are at least an average guesser—maybe better—and you should always go ahead and guess on the real exam. If the number you got right is significantly lower than one-fourth of the number you guessed on, you would, frankly, be safe in guessing anyway, but maybe you would feel more comfortable if you guessed only selectively, when you can eliminate a wrong answer or at least have a good feeling about one of the answer choices.

Frankly, even if you are a play-it-safe person with lousy intuition, you are still safe guessing every time.

entrance exams don't tend to work like that. The number of questions you answer correctly yields your raw score. So you have nothing to lose and everything to gain by guessing.

The more complicated answer to the question "Should I guess?" depends on you—your personality and your "guessing intuition." There are two things you need to know about yourself before you go into the exam:

Are you a risk-taker?
Are you a good guesser?

You will have to decide about your risk-taking quotient on your own. To find out if you are a good guesser, complete the worksheet, *Your Guessing Ability*, on page 18.

▶ Step 7: Reach Your Peak Performance Zone

Activity: Complete the Physical Preparation Checklist.
To get ready for a challenge like a big exam, you have to take control of your physical, as well as your mental, state. Exercise, proper diet, and rest in the weeks prior to the test will ensure that your body works with, rather than against, your mind on test day, as well as during your preparation.

Exercise

If you don't already have a regular exercise program going, the time during which you are preparing for an exam is actually an excellent time to start one. And if you are already keeping fit—or trying to get that way—don't let the pressure of preparing for an exam fool you into quitting now. Exercise helps reduce stress by pumping feel-good hormones, called endorphins, into your system. It also increases the oxygen supply throughout your body, including your brain, so you will be at peak performance on test day.

A half hour of vigorous activity—enough to raise a sweat—every day should be your aim. If you are really pressed for time, every other day is OK. Choose an activity you like and get out there and do it. Jogging with a friend always makes the time go faster, or take a portable radio or CD player.

But don't overdo it. You don't want to exhaust yourself. Moderation is the key.

Diet

First of all, cut out the junk. Go easy on caffeine and nicotine, and eliminate alcohol from your system at least two weeks before the exam. What your body needs for peak performance is simply a balanced diet. Eat plenty of fruits and vegetables, along with protein and carbohydrates. Foods that are high in lecithin (an amino acid), such as fish and beans, are especially good "brain foods."

The night before the exam, you might "carbo-load" the way athletes do before a contest. Eat a big plate of spaghetti, rice and beans, or whatever your favorite carbohydrate is.

Rest

You probably know how much sleep you need every night to be at your best, even if you don't always get it. Make sure you do get that much sleep, though, for at least a week before the exam. Moderation is important here, too. Extra sleep will just make you groggy.

If you are not a morning person and your exam will be given in the morning, you should reset your internal clock so that your body doesn't think you are taking an exam at 3 A.M. You have to start this process well before the exam. The way it works is to get up half an hour earlier each morning, and then go to bed half an hour earlier that night. Don't try it the other way around; you will just toss and turn if you go to bed early without having gotten up early. The next morning, get up another half an hour earlier, and so on. How long you will have to do this depends on how late you are used to getting up.

Physical Preparation Checklist

For the week before the test, write down 1) what physical exercise you engaged in and for how long and 2) what you ate for each meal. Remember, you're trying for at least half an hour of exercise every other day (preferably every day) and a balanced diet that's light on junk food.

Exam minus 7 days

Exercise: _____ for _____ minutes
Breakfast: _____
Lunch: _____
Dinner: _____
Snacks: _____

Exam minus 6 days

Exercise: _____ for _____ minutes
Breakfast: _____
Lunch: _____
Dinner: _____
Snacks: _____

Exam minus 5 days

Exercise: _____ for _____ minutes
Breakfast: _____
Lunch: _____
Dinner: _____
Snacks: _____

Exam minus 4 days

Exercise: _____ for _____ minutes
Breakfast: _____
Lunch: _____
Dinner: _____
Snacks: _____

Exam minus 3 days

Exercise: _____ for _____ minutes
Breakfast: _____
Lunch: _____
Dinner: _____
Snacks: _____

Exam minus 2 days

Exercise: _____ for _____ minutes
Breakfast: _____
Lunch: _____
Dinner: _____
Snacks: _____

Exam minus 1 day

Exercise: _____ for _____ minutes
Breakfast: _____
Lunch: _____
Dinner: _____
Snacks: _____

▶ Step 8: Get Your Act Together

Activity: Complete Final Preparations worksheet.
You are in control of your mind and body; you are in charge of test anxiety, your preparation, and your test-taking strategies. Now it is time to take charge of external factors, like the testing site and the materials you need to take the exam.

Find Out Where the Test Is and Make a Trial Run

The testing agency or your healthcare course instructor will notify you when and where your exam is being held. Do you know how to get to the testing site? Do you know how long it will take to get there? If not, make a trial run, preferably on the same day of the week at the same time of day. Make note, on the worksheet *Final Preparations* on page 23, of the amount of time it will take you to get to the exam site. Plan on arriving at least 10–15 minutes early so you can get the lay of the land, use the bathroom, and calm down. Then figure out how early you will have to get up that morning, and make sure you get up that early every day for a week before the exam.

Gather Your Materials

The night before the exam, lay out the clothes you will wear and the materials you have to bring with you to the exam. Plan on dressing in layers; you won't have any control over the temperature of the examination room. Have a sweater or jacket you can take off if it is warm. Use the checklist on the worksheet *Final Preparations* on the following page to help you pull together what you will need.

Don't Skip Breakfast

Even if you don't usually eat breakfast, do so on exam morning. A cup of coffee doesn't count. Don't eat doughnuts or other sweet foods, either. A sugar high will leave you with a sugar low in the middle of the exam. A mix of protein and carbohydrates is best: Cereal with milk and just a little sugar, or eggs with toast, will do your body a world of good.

▶ Step 9: Do It!

Activity: Ace the health occupations entrance exam!
Fast forward to exam day. You are ready. You made a study plan and followed through. You practiced your test-taking strategies while working through this book. You are in control of your physical, mental, and emotional states. You know when and where to show up and what to bring with you. In other words, you are better prepared than most of the other people taking the health occupations entrance exam with you. You are psyched.

Just one more thing . . . When you are done with the exam, you deserve a reward. Plan a celebration. Call up your friends and plan a party, or have a nice dinner for two—whatever your heart desires. Give yourself something to look forward to.

And then do it. Go into the exam, full of confidence, armed with test-taking strategies you have practiced until they are second nature. You are in control of yourself, your environment, and your performance on the exam. You are ready to succeed. So do it. Go in there and ace the exam. And look forward to your future career as a healthcare professional!

Final Preparations

Getting to the Exam Site

Location of exam site: _____

Date: _____

Departure time: _____

Do I know how to get to the exam site? Yes ___ No ___ (If no, make a trial run.)

Time it will take to get to exam site: _____

Things to Lay Out the Night Before

Clothes I will wear ___

Sweater/jacket ___

Watch ___

Photo ID ___

Four #2 pencils ___

Other Things to Bring/Remember

_____ _____

_____ _____

_____ _____

_____ _____

CHAPTER

3 Practice Exam I

CHAPTER SUMMARY

This is the first of three practice exams in this book based on actual health occupations entrance exams commonly used in the field today. Use this test to see how you would do if you had to take the test today.

THE PRACTICE TEST in this chapter is modeled after real entrance exams required by health education programs. Like many health occupations entrance exams, the practice test measures your skills, abilities, and knowledge of six core subjects: Verbal Ability, Quantitative Ability, General Science, Biology, Chemistry, and Reading Comprehension. It uses a multiple-choice format, with four answer choices, **a**–**d**. The types of questions in the practice test reflect the kinds of test questions you will likely encounter on your entrance exam. For example, the section on Quantitative Ability includes analytical reasoning questions and the Verbal Ability section features spelling questions, two types of questions that are part of the current HOAE.

The practice test is divided into six sections, covering the six main topics outlined above. In the actual test, each section will be timed separately, with the whole test taking from about two and a half to three hours. Here, you do not have to worry about timing—just try to relax and do your best. Remember the goal of the practice test is to familiarize yourself with the test format and type of questions and to highlight the areas where you need to concentrate your study and preparation. Make sure that you have scheduled enough time to complete the test without major interruptions, taking only short breaks between sections.

On the following pages, you will find an answer sheet. Use this sheet to mark your answers, filling in the ovals that correspond with your answer choices. Each question has only one correct answer, so do not fill in more than one oval per item. The answer key is located on page 27. Although you should not refer to it while you take the practice test, be sure to review the answer explanations carefully after you have finished. A section about how to score your exam follows the answer key.

► Section 1: Verbal Ability

1.	a	b	c	d
2.	a	b	c	d
3.	a	b	c	d
4.	a	b	c	d
5.	a	b	c	d
6.	a	b	c	d
7.	a	b	c	d
8.	a	b	c	d
9.	a	b	c	d
10.	a	b	c	d
11.	a	b	c	d
12.	a	b	c	d
13.	a	b	c	d
14.	a	b	c	d
15.	a	b	c	d
16.	a	b	c	d
17.	a	b	c	d
18.	a	b	c	d
19.	a	b	c	d
20.	a	b	c	d
21.	a	b	c	d
22.	a	b	c	d
23.	a	b	c	d
24.	a	b	c	d
25.	a	b	c	d
26.	a	b	c	d
27.	a	b	c	d
28.	a	b	c	d
29.	a	b	c	d
30.	a	b	c	d
31.	a	b	c	d
32.	a	b	c	d
33.	a	b	c	d
34.	a	b	c	d
35.	a	b	c	d
36.	a	b	c	d
37.	a	b	c	d
38.	a	b	c	d
39.	a	b	c	d
40.	a	b	c	d
41.	a	b	c	d
42.	a	b	c	d
43.	a	b	c	d
44.	a	b	c	d
45.	a	b	c	d
46.	a	b	c	d
47.	a	b	c	d
48.	a	b	c	d
49.	a	b	c	d
50.	a	b	c	d

► Section 2: Reading Comprehension

1.	a	b	c	d
2.	a	b	c	d
3.	a	b	c	d
4.	a	b	c	d
5.	a	b	c	d
6.	a	b	c	d
7.	a	b	c	d
8.	a	b	c	d
9.	a	b	c	d
10.	a	b	c	d
11.	a	b	c	d
12.	a	b	c	d
13.	a	b	c	d
14.	a	b	c	d
15.	a	b	c	d
16.	a	b	c	d
17.	a	b	c	d
18.	a	b	c	d
19.	a	b	c	d
20.	a	b	c	d
21.	a	b	c	d
22.	a	b	c	d
23.	a	b	c	d
24.	a	b	c	d
25.	a	b	c	d
26.	a	b	c	d
27.	a	b	c	d
28.	a	b	c	d
29.	a	b	c	d
30.	a	b	c	d
31.	a	b	c	d
32.	a	b	c	d
33.	a	b	c	d
34.	a	b	c	d
35.	a	b	c	d
36.	a	b	c	d
37.	a	b	c	d
38.	a	b	c	d
39.	a	b	c	d
40.	a	b	c	d
41.	a	b	c	d
42.	a	b	c	d
43.	a	b	c	d
44.	a	b	c	d
45.	a	b	c	d

▶ Section 3: Quantitative Ability

1.	a	b	c	d
2.	a	b	c	d
3.	a	b	c	d
4.	a	b	c	d
5.	a	b	c	d
6.	a	b	c	d
7.	a	b	c	d
8.	a	b	c	d
9.	a	b	c	d
10.	a	b	c	d
11.	a	b	c	d
12.	a	b	c	d
13.	a	b	c	d
14.	a	b	c	d
15.	a	b	c	d
16.	a	b	c	d
17.	a	b	c	d
18.	a	b	c	d
19.	a	b	c	d
20.	a	b	c	d
21.	a	b	c	d
22.	a	b	c	d
23.	a	b	c	d
24.	a	b	c	d
25.	a	b	c	d
26.	a	b	c	d
27.	a	b	c	d
28.	a	b	c	d
29.	a	b	c	d
30.	a	b	c	d
31.	a	b	c	d
32.	a	b	c	d
33.	a	b	c	d
34.	a	b	c	d
35.	a	b	c	d
36.	a	b	c	d
37.	a	b	c	d
38.	a	b	c	d
39.	a	b	c	d
40.	a	b	c	d
41.	a	b	c	d
42.	a	b	c	d
43.	a	b	c	d
44.	a	b	c	d
45.	a	b	c	d
46.	a	b	c	d
47.	a	b	c	d
48.	a	b	c	d
49.	a	b	c	d
50.	a	b	c	d

▶ Section 4: General Science

1.	a	b	c	d
2.	a	b	c	d
3.	a	b	c	d
4.	a	b	c	d
5.	a	b	c	d
6.	a	b	c	d
7.	a	b	c	d
8.	a	b	c	d
9.	a	b	c	d
10.	a	b	c	d
11.	a	b	c	d
12.	a	b	c	d
13.	a	b	c	d
14.	a	b	c	d
15.	a	b	c	d
16.	a	b	c	d
17.	a	b	c	d
18.	a	b	c	d
19.	a	b	c	d
20.	a	b	c	d
21.	a	b	c	d
22.	a	b	c	d
23.	a	b	c	d
24.	a	b	c	d
25.	a	b	c	d
26.	a	b	c	d
27.	a	b	c	d
28.	a	b	c	d
29.	a	b	c	d
30.	a	b	c	d
31.	a	b	c	d
32.	a	b	c	d
33.	a	b	c	d
34.	a	b	c	d
35.	a	b	c	d
36.	a	b	c	d
37.	a	b	c	d
38.	a	b	c	d
39.	a	b	c	d
40.	a	b	c	d
41.	a	b	c	d
42.	a	b	c	d
43.	a	b	c	d
44.	a	b	c	d
45.	a	b	c	d
46.	a	b	c	d
47.	a	b	c	d
48.	a	b	c	d
49.	a	b	c	d
50.	a	b	c	d

► Section 5: Biology

1.	a	b	c	d
2.	a	b	c	d
3.	a	b	c	d
4.	a	b	c	d
5.	a	b	c	d
6.	a	b	c	d
7.	a	b	c	d
8.	a	b	c	d
9.	a	b	c	d
10.	a	b	c	d
11.	a	b	c	d
12.	a	b	c	d
13.	a	b	c	d
14.	a	b	c	d
15.	a	b	c	d
16.	a	b	c	d
17.	a	b	c	d
18.	a	b	c	d
19.	a	b	c	d
20.	a	b	c	d
21.	a	b	c	d
22.	a	b	c	d
23.	a	b	c	d
24.	a	b	c	d
25.	a	b	c	d
26.	a	b	c	d
27.	a	b	c	d
28.	a	b	c	d
29.	a	b	c	d
30.	a	b	c	d
31.	a	b	c	d
32.	a	b	c	d
33.	a	b	c	d
34.	a	b	c	d
35.	a	b	c	d
36.	a	b	c	d
37.	a	b	c	d
38.	a	b	c	d
39.	a	b	c	d
40.	a	b	c	d
41.	a	b	c	d
42.	a	b	c	d
43.	a	b	c	d
44.	a	b	c	d
45.	a	b	c	d
46.	a	b	c	d
47.	a	b	c	d
48.	a	b	c	d
49.	a	b	c	d
50.	a	b	c	d

► Section 6: Chemistry

1.	a	b	c	d
2.	a	b	c	d
3.	a	b	c	d
4.	a	b	c	d
5.	a	b	c	d
6.	a	b	c	d
7.	a	b	c	d
8.	a	b	c	d
9.	a	b	c	d
10.	a	b	c	d
11.	a	b	c	d
12.	a	b	c	d
13.	a	b	c	d
14.	a	b	c	d
15.	a	b	c	d
16.	a	b	c	d
17.	a	b	c	d
18.	a	b	c	d
19.	a	b	c	d
20.	a	b	c	d
21.	a	b	c	d
22.	a	b	c	d
23.	a	b	c	d
24.	a	b	c	d
25.	a	b	c	d
26.	a	b	c	d
27.	a	b	c	d
28.	a	b	c	d
29.	a	b	c	d
30.	a	b	c	d
31.	a	b	c	d
32.	a	b	c	d
33.	a	b	c	d
34.	a	b	c	d
35.	a	b	c	d
36.	a	b	c	d
37.	a	b	c	d
38.	a	b	c	d
39.	a	b	c	d
40.	a	b	c	d
41.	a	b	c	d
42.	a	b	c	d
43.	a	b	c	d
44.	a	b	c	d
45.	a	b	c	d
46.	a	b	c	d
47.	a	b	c	d
48.	a	b	c	d
49.	a	b	c	d
50.	a	b	c	d

▶ Section 1: Verbal Ability

Find the correctly spelled word in the following questions.

1. **a.** magically
b. magickelly
c. majicelly
d. magicaly

2. **a.** beleif
b. bilief
c. belief
d. beleaf

3. **a.** magizine
b. magazene
c. magezine
d. magazine

4. **a.** breach
b. breche
c. braech
d. briech

5. **a.** percieved
b. preceived
c. perceived
d. precieved

6. **a.** shriveled
b. shrivvelled
c. shrivelled
d. shrivaled

7. **a.** sittuation
b. situation
c. situashun
d. sitiation

8. **a.** superb
b. supperb
c. supurb
d. sepurb

9. **a.** obssession
b. obsessian
c. obsession
d. obsessiun

10. **a.** jeoperdy
b. jepardy
c. jeapardy
d. jeopardy

11. **a.** magnifisint
b. magnifisent
c. magnificent
d. magnifficent

12. **a.** mechinically
b. mechanically
c. mechenicaly
d. machanically

13. **a.** elicitt
b. ellicit
c. illicet
d. illicit

14. **a.** inquiry
b. inquirry
c. enquirry
d. enquery

15. **a.** terminated
b. termenated
c. terrminated
d. termanated

16. **a.** persecution
b. pursecution
c. presecution
d. persecusion

17. **a.** peculior
b. peculiar
c. peculliar
d. piculear

18. **a.** psycology
b. psycholigy
c. psychollogy
d. psychology

19. **a.** lisense
b. lisence
c. lycence
d. license

20. **a.** concise
b. concize
c. consise
d. cuncise

21. **a.** nieghbor
b. neihbor
c. niehbor
d. neighbor

22. **a.** stabilize
b. stablize
c. stableize
d. stabalize

23. **a.** irelevent
b. irelevant
c. irrelevant
d. irrelevent

24. **a.** asspirations
b. asparations
c. aspirrations
d. aspirations

25. **a.** excercise
b. exercise
c. exersize
d. exercize

Find the misspelled word in the following questions.

26. **a.** villin
b. volunteer
c. voracious
d. no mistakes

27. **a.** hindrence
b. equipped
c. possessive
d. no mistakes

28. **a.** procedure
b. judgment
c. testamony
d. no mistakes

29. **a.** explicit
b. abduct
c. rotate
d. no mistakes

30. **a.** through
b. threw
c. thorough
d. no mistakes

31. **a.** quantaty
b. quality
c. quaint
d. no mistakes

32. **a.** requirement
b. reverence
c. resistent
d. no mistakes

33. **a.** incorporate
b. contridict
c. exhale
d. no mistakes

34. **a.** pertain
b. reversel
c. memorization
d. no mistakes

35. **a.** optimum
b. palpable
c. foriegn
d. no mistakes

36. **a.** ravinous
b. miraculous
c. wondrous
d. no mistakes

37. **a.** phenomonal
b. emulate
c. misconception
d. no mistakes

38. **a.** mischief
b. temperture
c. lovable
d. no mistakes

39. **a.** dictionary
b. auditorium
c. biology
d. no mistakes

40. **a.** geometry
b. perimeter
c. circumferance
d. no mistakes

41. **a.** transparent
b. worrys
c. lightning
d. no mistakes

42. **a.** primarily
b. finallity
c. specifically
d. no mistakes

43. **a.** relegious
b. insurance
c. military
d. no mistakes

44. **a.** mortar
b. outweigh
c. pursue
d. no mistakes

45. **a.** balcony
b. delenquent
c. emergency
d. no mistakes

46. **a.** gratitude
b. horrendous
c. forcast
d. no mistakes

47. **a.** rightious
b. strenuous
c. manageable
d. no mistakes

48. **a.** sincerly
b. faithfully
c. reliably
d. no mistakes

49. **a.** label
b. vacency
c. medal
d. no mistakes

50. **a.** digestion
b. resperation
c. circulation
d. no mistakes

▶ Section 2: Reading Comprehension

Read each passage and answer the accompanying questions based solely on the information found in the passage. You have 45 minutes to complete this section.

No longer is asthma considered a condition with isolated, acute episodes of bronchospasm. Rather, asthma is now understood to be a chronic inflammatory disorder of the airways—that is, inflammation makes the airways chronically sensitive. When these hyper-responsive airways are irritated, air flow is limited, and attacks of coughing, wheezing, chest tightness, and difficulty in breathing occur.

Asthma involves complex interactions among inflammatory cells, mediators, and the cells and tissues in the airways. The interactions result in airflow limitation from acute bronchoconstriction, swelling of the airway wall, increased mucus secretion, and airway remodeling. The inflammation also causes an increase in airway responsiveness. During an asthma attack, the patient attempts to compensate by breathing at a higher lung volume in order to keep the air flowing through the constricted airways, and the greater the airway limitation, the higher the lung volume must be to keep airways open. The morphologic changes that occur in asthma include bronchial infiltration by inflammatory cells. Key effector cells in the inflammatory response are the mast cells, lymphocytes, and eosinophils. Mast cells and eosinophils are also significant participants in allergic responses, hence the similarities between allergic reactions and asthma attacks. Other changes include mucus plugging of the airways, interstitial edema, and microvascular leakage. Destruction of bronchial epithelium and thickening of the subbasement membrane is also characteristic. In addition, there may be hypertrophy and hyperplasia of airway smooth muscle, increase in goblet cell number, and enlargement of submucous glands.

Although causes of the initial tendency toward inflammation in the airways of patients with asthma are not yet certain, to date the strongest identified risk factor is atopy. This inherited familial tendency to have allergic reactions includes increased sensitivity to allergens that are risk factors for developing asthma. Some of these allergens include domestic dust mites, animals with fur, cockroaches, pollens, and molds. Additionally, asthma may be triggered by viral respiratory infections, especially in children. By avoiding these allergens and triggers, a person with asthma lowers the risk of irritating sensitive airways. A few avoidance techniques include keeping the home clean and well-ventilated, using an air conditioner in the summer months when pollen and mold counts are high, and getting an annual influenza vaccination. Of course, asthma sufferers should avoid tobacco smoke altogether. Cigar, cigarette, and pipe smoke are triggers whether the patient smokes or breathes in the smoke from others. Smoke increases the risk of allergic sensitization in children and increases the severity of symptoms in children who already have asthma. Many of the risk factors for developing asthma may also provoke asthma attacks, and people with asthma may have one or more triggers, which vary from individual to individual. The risk can be further reduced by taking medications that decrease airway inflammation. Most exacerbations can be prevented by the combination of avoiding triggers and taking anti-inflammatory medications. An exception is physical activity, which is a common trigger of exacerbations in asthma patients. However, asthma patients should not necessarily avoid all physical exertion, because some types of activity have been proven to reduce symptoms. Rather, they should work in conjunction with a

doctor to design a proper training regimen including the use of medication.

In order to diagnose asthma, a healthcare professional must appreciate the underlying disorder that leads to asthma symptoms and understand how to recognize the condition through information gathered from the patient's history, physical examination, measurements of lung function, and allergic status. Because asthma symptoms vary throughout the day, the respiratory system may appear normal during physical examination. Clinical signs are more likely to be present when a patient is experiencing symptoms; however, the absence of symptoms at the time of the examination does not exclude the diagnosis of asthma.

1. What is the name for the familial inclination to have hypersensitivity to certain allergens?
- **a.** interstitial edema
- **b.** hyperplasia
- **c.** hypertrophy
- **d.** atopy

2. Why does a person suffering from an asthma attack attempt to inhale more air?
- **a.** to prevent the loss of consciousness
- **b.** to keep air flowing through shrunken air passageways
- **c.** to prevent hyperplasia
- **d.** to compensate for weakened mast cells, lymphocytes, and eosinophils

3. The passage suggests that in the past, asthma was regarded as
- **a.** a result of the overuse of tobacco products.
- **b.** a hysterical condition.
- **c.** mysterious, unrelated attacks affecting the lungs.
- **d.** a chronic condition.

4. Which of the following would be the best replacement for the word *exacerbations* in this passage?
- **a.** attacks
- **b.** allergies
- **c.** triggers
- **d.** allergens

5. The passage mentions all of the following bodily changes during an asthma attack EXCEPT
- **a.** severe cramping in the patient's side.
- **b.** heavy breathing.
- **c.** airways blocked by fluids.
- **d.** constricted airways.

6. Which of the following triggers, albeit surprising, is mentioned as possibly reducing the symptoms of asthma in some patients?
- **a.** using a fan instead of an air conditioner
- **b.** second-hand cigarette smoke
- **c.** a family pet
- **d.** physical exercise

7. Why might a patient with asthma have an apparently normal respiratory system during an examination by a doctor?
- **a.** Asthma symptoms come and go throughout the day.
- **b.** Severe asthma occurs only after strenuous physical exertion.
- **c.** Doctors' offices are usually smoke-free and very clean.
- **d.** The pollen and mold count may be low that day.

8. Who might be the most logical audience for this passage?
- **a.** researchers studying the respiratory system
- **b.** healthcare professionals
- **c.** a mother whose child has been diagnosed with asthma
- **d.** an anti-smoking activist

9. What is the reason given for why second-hand smoke should be avoided by children?

a. A smoke-filled room is most likely a breeding ground for viral respiratory infections.
b. Smoke can stunt an asthmatic child's growth.
c. Breathing smoke can lead to a fatal asthma attack.
d. Smoke can heighten the intensity of asthma symptoms.

Spina bifida is a defect of the spinal column that occurs during the first 28 days after fertilization of a human ovum. The broad definition of spina bifida is the condition in which the bones of the spinal column surrounding the spinal cord do not close properly, and the cord or spinal fluid bulges through a section of the lower back. Any portion of the spinal cord outside the vertebrae is undeveloped or damaged and will inevitably cause paralysis and incontinence. However, there is a minor and a major form of this condition. The symptom of the mild form, called spina bifida *occulata* ("hidden"), is a small gap in the spine covered by a dimple in the skin. This condition can be so mild that some people who have spina bifida occulata may never even know they have it.

In contrast, the more disabling form, called spina bifida *aperta*, is what most people refer to as spina bifida. On rare occasions, spina bifida aperta results in a small but noticeable sac called a *meningocele* forming on the fetus's back. The meningocele may be repaired after birth in a major surgical procedure. Afterward, the patient may suffer little or no muscle paralysis. However, in 90% of all spina bifida aperta cases, a portion of the undeveloped spinal cord itself protrudes through the spine and forms a sac. This so-called *myelocele* (or *meningomyelocele*) is visible on the baby's back. The location of the myelocele determines how severely disabled the child will be. In general, the higher it is on the spinal column, the more paralysis is possible. Doctors must repair any opening of the spine shortly after birth or the child will die. Other major surgeries often follow in the child's first years.

Depending on the severity of their condition, children with spina bifida have varying degrees of paralysis and incontinence. About 85% of them develop *hydrocephalus*, an accumulation of cerebrospinal fluid surrounding the brain. This fluid must be drained to the abdomen or blood stream with a surgically implanted tube. Some children with spina bifida develop foot and knee deformities caused by an interruption of spinal nerve circuits. Many patients require leg braces, crutches, and other devices to help them walk. They may have learning disabilities, and about 30% of these children have slight to severe mental retardation. Other results of this condition are chronic bladder infections and kidney problems, which require lifelong medical attention. Despite their need for medical attention, children with spina bifida can learn to care for many of their own needs. While once all of these children died, with proper medical treatment, between 85% and 90% of them now live to adulthood.

10. Which of the following statements is true of the majority of spina bifida aperta cases?

a. The only noticeable symptom is an indentation in the skin on the patient's back.
b. A part of the undeveloped spinal cord forms a myelocele protruding from the back.
c. About 85% of children with spina bifida aperta die following surgery.
d. Most children with spina bifida aperta have fewer symptoms than children with spina bifida occulata.

11. All of the following are mentioned in the passage as results of spina bifida EXCEPT
- **a.** learning disabilities.
- **b.** chronic bladder infections.
- **c.** foot and knee deformities.
- **d.** hyperactivity.

12. The human vertebral column consists of the following groups of vertebrae, listed here from the highest, or top, down to the lowest, or bottom, of the spinal column: the cervical vertebrae, the thoracic vertebrae, the lumbar vertebrae, the sacrum, and the coccyx. On which vertebrae group would a myelocele cause the most severe disability?
- **a.** the thoracic vertebrae
- **b.** the sacrum
- **c.** the cervical vertebrae
- **d.** the lumbar vertebrae

13. Which of the following is the term for a pool of cerebrospinal fluid in the area around the brain?
- **a.** catheterization
- **b.** spina bifida
- **c.** hydrocephalus
- **d.** meningomyelocele

14. Which of the following is the small sac that may result in little or no muscle paralysis or incontinence after being repaired?
- **a.** a meningocele
- **b.** a myelocele
- **c.** a meningomyelocele
- **d.** a vertebrae

15. The conclusion of this passage could best be summarized by which of the following statements?
- **a.** All pregnant women should have their fetuses tested for spina bifida.
- **b.** Infants with spina bifida are smaller than other infants.
- **c.** Spina bifida is a birth defect that kills millions of innocent children each year.
- **d.** People who have spina bifida may lead productive lives with proper medical attention.

Medical waste has been a growing concern because of recent incidents of public exposure to discarded blood vials, needles (sharps), empty prescription bottles, and syringes. Medical waste can typically include general refuse, human blood and blood products, cultures and stocks of infectious agents, laboratory animal carcasses, contaminated bedding material, and pathological wastes.

Wastes are collected by gravity chutes, carts, or pneumatic tubes. Chutes are limited to vertical transport, and there is some risk of exhausting contaminants into hallways if a door is left open during use. Another disadvantage of gravity chutes is that the waste container may get jammed while dropping or broken upon hitting the bottom. Carts are primarily for horizontal transport of bagged or containerized wastes. The main risk here is that bags may be broken or torn during transport, potentially exposing the worker to the wastes. Using automated carts can reduce the potential for exposure. Pneumatic tubes offer the best performance for waste transport in a large facility. Advantages include high-speed movement, movement in any direction, and minimal intermediate storage of untreated wastes. However, some objects cannot be conveyed pneumatically.

Off-site disposal of regulated medical wastes remains a viable option for smaller hospitals (those with fewer than 150 beds). Some

preliminary on-site processing, such as compaction or hydropulping, may be necessary prior to sending the waste off-site. Compaction reduces the total volume of solid wastes, often reducing transportation and disposal costs, but does not change the hazardous characteristics of the waste. However, compaction may "not be economical if transportation and disposal costs are based on weight rather than volume.

Hydropulping involves grounding the waste in the presence of an oxidizing fluid, such as hypochlorite solution. The liquid is separated from the pulp and discharged directly into the sewer unless local limits require additional pretreatment prior to discharge. The pulp can often be disposed of at a landfill. One advantage is that waste can be rendered innocuous and reduced in size within the same system. Disadvantages are the added operating burden, difficulty of controlling fugitive emission, and the difficulty of conducting microbiological tests to determine whether all organic matters and infectious organisms from the waste have been destroyed.

On-site disposal is a feasible alternative for hospitals generating two tons per day or more of total solid waste. Common treatment techniques include steam sterilization and incineration. Although other options are available, incineration is currently the preferred method for on-site treatment of hospital waste.

Steam sterilization is limited in the types of medical waste it can treat but is appropriate for laboratory cultures and/or substances contaminated with infectious organisms. The waste is subjected to steam in a sealed, pressurized chamber. The liquid that may form is drained off to the sewer or sent for processing. The unit is then reopened after a vapor release to the atmosphere, and the solid waste is taken out for further processing or disposal. One advantage of steam sterilization is that it has been used for many years in hospitals to sterilize instruments and containers and to treat small quantities of waste. However, since sterilization does not change the appearance of the waste, there could be a problem in gaining acceptance of the waste for landfilling.

A properly designed, maintained, and operated incinerator achieves a relatively high level of organism destruction. Incineration reduces the weight and volume of the waste as much as 95% and is especially appropriate for pathological wastes and sharps. The most common incineration system for medical waste is the controlled-air type. The principal advantage of this type of incinerator is low particulate emissions. Rotary kiln and grate-type units have been used, but use of grate-type units has been discontinued due to high air emissions. The rotary kiln also puts out high emissions, and the costs have been prohibitive for smaller units.

16. One disadvantage of the compaction method of waste disposal is that it
- **a.** cannot reduce transportation costs.
- **b.** reduces the volume of solid waste material.
- **c.** does not allow hospitals to confirm that organic matter has been eliminated.
- **d.** does not reduce the weight of solid waste material.

17. For hospitals that dispose of waste on their own premises, the optimum treatment method is
- **a.** incineration.
- **b.** compaction.
- **c.** sterilization.
- **d.** hydropulping.

18. Which of the following could be safely disposed of in a landfill but might not be accepted by landfill facilities?
a. hydropulped material
b. sterilized waste
c. incinerated waste
d. laboratory cultures

19. The two processes mentioned that involve the formation of liquid are
a. compaction and hydropulping.
b. incineration and compaction.
c. hydropulping and sterilization.
d. sterilization and incineration.

20. Two effective methods for treating waste caused by infectious matter are
a. steam sterilization and incineration.
b. hydropulping and steam sterilization.
c. incineration and compaction.
d. hydropulping and incineration.

21. Hospitals can minimize employee contact with dangerous waste by switching from
a. a manual cart to a gravity chute.
b. an automated cart to a hydropulping machine.
c. a gravity chute to a manual cart.
d. a manual cart to an automated cart.

22. The process that transforms waste from hazardous to harmless AND diminishes waste volume is
a. sterilization.
b. hydropulping.
c. oxidizing.
d. compacting.

23. As it is used in the second paragraph of the passage, the word *exhausting* most nearly means
a. debilitating.
b. disregarding.
c. detonating.
d. discharging.

24. Budgetary constraints have precluded some small hospitals from purchasing
a. pneumatic tubes.
b. rotary kilns.
c. sterilization equipment.
d. controlled-air kilns.

The immune system is equal in complexity to the combined intricacies of the brain and nervous system. The success of the immune system in defending the body relies on a dynamic regulatory-communications network consisting of millions and millions of cells. Organized into sets and subsets, these cells pass information back and forth like clouds of bees swarming around a hive. The result is a sensitive system of checks and balances, which produces an immune response that is prompt, appropriate, effective, and self-limiting.

At the heart of the immune system is the ability to distinguish between *self* and *nonself*. When immune defenders encounter cells or organisms carrying foreign or nonself molecules, the immune troops move quickly to eliminate the intruders. Virtually every body cell carries distinctive molecules that identify it as self. The body's immune defenses do not normally attack tissues that carry a self marker. Rather, immune cells and other body cells coexist peaceably in a state known as self-tolerance. When a normally functioning immune system attacks a nonself molecule, the system has the ability to "remember" the specifics of the foreign body. Upon subsequent encounters with the same species of molecules, the immune system reacts

accordingly. With the possible exception of antibodies passed during lactation, this so-called immune system memory is not inherited. Despite the occurrence of a virus in your family, your immune system must "learn" from experience with the many millions of distinctive nonself molecules in the sea of microbes in which we live. Learning entails producing the appropriate molecules and cells to match up with and counteract each nonself invader.

Any substance capable of triggering an immune response is called an *antigen*. Antigens are not to be confused with *allergens*, which are most often harmless substances (such as ragweed pollen or cat hair) that provoke the immune system to set off the inappropriate and harmful response known as *allergy*. An antigen can be a virus, a bacterium, a fungus, a parasite, or even a portion or product of one of these organisms. Tissues or cells from another individual (except an identical twin, whose cells carry identical self markers) also act as antigens; because the immune system recognizes transplanted tissues as foreign, it rejects them. The body will even reject nourishing proteins unless they are first broken down by the digestive system into their primary, non-antigenic building blocks. An antigen announces its foreignness by means of intricate and characteristic shapes called *epitopes*, which protrude from its surface. Most antigens, even the simplest microbes, carry several different kinds of epitopes on their surface; some may even carry several hundred. Some epitopes will be more effective than others at stimulating an immune response. Only in abnormal situations does the immune system wrongly identify self as nonself and execute a misdirected immune attack. The result can be a so-called autoimmune disease such as rheumatoid arthritis or systemic lupus erythematosus. The painful side effects of these diseases are caused by a person's immune system actually attacking itself.

25. Which of the following is the analogy used in the passage to describe the communications network among the cells in the immune system?
- **a.** the immune system's memory
- **b.** immune troops eliminating intruders
- **c.** bees swarming around a hive
- **d.** a sea of microbes

26. The immune cells and other cells in the body coexist peaceably in a state known as
- **a.** equilibrium.
- **b.** self-tolerance.
- **c.** harmony.
- **d.** tolerance.

27. What is the specific term used in the passage for the substance capable of triggering an inappropriate or harmful immune response to a harmless substance such as ragweed pollen?
- **a.** antigen
- **b.** microbe
- **c.** allergen
- **d.** autoimmune disease

28. How do the cells in the immune system recognize an antigen as "foreign" or "nonself"?
- **a.** through an allergic response
- **b.** through blood type
- **c.** through fine hairs protruding from the antigen surface
- **d.** through characteristic shapes on the antigen surface

29. After you have had the chicken pox, your immune system will be able to do all of the following EXCEPT
- **a.** protect your offspring from infection by the chicken pox virus.
- **b.** distinguish between your body cells and those of the chicken pox virus.
- **c.** "remember" previous experiences with the chicken pox virus.
- **d.** match up and counteract nonself molecules in the form of the chicken pox virus.

30. Which of the following best expresses the main idea of this passage?
- **a.** The basic function of the immune system is to distinguish between self and nonself.
- **b.** An antigen is any substance that triggers an immune response.
- **c.** One of the immune system's primary functions is the allergic response.
- **d.** The human body presents an opportune habitat for microbes.

31. Based on the information in the passage, why would tissue transplanted from father to daughter have a greater risk of being detected as foreign than tissue transplanted between identical twins?
- **a.** The age of the twins' tissue would be the same and therefore less likely to be rejected.
- **b.** The twins' tissue would carry the same self markers and would therefore be less likely to be rejected.
- **c.** The difference in the sex of the father and daughter would cause the tissue to be rejected by the daughter's immune system.
- **d.** The twins' immune systems would "remember" the same encounters with childhood illnesses.

Sometimes your protective immune system can suddenly become your worst enemy. When that happens, rogue killer cells may attack organs or tissues that are essential to your survival. In recent years, scientists have identified this scenario, known as an *autoimmune attack*, as the cause of many diseases whose origins previously were unknown. Psoriasis is among the latest to be included in this category.

Psoriasis is a skin disease that in severe cases disfigures patients' bodies and makes their lives miserable. Affected areas of the skin—often spreading out from elbows and knees—are red and inflamed and may be covered by silvery scales. It has long been known that many psoriasis patients belong to families that have a history of the disease, and in these psoriasis-prone families certain genetic markers, known as HLA antigens, are inherited more often than in the general population. However, until recently, it was not known whether psoriasis was primarily an immune disease or an epidermal skin disease.

Data existed that suggested immune system involvement. In studies of psoriatic skin, investigators detected immune cells, known as *T cells*, that have surface receptors for interleukin-2 (IL-2), a cellular hormone that is an important mediator of immune reactions. What wasn't clear from the studies was whether the immune contribution was a secondary phenomenon. To distinguish between the roles of the scaling, nonimmune epidermal skin cells, called *keratinocytes*, and the immune cells, scientists used an experimental drug that eliminated specific T cells. They reasoned that if the absence of these cells improved the patients' psoriasis, immune cells, not epidermal skin cells, were probably the main culprit in causing the disease.

Since only T cells that are activated to participate in immune reactions carry the IL-2 receptor, selective removal of these cells did not

endanger all T cells in the body. Scientists theorize that in psoriasis there is an as-yet-undefined antigen that the T cells react to in an autoimmune fashion. Those reactive cells proliferate and express the IL-2 receptor.

To target and kill the activated T cells, scientists use a molecule manufactured by fusing IL-2 and diphtheria toxin. The innocuous IL-2 part of the fusion molecule binds to T cells that have IL-2 receptors and thereby delivers its poisonous partner to the target. After binding, the fusion molecule enters the cells and the diphtheria toxin blocks their protein-synthesizing machinery, killing the cells.

Scientists tested the experimental drug in ten patients who had severe psoriasis. The patients were admitted to a research center where they received the drug in five daily intravenous doses. Subsequently they were assessed as outpatients for 23 days. After this, they received an additional round of five intravenous doses of the drug followed by another 23-day assessment period. Four of the patients showed striking clinical improvement, four had moderate improvement, and two had minimal improvement after two cycles of treatment with the drug. Among the improvements were, most significantly, thinning of the psoriatic areas, reduced keratinocyte proliferation, and reduced inflammation with fewer T cells in the epidermis.

These studies suggest that the molecule is likely to be effective, but scientists caution there is a long way to go before claiming that this drug is safe and widely effective. The low doses are reasonably well tolerated, and studies have revealed that at least some cases of psoriasis are caused by a defective immune system. There is no data that refute the hypothesis that the disease is immune-mediated. Scientists point out, however, that the response was mixed since not all patients responded to the drug.

Scientists are continuing their studies with higher doses of the IL-2/diphtheria toxin drug to see if a higher proportion of the patients may respond. Because psoriasis is a uniquely human disease, it cannot be studied in animal models, an approach that allows experimental studies of many other diseases.

32. The process of eliminating activated T cells involves combining
- **a.** IL-2 and HLA antigens.
- **b.** keratinocytes and T cells.
- **c.** diphtheria toxin and IL-2.
- **d.** HLA antigens and diphtheria toxin.

33. One reason researchers used an experimental drug was to
- **a.** gauge the impact of missing immune cells on psoriasis patients.
- **b.** identify epidermal skin cells as the cause of psoriasis.
- **c.** trace the genetic history of psoriasis.
- **d.** rule out autoimmune attacks as a cause of psoriasis.

34. When lethal cells invade skin tissue, the result is known as
- **a.** a secondary phenomenon.
- **b.** an autoimmune attack.
- **c.** a genetic marker.
- **d.** a surface receptor.

35. The use of animals in testing for the cause of psoriasis would be
- **a.** somewhat effective.
- **b.** highly effective.
- **c.** only effective with higher drug doses.
- **d.** ineffective.

36. The impact of the experimental drugs was extraordinary
- **a.** for over half the patients.
- **b.** because epidermal skin cells multiplied.
- **c.** for fewer than half the patients.
- **d.** because the drug received universal acceptance.

37. IL-2 receptors are transported by
- **a.** undefined antigens.
- **b.** cellular hormones.
- **c.** activated T cells.
- **d.** epidermal cells.

38. Which of the following was NOT a positive result of the drug experiment?
- **a.** lower amounts of epidermal cells
- **b.** reduced tolerance to lower doses
- **c.** diminished redness and inflammation
- **d.** reduced numbers of T cells in the epidermis

39. The main idea of the passage is that scientists
- **a.** are closer than before to comprehending the causes of psoriasis.
- **b.** can now prove psoriasis is a genetic disease.
- **c.** can rule out epidermal cells as the cause of psoriasis.
- **d.** are closer to discrediting an immune-related cause of psoriasis.

40. The function of IL-2 in the fusion molecule is to
- **a.** carry out a poisonous mission.
- **b.** thwart protein construction.
- **c.** attach to T cells.
- **d.** produce higher cell counts.

Genetic engineering, more formally known as recombinant DNA technology, allows scientists to cut segments of DNA from one type of organism and combine them with the genes of a second organism. In this way, relatively simple organisms such as bacteria or yeast, or even mammalian cells in culture, can be induced to make quantities of human proteins, including interferons or interleukins. This technology has enabled scientists to grow tobacco plants that produce monoclonal antibodies, and goats that secrete a clot-dissolving heart attack drug, *tissue plasminogen activator* (TPA), in their milk.

Another facet of recombinant DNA technology involves gene therapy. The goal of this therapy is to replace defective genes, or to endow a cell with new capabilities. In 1989, the feasibility and safety of gene transfer was demonstrated when *tumor-infiltrating lymphocytes* (TILs) were extracted from a patient, equipped with a marker gene (so they could be tracked and monitored), and then reinjected into patients with advanced cancer. To deliver the gene into the TIL, the scientists used a virus, exploiting its natural tendency to invade cells. Before being used as a vector, the virus was altered so that it could not reproduce or cause disease. This experiment demonstrated that gene-modified cells could survive for long periods in the bloodstream and in tumor deposits without harm to the patient.

The earliest attempts to use genes therapeutically focused on a form of *severe combined immunodeficiency disease* (SCID), which is caused by the lack of an enzyme due to a single abnormal gene. The gene for this enzyme—*adenosine deaminase* (ADA)—is delivered into the patient's T cells by a modified retrovirus. When the virus splices its genes into those of the T cells, it simultaneously introduces the gene for the missing enzyme. After the treated T cells begin to produce the missing enzyme, they are injected back into the patient.

Gene therapy is now being used with some cancer patients. TILs reinforced with a gene for the anti-tumor cytokine known as *tumor necro-*

sis factor (TNF) have been administered to patients with advanced melanoma, a deadly form of skin cancer. Plans are underway to engineer a cancer "vaccine" designed to improve anti-cancer immune responses by taking small bits of tumor from patients with cancer, outfitting the tumor cells with genes for immune-cell-activating cytokines such as IL-2, and reinjecting these gene-modified tumors into the patient. While the thought of reintroducing a cancerous tumor into a patient seems somewhat frightening, the enhanced immune response triggered by this technique may help prevent the recurrence of cancer.

41. What innate characteristic of viruses did researchers take advantage of in order to transport genes into TILs?
- **a.** protective protein coat
- **b.** affinity for invading cells
- **c.** noncellular consistency
- **d.** ability to produce DNA from RNA

42. SCID is caused by
- **a.** an overabundance of monoclonal antibodies.
- **b.** an overabundance of tumor necrosis factor.
- **c.** a lack of tumor necrosis factor.
- **d.** a lack of adenosine deaminase.

43. Why might cancer patients be leery of the prospect of a cancer "vaccine"?
- **a.** Vaccine recipients will be reinjected with cancerous material.
- **b.** The vaccine is derived from the tobacco plant.
- **c.** The safety of genetic transfer has not yet been proven.
- **d.** Genetic material from the vector could invade the vaccine recipient's bloodstream.

44. Which of the following organisms is mentioned in the passage as having been employed by researchers to produce human proteins?
- **a.** fungi
- **b.** plankton
- **c.** yeast
- **d.** viruses

45. Adenosine deaminase (ADA) is transferred into the T cells of a patient via which of the following?
- **a.** marker gene
- **b.** TIL
- **c.** interferon
- **d.** modified retrovirus

▶ Section 3: Quantitative Ability

Use scratch paper if needed to answer the following 50 questions. You have 45 minutes to complete this section.

1. 292×50 is equal to
- **a.** 14,600.
- **b.** 14,500.
- **c.** 10,500.
- **d.** 1,450.

2. $\frac{1}{6} + \frac{7}{12} + \frac{2}{3}$ is equal to
- **a.** $\frac{10}{24}$.
- **b.** $2\frac{1}{6}$.
- **c.** $1\frac{5}{6}$.
- **d.** $1\frac{5}{12}$.

3. $4\frac{1}{3} + 3\frac{3}{10}$ is equal to
- **a.** $7\frac{2}{15}$.
- **b.** $7\frac{4}{13}$.
- **c.** $7\frac{2}{3}$.
- **d.** $7\frac{19}{30}$.

4. $426 - 7.2$ is equal to
- **a.** 418.8.
- **b.** 354.0.
- **c.** 425.28.
- **d.** 41.88.

5. $\frac{-\frac{1}{4}}{-\frac{1}{8}}$ is equal to
- **a.** 2.
- **b.** $\frac{1}{2}$.
- **c.** $-\frac{1}{2}$.
- **d.** –2.

6. About how many liters of water will a 5-gallon container hold? (1 liter = 1.06 quarts)
- **a.** 5
- **b.** 11
- **c.** 20
- **d.** 21

7. What is another way to write 20,706?
- **a.** 200 + 70 + 6
- **b.** 2,000 + 700 + 6
- **c.** 20,000 + 70 + 6
- **d.** 20,000 + 700 + 6

8. If $\frac{x}{54} = \frac{2}{9}$, then x is
- **a.** 6.
- **b.** 12.
- **c.** 18.
- **d.** 108.

9. Which of the following is divisible by 6 and 7?
- **a.** 63
- **b.** 74
- **c.** 84
- **d.** 96

10. What is another way to write $4 \times 4 \times 4$?
- **a.** 3×4
- **b.** 8×4
- **c.** 4^3
- **d.** 3^4

11. What is the estimated product when 157 and 817 are rounded to the nearest hundred and multiplied?
- **a.** 180,000
- **b.** 160,000
- **c.** 16,000
- **d.** 80,000

12. The perimeter of a rectangle is 148 feet. Its two longest sides add up to 86 feet. What is the length of each of its two shortest sides?
- **a.** 31 ft.
- **b.** 42 ft.
- **c.** 62ft.
- **d.** 74 ft.

13. The cost of a list of supplies for a hospital ward is as follows: \$19.98, \$52.20, \$12.64, and \$7.79. What is the total cost?

a. \$91.30
b. \$92.61
c. \$93.60
d. \$93.61

14. If jogging for one mile uses 150 calories and brisk walking for one mile uses 100 calories, a jogger has to go how many times as far as a walker to use the same number of calories?

a. $\frac{1}{2}$
b. $\frac{2}{3}$
c. $\frac{3}{2}$
d. 2

15. A dosage of a certain medication is 12 cc per 100 pounds. What is the dosage for a patient who weighs 175 pounds?

a. 15 cc
b. 18 cc
c. 21 cc
d. 24 cc

16. A gram of fat contains 9 calories. An 1,800-calorie diet allows no more than 20% of calories from fat. How many grams of fat are allowed in that diet?

a. 40 g
b. 90 g
c. 200 g
d. 360 g

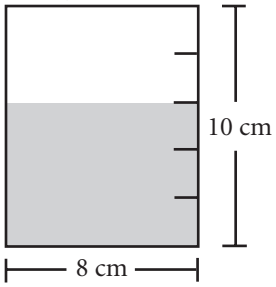
17. How much water must be added to 1 liter of a 5% saline solution to get a 2% saline solution?

a. 1 liter
b. 1.5 liters
c. 2 liters
d. 2.5 liters

18. A 15 cc dosage must be increased by 20%. What is the new dosage?

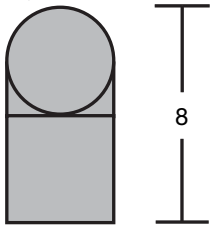
a. 17 cc
b. 18 cc
c. 30 cc
d. 35 cc

19. What is the volume of liquid that is remaining in this cylinder?



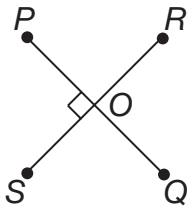
a. 64π cm^3
b. 80π cm^3
c. 96π cm^3
d. 160π cm^3

20. The following figure contains both a circle and a square. What is the area of the entire shaded figure?



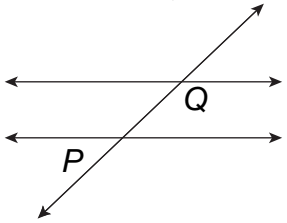
a. $16 + 4\pi$
b. $16 + 16\pi$
c. $24+ 2\pi$
d. $24 + 4\pi$

21. In the figure below, angle *POS* measures 90 degrees. What is the measure of angle *ROQ*?



a. 45 degrees
b. 90 degrees
c. 180 degrees
d. 270 degrees

22. A line intersects two parallel lines in the figure below. If angle *P* measures 40 degrees, what is the measure of angle *Q*?



a. 50
b. 60
c. 80
d. 140

23. During exercise, a person's heart rate should be between 60% and 90% of the difference between 220 and the person's age. According to this guideline, what should a 30-year-old person's maximum heart rate be during exercise?
a. 114
b. 132
c. 171
d. 198

24. Of 9,125 patients treated in a certain emergency room in one year, 72% were male. Among the males, 3 out of 5 were under the age of 25. How many of the emergency room patients were males age 25 or older?
a. 2,628
b. 3,942
c. 5,475
d. 6,570

25. 62.5% is equal to
a. $\frac{1}{16}$.
b. $\frac{5}{8}$.
c. $6\frac{1}{4}$.
d. $6\frac{2}{5}$.

26. $\frac{7}{40}$ is equal to
a. 0.0175.
b. 0.175.
c. 1.75.
d. 17.5.

27. A certain water pollutant is unsafe at a level of 20 ppm (parts per million). A city's water supply now contains 50 ppm of this pollutant. What percentage improvement will make the water safe?
a. 30%
b. 40%
c. 50%
d. 60%

28. In half of migraine sufferers, a certain drug reduces the number of migraines by 50%. What percentage of all migraines can be eliminated by this drug?
a. 25%
b. 50%
c. 75%
d. 100%

29. Nationwide, in one year, there were about 21,500 fire-related injuries associated with furniture. Of these, 11,350 were caused by smoking materials. About what percent of the fire-related injuries were smoking-related?

a. 47%
b. 49%
c. 51%
d. 53%

30. 0.63×0.42 is equal to

a. 26.46.
b. 2.646.
c. 0.2646.
d. 0.02646.

31. $\frac{2\frac{1}{4}}{\frac{2}{3}}$ is equal to

a. $\frac{8}{27}$.
b. $1\frac{1}{2}$.
c. $3\frac{3}{8}$.
d. $3\frac{1}{2}$.

32. $3\frac{9}{16} - 1\frac{7}{8}$ is equal to

a. $1\frac{11}{16}$.
b. $2\frac{1}{8}$.
c. $2\frac{1}{4}$.
d. $2\frac{5}{16}$.

33. If the average woman burns 8.2 calories per minute while riding a bicycle, how many calories will she burn if she rides for 35 minutes?

a. 286
b. 287
c. 387
d. 980

34. The basal metabolic rate (BMR) is the rate at which our body uses calories. The BMR for a man in his twenties is about 1,700 calories per day. If 204 of those calories should come from protein, about what percentage of this man's diet should be protein?

a. 1.2%
b. 8.3%
c. 12%
d. 16%

35. One lap on a particular outdoor track measures a quarter of a mile around. To run a total of $3\frac{1}{2}$ miles, how many complete laps must a person finish?

a. 7
b. 10
c. 13
d. 14

36. Down's syndrome occurs in about 1 in 1,500 children when the mothers are in their twenties. About what percentage of all children born to mothers in their twenties are likely to have Down's syndrome?

a. 0.0067%
b. 0.067%
c. 0.67%
d. 6.7%

37. If a population of yeast cells grows from 10 to 320 in a period of 5 hours, what is the rate of growth?

a. It doubles its numbers every hour.
b. It triples its numbers every hour.
c. It doubles its numbers every two hours.
d. It triples its numbers every two hours.

38. Which value of x will make this number sentence true? $x + 25 \leq 13$.
- **a.** -13
- **b.** -11
- **c.** 12
- **d.** 38

39. How many faces does a cube have?
- **a.** 4
- **b.** 6
- **c.** 8
- **d.** 12

40. What is the length of a rectangle if its width is 9 ft. and its area is 117 sq ft?
- **a.** 1.3 ft.
- **b.** 10.5 ft.
- **c.** 12 ft.
- **d.** 13 ft.

41. Which of the following numbers is the smallest?
- **a.** $\frac{8}{15}$
- **b.** $\frac{6}{10}$
- **c.** $\frac{33}{60}$
- **d.** $\frac{11}{20}$

42. $2\frac{1}{4} + 4\frac{5}{8} + \frac{1}{2}$ is equal to
- **a.** $6\frac{7}{8}$.
- **b.** $7\frac{1}{4}$.
- **c.** $7\frac{3}{8}$.
- **d.** $7\frac{3}{4}$.

43. What percentage of 600 is 750?
- **a.** 80%
- **b.** 85%
- **c.** 110%
- **d.** 125%

44. Which of the following is the equivalent of $\frac{13}{25}$?
- **a.** 0.38
- **b.** 0.4
- **c.** 0.48
- **d.** 0.52

45. What is another way to write 0.32×10^3?
- **a.** 3.2
- **b.** 32
- **c.** 320
- **d.** 3,200

46. Which of the following statements is true?
- **a.** Parallel lines intersect at right angles.
- **b.** Parallel lines never intersect.
- **c.** Perpendicular lines never intersect.
- **d.** Intersecting lines have two points in common.

47. 3.6 – 1.89 is equal to
- **a.** 1.47.
- **b.** 1.53.
- **c.** 1.71.
- **d.** 2.42.

48. If a particular woman's resting heartbeat is 72 beats per minute and she is at rest for $6\frac{1}{2}$ hours, about how many times will her heart beat during that period of time?
- **a.** 4,320
- **b.** 4,680
- **c.** 28,080
- **d.** 43,200

49. The number of red blood corpuscles in one cubic millimeter is about 5 million, and the number of white blood corpuscles in one cubic millimeter is about 8,000. What, then, is the ratio of white blood corpuscles to red blood corpuscles?

a. 1:625

b. 1:40

c. 4:10

d. 5:1,250

50. $\frac{5}{12} - \frac{3}{8}$ is equal to

a. $\frac{1}{10}$.

b. $\frac{1}{24}$.

c. $\frac{5}{48}$.

d. $\frac{19}{24}$.

▶ Section 4: General Science

This section will test your accumulated knowledge in general science.

1. He shouted "eureka" running down the street naked, because he had figured out the problem of how to determine the volume and therefore the density of a complicated object like a crown.
a. Plato
b. Aristotle
c. Archimedes
d. Hippocrates

2. This Dutchman charmed Europe with his letters that contained drawings depicting the extraordinary details visible under the high-power microscopes he built himself.
a. Isaac Newton
b. Baron von Humbolt
c. Anton von Leeuwenhoek
d. Benedict Spinoza

3. When studying the orbit of the planet Mars, he discovered the law that planets move around the Sun in ellipses.
a. Kepler
b. Galileo
c. Newton
d. Copernicus

4. He discovered the periodical table of elements, a major breakthrough in the field of chemistry.
a. Schrödinger
b. Einstein
c. Watson
d. Mendeleyev

5. He was the Austrian monk who spent years in scientific isolation while he bred pea plants and studied the results, what we now know as heredity.
a. Rutherford
b. Darwin
c. Mendel
d. Watson

6. Hippocrates
a. discovered the right triangle.
b. is called the "father" of geology.
c. is called the "father" of medicine.
d. discovered colors in light.

7. What did Galileo do?
a. first split light into its colors
b. first used the *x*- and *y*-axis
c. first realized the antiquity of Earth
d. first observed the moons of Jupiter

8. If you want to test the effect of a new malaria vaccine, the group of people who receive shots but the shots contain no vaccine is called the
a. control group.
b. experiment group.
c. fake group.
d. zero group.

9. The search in science for the simplest possible explanation is said to use the principle of
a. relativity.
b. predictability.
c. Pasteur's flasks.
d. Occam's razor.

10. The biggest concepts in science are called
a. predictions.
b. theories.
c. experiments.
d. hypotheses.

11. Doing science in a Popperian manner means
- **a.** selecting only data that fits your hypothesis.
- **b.** actively seeking experiments that will falsify your hypothesis.
- **c.** creating data that goes with hypothetical explanations.
- **d.** wanting your experiments to work.

12. Which statement best summarizes the process of truth in science?
- **a.** Truth is tentative but not arbitrary.
- **b.** Truth is arbitrary and social.
- **c.** Truth itself is a variable.
- **d.** Truth cannot be known from experiments.

13. When the explanations of scientists take the form of complex mathematical systems, for example, in predicting Earth's future climate under a greenhouse effect, the explanations are called
- **a.** formulations.
- **b.** paradigms.
- **c.** models.
- **d.** assumptions.

14. Reductionism in science refers to what?
- **a.** rejecting holism as unessential
- **b.** making the hypothesis small enough to fit the facts
- **c.** creating an alternative pattern that uses previous ideas
- **d.** explaining behaviors in terms of interacting parts

15. The word *geometry* originally meant
- **a.** the thrill of measuring.
- **b.** measuring the land.
- **c.** the metric system.
- **d.** movements of the constellations.

16. The typical human hair is about 50 micrometers in diameter. That means it is 50 _____ of a meter.
- **a.** billionths
- **b.** thousandths
- **c.** parts
- **d.** millionths

17. Humans are putting about 6 billion tons of carbon into the atmosphere each year in the form of carbon dioxide. Another way of saying this number is how many tons of carbon?
- **a.** 6 megatons
- **b.** 6 kilotons
- **c.** 6 petatons
- **d.** 6 gigatons

18. Which unit is not in the metric system?
- **a.** second
- **b.** joule
- **c.** kilogram
- **d.** foot

19. What exponent or power of ten would you use to express how many meters are in a kilometer?
- **a.** 10^5
- **b.** 10^3
- **c.** 10^4
- **d.** 10^2

20. Compute the number of seconds in a year.
- **a.** about one million
- **b.** about thirty million
- **c.** about one hundred thousand
- **d.** about three million

21. The nanosecond is a _____ of one second.
- **a.** thousandth
- **b.** millionth
- **c.** billionth
- **d.** trillionth

22. One millimeter contains how many μm?
- **a.** 10
- **b.** 100
- **c.** 1,000
- **d.** 10,000

23. Satellites have measured differences in this quantity, which came into existence before the formation of galaxies and shows that inhomogeneities existed in the early universe, in other words, that the universe was "lumpy." What is the quantity?
- **a.** radiation temperature
- **b.** black hole wavelength
- **c.** electron density
- **d.** galaxy patterns

24. How many years ago was the Big Bang?
- **a.** 13.7 trillion years ago
- **b.** 13.7 quadrillion years ago
- **c.** 13.7 million years ago
- **d.** 13.7 billion years ago

25. Put in order the following events, from earliest (closest in time to the Big Bang) to latest (closest in time to today): electrons become stable around atomic nuclei (E); stable combinations of protons and neutrons (S); near annihilation of matter and antimatter (N); protogalaxies start to form (P).
- **a.** N-S-E-P
- **b.** E-S-N-P
- **c.** P-E-S-N
- **d.** S-E-P-N

26. In the electromagnetic spectrum, infrared wavelengths are slightly longer than those of visible red, and ultraviolet wavelengths are slightly shorter than visible blue. If an absorption spectrum from a calcium atom here on Earth has a characteristic pattern in the red wavelengths, looking at calcium in the absorption spectrum of a distant galaxy will show the same characteristic pattern toward the
- **a.** ultraviolet.
- **b.** blue.
- **c.** red (the same).
- **d.** infrared.

27. In the stages of nuclear fusion inside stars, which element in the list, compared to the others, is formed last?
- **a.** hydrogen
- **b.** helium
- **c.** carbon
- **d.** oxygen

28. Which is the best answer for the events or processes that disperse elements born in the internal nuclear fires of stars, making those elements available for subsequent formations of new stars and planets?
- **a.** supernovas
- **b.** expanding universe
- **c.** fusion reactions
- **d.** red shift

29. Which element is not made in stars?
- **a.** aluminum
- **b.** boron
- **c.** carbon
- **d.** hydrogen

30. Which element in the universe (including inside our Sun) is both primordial (meaning some of it was made shortly after the Big Bang, before any stars formed) and made inside stars during fusion reactions?
a. carbon
b. hydrogen
c. helium
d. iron

31. Which increases in density as the universe ages?
a. energy
b. microwave radiation
c. hydrogen
d. carbon

32. About how long after the Big Bang did our Sun form?
a. 14 billion years ago
b. 4 billion years ago
c. 9 billion years ago
d. 36 billion years ago

33. Astronomers sometimes make units that fit the large scales of space and time. Consider the time interval from today back to the formation of Earth (in other words, Earth's condensation from the gas cloud that also formed the Sun). For just this question, call this amount of time one Earth Formation Unit (1 EFU). About how many EFUs from today must you go back in time to reach the Big Bang?
a. 1 EFU
b. 3 EFUs
c. 8 EFUs
d. 15 EFUs

34. Our best dates for the origin of the solar system come from
a. rocks found on the Moon.
b. the oldest rocks on Earth.
c. meteorites.
d. gases in the Sun.

35. The planet nearest to the Sun is
a. the asteroids.
b. Phobos.
c. Venus.
d. Mercury.

36. Humans are currently in space on the
a. Mir space station.
b. international space station.
c. space shuttle.
d. Apollo capsule.

37. What important event happened in 1969?
a. first landing a rover on Mars
b. first human landing on the Moon
c. first satellite to be put into orbit
d. first human to orbit the Earth

38. Which body in our solar system has very good evidence for the presence, at one time in the past, for liquid water?
a. Moon
b. Mars
c. Venus
d. Mercury

39. The Cassini space probe will explore the planet with rings. Before reaching that planet, Cassini has to pass the orbit of which planet?
a. Pluto
b. Saturn
c. Jupiter
d. Neptune

40. We know there is matter that cannot be seen by any means available to us, including the different wavelengths of the electromagnetic spectrum. Yet we know this so-called "dark matter" exists. How?
- **a.** Black holes have consumed much of the matter that once existed.
- **b.** At the origin of the universe was a large amount of antimatter that became hidden.
- **c.** Einstein's equation shows us the equivalence of energy that could also be considered matter.
- **d.** The spins of galaxies cannot be explained by the amount of known, ordinary matter.

41. Today, we know fairly well the composition of the universe, in terms of types of matter (or types of energy that can be put into amounts of equivalent matter, using Einstein's equation $E = mc^2$). What percentage of the universe is dark energy?
- **a.** 98%
- **b.** 73%
- **c.** 23%
- **d.** 4%

42. One element crucial to life is carbon, which forms about 40% of our body's dry weight. If planets had formed around the very earliest stars in the universe, why would it have been unlikely for life to start on those earliest planets?
- **a.** Carbon is made slowly as the expanding energy is converted to matter.
- **b.** Carbon leaks into our universe through black holes.
- **c.** Carbon is made by fusion reactions in stars.
- **d.** Carbon is made by the fission of oxygen.

43. The geographical region of the ocean that meets the deep ocean floor is the
- **a.** continental alluvium.
- **b.** continental abyss.
- **c.** continental slope.
- **d.** continental shelf.

44. What word in ancient Greek meant indivisible?
- **a.** atom
- **b.** molecule
- **c.** ion
- **d.** isotope

45. The radioactive isotope of carbon is
- **a.** carbon-11.
- **b.** carbon-12.
- **c.** carbon-13.
- **d.** carbon-14.

46. Protons and neutrons are made of what?
- **a.** electrons
- **b.** neutrinos
- **c.** quarks
- **d.** mesons

47. Parts of the atomic nucleus are sometimes collectively called *nucleons*. Nucleons are therefore
- **a.** protons and mesons.
- **b.** electrons and neutrons.
- **c.** mesons and electrons.
- **d.** neutrons and protons.

48. In measuring electricity, the unit for resistance is the
- **a.** volt.
- **b.** ohm.
- **c.** amp.
- **d.** watt.

49. The momentum of the spinning Earth is measured as
a. rotational momentum.
b. gyrate momentum.
c. angular momentum.
d. circular momentum.

50. This fundamental force of physics could be called the secret behind the chemical bond of molecules.
a. gravity
b. weak nuclear force
c. electromagnetism
d. strong nuclear force

▶ Section 5: Biology

There are 50 questions in this section. You have 45 minutes to complete this section.

1. Which of the following is NOT a pyrimidine base of nucleic acids?
a. thymine
b. cytosine
c. uracil
d. guanine

2. In primates, what is the epithelial lining of the uterus?
a. fimbria
b. cervix
c. myometrium
d. endometrium

3. What is the clinical term for abnormal tissue growth?
a. atrophy
b. karyolysis
c. dysplasia
d. thrombosis

4. Which of the following is another term for vitamin A?
a. retinol
b. thiamin
c. tocopherol
d. ascorbic acid

5. What is the protein covering of a virus?
a. cell wall
b. myelin sheath
c. envelope
d. capsid

6. The loop of Henle is part of which of the following organs?
a. heart
b. kidney
c. pancreas
d. liver

7. Which of the following animals is an ectotherm?
a. lemur
b. wren
c. opossum
d. salamander

8. What is 10^{-12} meters?
a. a picometer
b. a nanometer
c. a micrometer
d. a femtometer

9. Which of the following is an air- or fluid-filled space in the cytoplasm of a living cell?
a. a vacuum
b. a vacuole
c. a centriole
d. a centrosome

10. Which of the following structures is part of a plant cell but not of an animal cell?
a. a mitochondrion
b. a ribosome
c. a chloroplast
d. an endoplasmic reticulum

11. The amount of iron in the human body is vital to the formation of
a. the thyroid hormone thyroxine, which regulates basic metabolism.
b. hemoglobin, the oxygen-carrying pigment of the blood.
c. the enzyme pepsin, which aids in digestion.
d. calcium, which helps form bones and teeth.

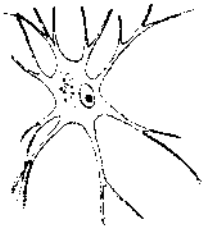
12. Which of the following lists the phases of mitosis in the correct order?
a. prophase, metaphase, anaphase, telophase
b. prophase, anaphase, telophase, metaphase
c. metaphase, prophase, anaphase, telophase
d. telophase, metaphase, anaphase, prophase

13. A reproductive cell, or gamete, is a unique kind of cell because it
a. is a haploid cell.
b. is a diploid cell.
c. does not contain protein.
d. is much smaller than other cells.

14. How many chromosomes are in a human cell that has resulted from mitosis?
a. 4
b. 23
c. 46
d. 92

15. Using probability, determine the nature of the F_1 (first filial) generation of a cross between a tall pea plant (**TT**) and a short pea plant (**tt**).
a. One-fourth of the plants will be tall.
b. One-half of the plants will be tall.
c. All of the plants will be tall.
d. All of the plants will be short.

16. What type of cell is shown in the following figure?



a. a blood cell
b. a fat cell
c. a muscle cell
d. a nerve cell

17. Hepatitis is an inflammation of the
a. joints.
b. lungs.
c. liver.
d. large intestine.

18. Which of the following statements is true?
a. Cells form organs, which form tissues, which form systems.
b. Cells form tissues, which form organs, which form systems.
c. Tissues form cells, which form organs, which form systems.
d. Systems form cells, which form tissues, which form organs.

19. The principal function of blood platelets is to
a. help clot blood.
b. carry oxygen.
c. produce antibodies.
d. phagocytize bacteria.

20. The two or more related genes that control a trait are known as
a. chromosomes.
b. chromatids.
c. phenotypes.
d. alleles.

21. In guinea pigs, rough coat (**R**) is dominant to smooth coat (**r**). Black color (**B**) is dominant to albino (**b**). Which phenotypes are displayed in a guinea pig with the genotypes **Bbrr**?
a. black, rough coat
b. black, smooth coat
c. albino, smooth coat
d. albino, rough coat

22. The term *mutation* refers to
- **a.** a change in one or more genes.
- **b.** rapidly multiplying cells.
- **c.** a bacterial infection.
- **d.** a change in the organism's metabolic rate.

23. The complementary RNA sequence for CATTGAA is
- **a.** GTAACTT.
- **b.** TGCCTGG.
- **c.** GUAACUU.
- **d.** ACGGTCC.

24. In some flowers, the alleles for red and white produce pink flowers when heterozygous. This phenomenon is called
- **a.** the genotypic ratio.
- **b.** the law of independent assortment.
- **c.** incomplete metamorphosis.
- **d.** incomplete dominance.

25. The female organ of a flower is called the
- **a.** pistil.
- **b.** stamen.
- **c.** filament.
- **d.** pollen sac.

26. Which of the following is NOT a member of the class of fungi?
- **a.** common bread mold
- **b.** mushrooms
- **c.** kelp
- **d.** yeast

27. Which of the following is characteristic of viruses?

I. Viruses lack most of the structural and functional features of a cell.
II. Viruses can reproduce only when they are within living cells.
III. Nearly all viruses cause diseases.

- **a.** I only
- **b.** II only
- **c.** I and II only
- **d.** I, II, and III

28. Initial classification of a bacterium is based on its
- **a.** size.
- **b.** shape.
- **c.** color.
- **d.** ability to cause disease.

29. Which of the following is NOT caused by a virus?
- **a.** polio
- **b.** rabies
- **c.** malaria
- **d.** cold sores (herpes simplex)

30. Which of the following is NOT true of most bacteria?
- **a.** They are single-celled.
- **b.** They belong to the Kingdom Monera.
- **c.** They are eukaryotes.
- **d.** They are systematically classified by their biochemical make-up.

31. Which of the following animals is bipedal?
- **a.** salmon
- **b.** cat
- **c.** robin
- **d.** rattlesnake

32. When part of a chromosome breaks off and attaches to another chromosome, some genetic information is transferred. What is this occurrence called?
a. aneuploidy
b. transcription
c. translation
d. translocation

33. The structure formed by the union of male and female gametes is the
a. zoospore.
b. zygote.
c. ova.
d. oocyte.

34. The stamen on a flower consists of which of the following?
a. stigma and anther
b. anther and filament
c. filament and stigma
d. style and stigma

35. During strenuous exercise, a build-up of what substance may cause muscle cramps?
a. lactic acid
b. lactose
c. adrenaline
d. serotonin

36. Which of the following organs functions to absorb water and create feces from undigested food?
a. small intestine
b. liver
c. large intestine
d. stomach

37. During a latent period in muscle tissue, what is released from the sarcoplasmic reticulum?
a. calcium
b. sodium
c. lactic acid
d. acetylcholine

38. Beriberi is caused by a deficit of which vitamin?
a. vitamin B_1
b. vitamin C
c. vitamin E
d. vitamin D

39. Which of the following are the thigh muscles responsible for the knee-jerk response?
a. brachii
b. quadriceps femoris
c. biceps femoris
d. gastrocnemius

40. Which of the following is NOT characteristic of anaphylaxis?
a. circulatory shock
b. bronchospasm
c. hives
d. hypertension

41. What is the generic term for any substance which blocks ONLY the sensory perception of pain?
a. analgesic
b. general anesthetic
c. local anesthetic
d. acetylcholine

42. In mammals, the heart consists primarily of which of the following?
a. smooth muscle
b. myocardium
c. cartilage
d. pericardium

43. Cells that remove dead and dying red blood cells from the liver are known as
a. leukocytes.
b. erythrocytes.
c. eosinophils.
d. Kupffer cells.

44. *Drosophila melanogaster*, the subject of many studies in inheritance and development, is a
a. rabbit.
b. fruit fly.
c. pea plant.
d. orangutan.

45. In humans, an extra copy of chromosome 21 causes
a. Turner's syndrome.
b. Lesch-Nyhan syndrome.
c. Down's syndrome.
d. Klinefelter's syndrome.

46. The primary component of alcoholic beverages that acts as a central nervous system (CNS) depressant is
a. isopropyl alcohol.
b. methanol.
c. methionine.
d. ethanol.

47. A hepatectomy involves the surgical removal of
a. the hip.
b. the liver.
c. the kidney.
d. a stomach tumor.

48. A benign tumor usually caused by a *papillomavirus* is a
a. wart.
b. sarcoma.
c. adenoma.
d. cold sore.

49. What is the light-sensitive pigment found in the vertebrate retina?
a. cytochrome
b. hemoglobin
c. rhodopsin
d. melanin

50. What is another term for excessively high blood pressure?
a. cardiomyopathy
b. hypertension
c. hypoglycemia
d. hemophilia

▶ Section 6: Chemistry

There are 50 questions in this section. You have 45 minutes to complete this section. Use the periodic table on this page when necessary to help you answer the following questions.

IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1 **H** 1.00794																1 **H** 1.00794	2 **He** 4.002602
3 **Li** 6.941	4 **Be** 9.012182											5 **B** 10.811	6 **C** 12.0107	7 **N** 14.00674	8 **O** 15.9994	9 **F** 18.9984032	10 **Ne** 20.1797
11 **Na** 22.989770	12 **Mg** 24.3050											13 **Al** 26.981538	14 **Si** 28.0855	15 **P** 30.973761	16 **S** 32.066	17 **Cl** 35.4527	18 **Ar** 39.948
19 **K** 39.0983	20 **Ca** 40.078	21 **Sc** 44.955910	22 **Ti** 47.867	23 **V** 50.9415	24 **Cr** 51.9961	25 **Mn** 54.938049	26 **Fe** 55.845	27 **Co** 58.933200	28 **Ni** 58.6934	29 **Cu** 63.546	30 **Zn** 65.39	31 **Ga** 69.723	32 **Ge** 72.61	33 **As** 74.92160	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.80
37 **Rb** 85.4678	38 **Sr** 87.62	39 **Y** 88.90585	40 **Zr** 91.224	41 **Nb** 92.90638	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.90550	46 **Pd** 106.42	47 **Ag** 107.8682	48 **Cd** 112.411	49 **In** 114.818	50 **Sn** 118.710	51 **Sb** 121.760	52 **Te** 127.60	53 **I** 126.90447	54 **Xe** 131.29
55 **Cs** 132.90545	56 **Ba** 137.327	57 **La*** 138.9055	72 **Hf** 178.49	73 **Ta** 180.9479	74 **W** 183.84	75 **Re** 186.207	76 **Os** 190.23	77 **Ir** 192.217	78 **Pt** 195.078	79 **Au** 196.96655	80 **Hg** 200.59	81 **Tl** 204.3833	82 **Pb** 207.2	83 **Bi** 208.98038	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89 **Ac**** (227)	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)	110 **Ds** (269)	111 **Uuu** (272)	112 **Uub** (277)		114 **Uug** (289) (287)		116 **Uuh** (289)		118 **Uuo** (293)

* Lanthanide series	58 **Ce** 140.116	59 **Pr** 140.90765	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.964	64 **Gd** 157.25	65 **Tb** 158.92534	66 **Dy** 162.50	67 **Ho** 164.93032	68 **Er** 167.26	69 **Tm** 168.93421	70 **Yb** 173.04	71 **Lu** 174.967
** Actinide series	90 **Th** 232.0381	91 **Pa** 231.03588	92 **U** 238.0289	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

1. Which of the following substances has a pH closest to 7?
- **a.** ammonia
- **b.** blood
- **c.** lemon juice
- **d.** vinegar

2. Which of the following ions is NOT important in the conduction of nerve impulses in the body?
- **a.** Cl^-
- **b.** K^+
- **c.** Mg^{+2}
- **d.** Na

3. Which of the following groups is common to the majority of amino acids?
- **a.** CH_3
- **b.** H_2O
- **c.** NH_2
- **d.** SO_4^{-2}

4. When amino acids polymerize to make a protein, which of the following is produced as a byproduct?
- **a.** H_2O
- **b.** H_2
- **c.** O_2
- **d.** CO_2

5. Which of the following describes the primary structure of proteins?

a. the collective shape assumed by all of the chains in a protein containing multiple chains
b. the folding of an individual protein molecule
c. the regular repeated shape of the protein molecule's backbone
d. the sequence of amino acids bonded together by peptide bonds

6. Which of the following forms of radiation contains the least energy?

a. radio waves
b. gamma rays
c. ultraviolet radiation
d. visible light

7. By which of the following mechanisms does a catalyst operate?

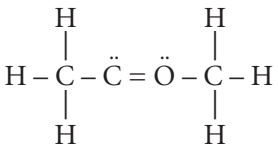
a. It decreases the activation energy barrier for a reaction.
b. It serves as a reactant and is consumed.
c. It increases the temperature of a reaction.
d. It increases the concentration of reactants.

8. If an atom has a mass number of 40 and an atomic number of 18, how many neutrons does it contain?

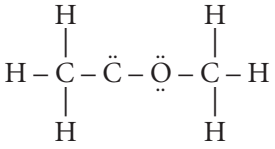
a. 18
b. 22
c. 40
d. 58

9. Which is the best Lewis structure for acetone, $CH_3C(O)CH_3$?

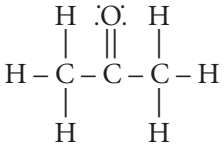
a.



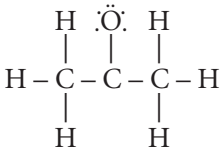
b.



c.



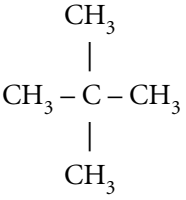
d.



10. Which of the following represents t-butane?

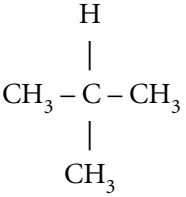
a. $CH_3 - CH_2 - CH_2 - CH_3$

b.



c. $CH_3 - CH_2 - CH_3$

d.



11. What are the most likely products of a reaction between $CH_3CH_2NH_2$ and H_2O?
- **a.** $[CH_3CH_2NH_3]^+ + OH^-$
- **b.** $[(CH_3)_2NH_2]^+ + OH^-$
- **c.** $[CH_3CH_2NH_2OH]^- + H^+$
- **d.** $[(CH_2)NH_2]^- + H_3O^+$

12. Which of the following is NOT a Lewis base?
- **a.** $C_6H_{10}O$
- **b.** $H\text{-}O\text{-}CH_3$
- **c.** Na
- **d.** $CH_3\text{-}CH_2\text{-}CH_2\text{-}CH(NH_2)\text{-}CH_3$

13. Which of the following is the correct, balanced equation for the combustion of propane?
- **a.** $C_3H_{8(g)} + 5O_{2(g)} + N_{2(g)} \rightarrow 3CO_{2(g)} + 2N0_{2(g)} + 4H_{2(g)}$
- **b.** $C_3H_8(g) + 50_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(g)}$
- **c.** $C_3H_{8(g)} + 6O_{2(g)} + 2H_{2(g)} \rightarrow 3CO_{2(g)} + 6H_2O_{(g)}$
- **d.** $C_3H_{8(g)} + O_{2(g)} + 4H_2O_{(g)} \rightarrow 3CO_{2(g)} + 6H_{2(g)}$

14. What is the electron configuration of a Cl^- ion?
- **a.** $[Ne]3s^23p^5$
- **b.** $[Ne]Ss^2p^63d^1$
- **c.** $[Ne]3s^23p^4$
- **d.** $[Ne]3s^23p^6$

15. Which of the following is the hybridization of the carbon atom in methane, CH_4?
- **a.** sp
- **b.** sp^2
- **c.** sp^3
- **d.** sp^4

16. Which of the following elements is the most electronegative?
- **a.** Na
- **b.** S
- **c.** Cl
- **d.** Br

17. When a liquid is at its boiling point, the vapor pressure of the liquid
- **a.** is less than the external pressure on the liquid.
- **b.** is equal to the external pressure on the liquid.
- **c.** is greater than the external pressure on the liquid.
- **d.** can be either less or greater than the external pressure on the liquid.

18. Which of the following is the formula for the compound cobalt (II) nitride?
- **a.** CoN_2
- **b.** Co_3N_2
- **c.** $CoNO_3$
- **d.** $CoNO_2$

19. Which of the following is the empirical formula for ethylene glycol, $C_2H_6O_2$?
- **a.** CH_3O
- **b.** $C_2H_6O_2$
- **c.** $C_4H_{12}O_4$
- **d.** CH_2

20. Given that the density of water at 25° Celsius is 0.997 g/cm^3, what is the approximate mass of 110 ml of water?
- **a.** 11.0 g
- **b.** 110 g
- **c.** 32.9 g
- **d.** 329 g

21. Which of the following is the chemical symbol for the species that has 16 protons, 17 neutrons, and 18 electrons?
- **a.** $^{33}_{16}S$
- **b.** $^{33}_{17}Cl$
- **c.** $^{35}_{17}Cl$
- **d.** $^{33}_{16}S^{2-}$

22. Which of the following equations correctly describes the reaction between $SO_{3(g)}$ and $KOH_{(aq)}$?
a. $4SO_{3(g)} + 4KOH_{(aq)} \rightarrow 2H_2SO_{4(aq)} + 4K_{(s)} + O_{2(g)}$
b. $SO_{3(g)} + 2KOH_{(aq)} \rightarrow K_2SO_{4(aq)} + H_2O_{(1)}$
c. $2SO_3 + 4KOH_{(aq)} \rightarrow 2K_2SO_{3(aq)} + 2H_2O_{(1)} + O_{2(g)}$
d. No reaction occurs.

23. How many moles are contained in a 54.0 g sample of Al?
a. 1.0
b. 2.0
c. 0.5
d. 4.0

24. Butane, C_4H_{10}, combusts to form CO_2 and H_2O. Which of the following is the balanced chemical equation that describes this reaction?
a. $C_4H_{10} + O_2 \rightarrow CO_2 + H_2O$
b. $C_4H_{10} + 7O_2 + H_2 \rightarrow 4CO_2 + 6H_2O$
c. $C_4H_{10} + 7O_2 \rightarrow 4CO_2 + 5H_2O$
d. $2C_4H_{10} \rightarrow 13O_2 + 8CO_2 + 10H_2O$

25. One liter of solution is made by dissolving 29.2 g of NaCl in water. What is the molarity of the solution?
a. 0.5M
b. 2.0 M
c. 1.3 M
d. 0.82 M

26. If a 2.0 M solution is diluted to 0.5 M, and the final volume is 100 ml, what was the original volume?
a. 400 ml
b. 200 ml
c. 50 ml
d. 25 ml

27. Which of the following is the oxidation number of sulfur in the compound sodium thiosulfate, $Na_2S_20_3$?
a. +1
b. –1
c. +2
d. –2

28. Two liters of air at a pressure of two atm are condensed to 0.5 liters. If the temperature is constant, what is the new pressure?
a. 16 atm
b. 8 atm
c. 2 atm
d. 0.5 atm

29. The composition of dry air consists of approximately 78% nitrogen, N_2, and 21% oxygen, O_2. If the air pressure of a 5-liter sample of dry air is 800 torr, what is the approximate partial pressure of oxygen?
a. 620 torr
b. 720 torr
c. 210 torr
d. 170 torr

30. What does the number 36 represent on the periodic table entry for krypton?
a. atomic number
b. relative atomic mass
c. group number
d. electron configuration

31. Which of the following has the largest first ionization energy?
a. Cs
b. Rb
c. Ba
d. Sr

32. If a gas is heated at a constant volume, the pressure
- **a.** increases, because molecules collide with walls more slowly.
- **b.** increases, because molecules collide with walls more quickly.
- **c.** decreases, because molecules collide with walls more slowly.
- **d.** decreases, because molecules collide with walls more quickly.

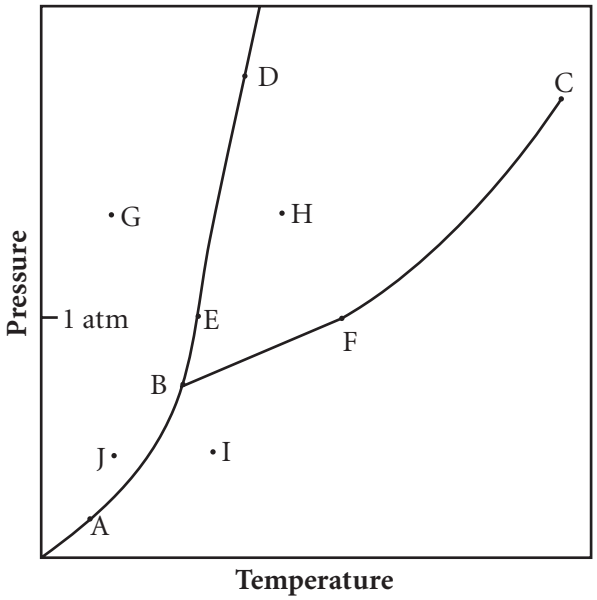
33. How much heat is required to raise the temperature of 100 grams of water from 25° C (near room temperature) to 100° C (its boiling point)? The specific heat of water is approximately 4.2 J per g-K.
- **a.** 3.2×10^4 J
- **b.** 32 J
- **c.** 4.2×10^4 J
- **d.** 76 J

34. Which of the following is NOT a characteristic of nonmetals?
- **a.** They are usually malleable as solids.
- **b.** They are poor conductors of heat and electricity.
- **c.** Most oxides are molecular, acidic compounds.
- **d.** They exist in aqueous solutions mainly as anions or oxyanions.

35. Primary intermolecular interactions between a K cation and H_2O molecules are
- **a.** hydrogen bonds.
- **b.** dipole-dipole interactions.
- **c.** ion-dipole interactions.
- **d.** London forces.

36. Which of the following variables are inversely proportional for an ideal gas if all other conditions are constant?
- **a.** pressure and volume
- **b.** pressure and temperature
- **c.** pressure and the number of moles
- **d.** No two variables are inversely proportional.

Answer questions 37 and 38 based on the following phase diagram for a compound.



37. At which point is the compound a solid?
- **a.** F
- **b.** G
- **c.** H
- **d.** I

38. Sublimation occurs when moving from
- **a.** G to H.
- **b.** I to J.
- **c.** J to I.
- **d.** I to H.

39. Which of following is the balanced equation for the reaction between NH_3 and O_2?
- **a.** $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$
- **b.** $2NH_3 + 3O_2 \rightarrow 2NO + 3H_2O$
- **c.** $2NH_3 + 2O_2 \rightarrow N_2O + 3H_2O$
- **d.** $NH_3 + O_2 \rightarrow N_2O + 3H_2O$

40. In the reaction $4A1 + 3O_2 \rightarrow 2A1_2O_3$, how many grams of O_2 are needed to completely react with 1.5 moles of Al?
a. 24 g
b. 36 g
c. 48 g
d. 60 g

41. What is the equilibrium constant K_c for the following equation?

$$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$$

a. $K_c = \frac{[SO_3]}{[SO_2][O_2]}$
b. $K_c = \frac{[SO_2][O_2]}{[SO_3]}$
c. $K_c = \frac{[SO_2]^2[O_2]}{[SO_3]^2}$
d. $K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$

42. A compound that is acidic by the Lewis definition only is
a. HCl.
b. $HClO_4$.
c. NH_4^+.
d. BF_3.

43. Which of the following has the highest electronegativity?
a. S
b. Se
c. Cl
d. Br

44. How many moles of 0.2 M HCl are needed to titrate 100 ml of 0.4 M NaOH?

$$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(1)}$$

a. 0.2 mol
b. 0.1 mol
c. 0.04 mol
d. 0.02 mol

45. Which of the following is an example of an ionic crystal?
a. LiF
b. SiO_2
c. CO_2
d. $C_{12}H_{22}O_{11}$

46. Which of the following is the most reactive with water?
a. Cs
b. Ba
c. Fr
d. Ra

47. Which of the following is the most likely charge on an ion of Sr? (Sr is a group IIA molecule.)
a. Sr^-
b. Sr^{2-}
c. Sr^+
d. Sr^{2+}

48. Which of the following ions is essential in the clotting of blood?
a. Ca^{2+}
b. F^-
c. Na^+
d. OH^-

49. Which of the following is most likely to bond with the ferrous (Fe^{2+}) ion in blood?
a. O_2
b. CO
c. CO_2
d. N_2

50. A fatty acid with no double bonds is known as a
a. polyunsaturated fatty acid.
b. monounsaturated fatty acid.
c. saturated fatty acid.
d. trans fatty acid.

▶ Answers

Section 1: Verbal Ability

1. **a.** magically
2. **c.** belief
3. **d.** magazine
4. **a.** breach
5. **c.** perceived
6. **a.** shriveled
7. **b.** situation
8. **a.** superb
9. **c.** obsession
10. **d.** jeopardy
11. **c.** magnificent
12. **b.** mechanically
13. **d.** illicit
14. **a.** inquiry
15. **a.** terminated
16. **a.** persecution
17. **b.** peculiar
18. **d.** psychology
19. **d.** license
20. **a.** concise
21. **d.** neighbor
22. **a.** stabilize
23. **c.** irrelevant
24. **d.** aspirations
25. **b.** exercise
26. **a.** villain
27. **a.** hindrance
28. **c.** testimony
29. **d.** no mistakes
30. **d.** no mistakes
31. **a.** quantity
32. **c.** resistant
33. **b.** contradict
34. **b.** reversal
35. **c.** foreign
36. **a.** ravenous
37. **a.** phenomenal
38. **b.** temperature
39. **d.** no mistakes
40. **c.** circumference
41. **b.** worries
42. **b.** finality
43. **a.** religious
44. **d.** no mistakes
45. **b.** delinquent
46. **c.** forecast
47. **a.** righteous
48. **a.** sincerely
49. **b.** vacancy
50. **b.** respiration

Section 2: Reading Comprehension

1. **d.** Many asthma sufferers have an inherited tendency to have allergies, referred to as *atopy* in the third paragraph.
2. **b.** The second paragraph explains that during an attack, the asthmatic will compensate for constricted airways by breathing a greater volume of air.
3. **c.** The first sentence of the passage begins, *No longer . . .*, indicating that in the past, asthma was considered an anomalous inflammation of the bronchi. Now asthma is considered a chronic condition of the lungs.
4. **a.** An *exacerbation* is usually defined as an aggravation of symptoms or increase in the severity of a disease. However, in this passage, *exacerbations* is interchangeable with *asthma attacks*.
5. **a.** Although cramping may occur during asthma attacks, it is not mentioned in the passage. See the bottom half of the second paragraph for a full explanation of the morphological effects of an attack.
6. **d.** The third paragraph discusses triggers in detail. Only physical activity is listed as a possible symptom reducer.
7. **a.** Since asthma symptoms vary throughout the day, relying on the presence of an attack or even just on the presence of a respiratory ailment to diagnose asthma is flawed logic.

8. b. All of the individuals listed would glean a certain amount of knowledge from the passage; however, a healthcare professional would find the broad overview of the effects of asthma, combined with the trigger-avoidance and diagnosis information, most relevant.

9. d. According to the third paragraph, secondhand smoke can increase the risk of allergic sensitization in children.

10. b. Spina bifida aperta is the more severe form of spina bifida, in which a noticeable sac protrudes from the infant's back. No post-surgical mortality rates are given in this passage.

11. d. Hyperactivity is not mentioned in the passage as a possible result of spina bifida.

12. c. The second paragraph states that the higher a myelocele is on the spinal column, the more severe the disability. The cervical vertebrae are the highest vertebrae listed in the question and answer choices.

13. c. Hydrocephalus is the correct term and is given in the final paragraph of the passage.

14. a. Meningoceles are small sacs that produce no muscular paralysis once repaired. A myelocele, also known as a *meningomyelocele*, refers to an actual portion of the undeveloped spinal cord that protrudes from the spine.

15. d. The passage concludes with the thought that although spina bifida is a serious condition, sufferers may lead productive lives. The other options are never stated or are false.

16. d. See the last sentence of the third paragraph. Compaction may well reduce transportation costs (choice **a**) according to the third paragraph. That it reduces the volume of waste (choice **b**) is an advantage, not a disadvantage. Compaction is not designed to eliminate organic matter, so confirming that it has been eliminated (choice **c**) is not an issue.

17. a. See the last sentence of the fifth paragraph, which states that *incineration is . . . the preferred method for on-site treatment.*

18. b. See the last sentence of the sixth paragraph, which points out that steam sterilization does not change the appearance of the waste, thus perhaps raising questions at a landfill.

19. c. The fourth paragraph states that liquid is separated from pulp in the hydropulping process. The sixth paragraph says that liquid may form during the sterilization process.

20. a. This response relies on an understanding of pathological wastes, which are wastes generated by infectious materials. The seventh paragraph points out that incineration is especially appropriate for pathological wastes. Previously, the sixth paragraph had said that steam sterilization is appropriate for substances contaminated with infectious organisms.

21. d. The second paragraph says that the main risk of manual carts is potential exposure from torn bags but automated carts can reduce that potential

22. b. See the next-to-last sentence of the fourth paragraph. Sterilization does not change the appearance of waste. While compacting does change the volume of the waste, it is not appropriate for eliminating hazardous materials.

23. d. See the second sentence of the second paragraph: *There is some risk of exhausting contaminants into hallways*, meaning waste might be discharged.

24. b. See the last sentence of the passage, which states, regarding the rotary kiln, that *the costs have been prohibitive for smaller units.*

25. c. In the first paragraph, the communication network of the millions of cells in the immune system is compared to bees swarming around a hive.

26. b. All of the answers indicate peaceful coexistence. However, according to the fifth sentence of the second paragraph, in this instance, the state is referred to as *self-tolerance.*

27. c. See the last paragraph. Allergens are responsible for triggering an inappropriate immune response to otherwise harmless substances such as ragweed pollen.

28. d. The last paragraph of the passage mentions that an antigen *announces its foreignness* with intricate shapes called *epitopes* that protrude from the surface.

29. a. Every individual's immune system must learn to recognize and deal with nonself molecules through experience. However, the last section of the second paragraph mentions that the immune system is capable of choices **b**, **c**, and **d**.

30. a. According to the second paragraph, the ability to distinguish between self and nonself is the heart of the immune system. This topic is further elucidated throughout the body of the passage.

31. b. The last paragraph mentions that tissues or cells from another individual may act as antigens *except* in the case of identical twins, whose cells carry identical self markers.

32. c. See the first sentence of the fifth paragraph, which discusses the fusion of IL-2 and diphtheria toxin.

33. a. The third paragraph of the passage discusses the researchers' studies to determine whether psoriasis is an autoimmune disease, or if it is more likely caused by nonimmune epidermal skin cells.

34. b. According to the first paragraph, an autoimmune attack occurs when *killer cells . . . attack organs or tissues*.

35. d. The last paragraph says that psoriasis *cannot be studied in animal models*.

36. c. According to the sixth paragraph of the passage, four out of ten patients showed *striking* improvement.

37. c. According to the fourth paragraph, *only T cells that are activated to participate in immune reactions carry the IL-2 receptor.*

38. b. See the last sentence of the sixth paragraph. The drug lowered the epidermal cell count, diminished redness, and reduced T cells, causing reduced inflammation.

39. a. Psoriasis does have a genetic link, but that is only one element in the passage. Scientists are still studying the epidermal vs. immune impact. There is no mention of scientists having anything negative to say about the immune-related cause of psoriasis. Therefore, it can be successfully argued that the only viable option is that scientists, based on this new research detailed throughout the passage, are closer to understanding the causes of psoriasis.

40. c. According to the fifth paragraph, the harmless IL-2 part of the fusion molecule *binds to T cells*.

41. b. Although all of the other answers are indeed characteristics of viruses, the passage states that scientists exploited a virus's tendency to occupy cells in order to deliver genes to TILs.

42. d. The enzyme ADA is missing from patients with *severe combined immunodeficiency disease*.

43. a. Included in the vaccine procedure is taking bits of tumor from a patient, treating those pieces of tumor with immune-cell-activating cytokines, and reinjecting the patient with the cancerous (albeit genetically altered) growths.

44. c. Yeast, bacteria, and mammalian cells in culture were said to have been used to create human proteins.

45. d. According to the third paragraph, ADA is delivered to the T cells by a modified retrovirus.

Section 3: Quantitative Ability

1. a. The correct answer is 14,600. The incorrect answers are common errors in computation, particularly not carrying digits to the next place.

2. d. You have to convert all three fractions to twelfths before adding them in order to get $1\frac{5}{12}$.

3. d. You must convert both fractions to thirtieths before adding them in order to get $7\frac{19}{30}$.

4. a. The correct answer is 418.8. The other answers were subtracted without aligning the decimal points.

5. a. The correct answer is 2. Because dividing two negatives yields a positive, answers **c** and **d** can be easily ruled out. Answer **b** is the result of dividing in the wrong order.

6. d. The answer to this question lies in knowing that there are four quarts to a gallon. There are 20 quarts in a 5-gallon container. Multiply 20 by 1.06 quarts per liter to get 21.2 liters, and then round off to 21.

7. d. Answer **a** equals 276; **b** equals 2,706; **c** equals 20,076.

8. b. Raise the fraction $\frac{2}{9}$ to 54ths by multiplying both numerator and denominator by 6.

9. c. $6(7)(2) = 84$.

10. c. The meaning of 4^3 is 4 times itself 3 times.

11. b. 157 is rounded to 200; 817 is rounded to 800. To get the product, multiply 200(800), which is 160,000.

12. a. The first step in solving the problem is to subtract 86 from 148. The remainder, 62, is then divided by 2 to get 31.

13. b. You simply add all the numbers together to get the correct answer, $92.61.

14. b. $150x = (100)(1)$, where x is the part of a mile a jogger has to go to burn the calories a walker burns in 1 mile. If you divide both sides of this equation by 150, you get $x = \frac{100}{150}$. Cancel 50 from the numerator and denominator to get $\frac{2}{3}$. This means that a jogger has to jog only $\frac{2}{3}$ of a mile to burn the same number of calories a walker burns in a mile of brisk walking.

15. c. The ratio is $\frac{12 \text{ cc}}{100 \text{ lbs.}} = \frac{x \text{ cc}}{175 \text{ lbs.}}$, where x is the number of cc's per 175 lbs. Multiply both sides by 175 in order to get $175 \times \frac{12}{100} = x$, so $x = 21$.

16. a. 20% of 1,800 = (0.2)(1,800) = 360 calories from fat. Since there are 9 calories in each gram of fat, you should divide 360 by 9 to find that 40 grams of fat are allowed.

17. b. 5% of 1 liter = $(0.05)(1) = 0.02x$, where x is the total amount of water in the resulting 2% solution. Solving for x, you get 2.5. Subtracting the 1 liter of water already present in the 5% solution, you will find that 1.5 liters need to be added.

18. b. 20% of 15 cc = (0.20)(15) = 3. Adding 3 to 15 gives 18 cc.

19. c. The volume of a cylinder $\pi r^2 h$, where r is the radius of the cylinder and h is the height. The radius is half the diameter, so the radius of this cylinder is $(\frac{1}{2})(8 \text{ cm}) = 4$ cm. The height of the volume is $10 - 4 = 6$ (the height of the whole cylinder minus the height of space in which the liquid has been poured out). So the volume $\pi r^2 h = \pi(4)^2(6) = \pi(16)(6) = 96\pi$ cm^3.

20. c. The easiest way to calculate the volume is to realize that the shaded figure is made up of half a circle of diameter 4 or radius 2 on top of a rectangle that is 4 units wide and 6 units tall. The area of a rectangle is length times width. The area of a half circle is πr^2. So the shaded area = $(4)(6) + \frac{1}{2}\pi 2^2 = 24 + 2\pi$.

21. b. $\overline{PQ}$ and $\overline{RS}$ are intersecting lines. The fact that angle POR is a 90-degree angle means that $\overline{PQ}$ and $\overline{RS}$ are perpendicular, indicating that all the angles formed by their intersection, including angle ROQ, measure 90 degrees.

22. d. A line that intersects two parallel lines forms complementary angles on either side of it. Complementary angles are angles whose measures add up to 180 degrees. So $P + Q =$ 180 degrees; $P = 40$, so $40 + Q = 180$. Subtracting 40 from each side yields $Q = 140$.

23. c. The difference between 220 and this person's age is 220 – 30, or 190. The maximum heart rate is 90% of this, or (0.9)(190) = 171.

24. a. 72% of 9,125 = (0.72)(9,125) = 6,570 males. If 3 out of 5 males were under 25, then 2 out of 5, or $\frac{1}{5}$, were 25 or older, so $(\frac{2}{5})(6{,}570) = 2{,}628$ male patients 25 or older.

25. b. 62.5% = $\frac{62.5}{100}$. You should multiply both the numerator and denominator by 10 to move the decimal point, resulting in $\frac{625}{1{,}000}$, and then factor both the numerator and denominator to find out how far you can reduce the fraction. If you cancel 5 from both the numerator and denominator three times (or cancel 125), you will get $\frac{5}{8}$.

26. b. Simply estimating the value of $\frac{7}{40}$ will probably let you know that 0.0175 is much too small and 1.75 is much too large. If that did not work for you, however, you could divide 7.0 by 40 in order to get 0.175.

27. d. 30 ppm of the pollutant would have to be removed to bring the 50 ppm down to 20 ppm; 30 ppm represents 60% of 50 ppm.

28. a. The drug is 50% effective for half (or 50%) of migraine sufferers, so it eliminates (0.50)(0.50) = 0.25 = 25% of all migraines.

29. d. Division is used to arrive at a decimal, which can then be rounded to the nearest hundredth and converted to a percentage: 11,350 ÷ 21,500 = 0.5279; 0.5279 rounded to the nearest hundredth is 0.53, or 53%.

30. c. Since there are two decimal places in each number you are multiplying, you need a total of four decimal places in the answer, 0.2646.

31. c. First, change $2\frac{1}{4}$ to an improper fraction: $\frac{9}{4}$. Next, in order to divide by $\frac{2}{3}$, invert that fraction to $\frac{3}{2}$ and multiply: $\frac{9}{4} \times \frac{3}{2} = \frac{27}{8} = 3\frac{3}{8}$.

32. a. First, find the least common denominator, 16; $\frac{7}{8} = \frac{14}{16}$, so you can rewrite the problem as $(3 + \frac{9}{16}) - (1 + \frac{14}{16})$. To get a large enough numerator from which to subtract 14, you borrow 1 from the 3 to rewrite the problem as $2\frac{26}{16} - 1\frac{14}{16} = 1\frac{11}{16}$.

33. b. This is a simple multiplication problem, which is solved by multiplying 35 × 8.2 in order to get 287.

34. c. The problem is solved by dividing 204 by 1,700. The answer, 0.12, is then converted to a percentage, 12%.

35. d. To solve this problem, you must convert $3\frac{1}{2}$ to $\frac{7}{2}$ and then divide $\frac{7}{2}$ by $\frac{1}{4}$, which is the same as multiplying $\frac{7}{2}$ by 4.

36. b. The simplest way to solve this problem is to divide 1 by 1,500, which is 0.0006667, and then count off two decimal places to arrive at the percentage 0.06667%. Since the question asks *about what percentage,* the nearest value is 0.067%.

37. a. You can use trial and error to arrive at a solution to this problem. Using choice **a**, after the first hour, the number would be 20, after the second hour 40, after the third hour 80, after the fourth hour 160, and after the fifth hour 320. The other answer choices do not have the same outcome.

38. a. Since the solution to the problem $x + 25 = 13$ is –12, choices **b**, **c**, and **d** are all too large to be correct.

39. b. A cube has 4 sides, a top, and a bottom, which means that it has 6 faces.

40. d. To solve this problem, you should use the formula $A = lw$, or $117 = 9l$. Next, you must divide 117 by 9 to find the answer, 13.

41. a. Fractions must be converted to the lowest common denominator, which is 60; $\frac{6}{10} = \frac{36}{60}$; $\frac{11}{20} = \frac{33}{60}$; $\frac{8}{15} = \frac{32}{60}$, which is the smallest fraction.

42. c. Add the whole numbers: 2 + 4 = 6. Use the least common denominator of 8 to add the fractions: $\frac{2}{8} + \frac{5}{8} + \frac{4}{8} = \frac{11}{8} = 1\frac{3}{8}$. Add 1 to the whole number sum: 1 + 6 = 7, and then add the fraction to get $7\frac{3}{8}$.

43. d. 750 is *n*% of 600, expressed as an equation, is $750 = (\frac{n}{100})(600)$. Cancel 100 in the right side of the equation: $750 = 6n$. Divide both sides by 6 to arrive at the answer, $n = 125$.

44. d. Multiply the numerator and denominator of $\frac{13}{25}$ by 4 to get $\frac{52}{100}$.

45. c. 0.32×10^3 is equal to $0.32 \times (10 \times 10 \times 10)$, or 320.

46. b. Because parallel lines never intersect, choice **a** is incorrect. Perpendicular lines do intersect, so choice **c** is incorrect. Choice **d** is incorrect because intersecting lines have only one point in common.

47. c. This is a simple subtraction problem, as long as the decimals are lined up correctly: 3.60 – 1.89.

48. c. This is a two-step multiplication problem. To find out how many heartbeats there would be in one hour, you must multiply 72 by 60 minutes, and then multiply this result, 4,320, by 6.5 hours in order to get 28,080.

49. a. The unreduced ratio is 8,000:5,000,000 or 8:5,000; 5,000 ÷ 8 = 625, for a ratio of 1:625.

50. b. The correct answer is $\frac{1}{24}$. Before subtracting, you must convert both fractions to 24ths.

Section 4: General Science

1. c. It was the ancient Greek, Archimedes, who also made many discoveries in geometry. See the text for the others.

2. c. von Leeuwenhoek was the famous early microscopist. Benedict Spinoza, though also Dutch, was a philosopher of science who claimed that God was the principle of nature being discovered by science.

3. a. Kepler. See the text.

4. d. Mendeleyev made cards of the properties of elements and found he could arrange the cards in rows in which the elements in the vertical columns had common properties, which we now know is related to the electron structures of the atoms. See the text for the others.

5. c. Mendel. Ernst Rutherford (1871–1937) was a British physicist who discovered the nucleus of atoms. See the text for the others.

6. c. Hippocrates learned all about the body and diseases, as much as he could in ancient Greece, and so is called the "father" of medicine.

7. d. Galileo made himself a small—but for that time powerful—telescope, turned it skyward, and made many discoveries, including the moons of Jupiter, craters of our Moon, and sunspots.

8. a. The control in an experiment is the baseline not subjected to the variable under study. Answers **c** and **d** are made up.

9. d. Occam's razor is the principle modeled after the philosophy of Englishman William of Occam.

10. b. Theories are the biggest concepts, such as Einstein's theory of relativity or Darwin's theory of evolution. Theories can contain more detailed hypotheses and good theories make predictions.

11. b. Famous philosopher of science Karl Popper emphasized the crucial importance that experiments play in falsifying hypotheses and claimed this is the way the best science truly works.

12. a. Truth can change as more facts come to be known, but this process is carefully controlled by the multitudes of scientists checking each other and, indeed, trying hard to prove each other wrong. Truth is therefore tentative but certainly not arbitrary.

13. c. Systems of math, especially those run by computers, are called models. This is an excellent word, because the explanations are imitations of nature itself; they thus model nature by corresponding to the features of reality attempted to be understood.

14. d. In reductionism, which most scientists strive for, how parts interact to form wholes is the focus. The other answers are made up and do not relate to the term reductionism.

15. b. The ancient Egyptians used measurement techniques to survey their lands, which became our word geometry, from ancient Greek.

16. d. The prefix *micro-* refers to millionths.

17. d. The prefix *giga-* refers to billions.

18. d. The foot is a unit of length found only in the English system.

19. b. There are 1,000 or 10^3 meters in a kilometer.

20. b. Multiplying 60 seconds per minute by 60 minutes per hour times 24 hours per day by 365 days in a year (actually 365.25) yields the answer of between 31 and 32 million seconds per year.

21. c. The prefix *nano-* refers to a billionth.

22. c. The μm (micrometer or micron) is $\frac{1}{1{,}000}$ of a millimeter; therefore, there are 1,000 μm in one millimeter.

23. a. Small differences in the spatial patterns of temperature of the cosmic background radiation, which originated after the Big Bang but before the formation of galaxies, show the lumpiness that eventually resulted in differences of gravity that could contract matter into galaxies.

24. d. The Big Bang occurred 13.7 BYA, or billion years ago. The other answers are too large (**a** and **b**) or too small (**c**).

25. a. N-S-E-P; the order of events is discussed in the text.

26. d. Patterns from distant galaxies are shifted "red," which means toward longer wavelengths. In this case, going from a pattern in the red toward a pattern in longer wavelengths means the infrared.

27. d. Oxygen is formed last because it is the most massive and complex. Fusion reactions build from the simplest to the most complex, and the stages of fusion take hydrogen and then the other elements built in sequence as starting points for more complex elements.

28. a. Supernova explosions, which are catastrophic events at the end of the lives of giant stars, scatter elements previously made by fusion reactions in the star over their lifetimes, as well as elements born in the intense temperatures and pressures of the supernova explosion itself.

29. d. Hydrogen is primordial, made shortly after the Big Bang when the universe cooled enough for atoms to condense. The other elements are all made by nuclear fusion reactions in stars. These reactions consume hydrogen.

30. c. Helium is both primordial and made during fusion reactions when two hydrogen nuclei are fused together inside stars. This fusion reaction is the main source of energy for stars.

31. d. Carbon increases in density because as time passes, more and more carbon is made in the fusion reactions inside stars. Answers **a** and **b** actually decrease in density as the universe expands, and answer **c** also decreases in density as hydrogen is consumed in fusion reactions.

32. c. Because the Big Bang was 13.7 billion years ago and the Sun formed between 5 and 4.5 billion years ago, then, subtracting, the Sun formed about 9 billion years after the Big Bang.

33. b. If the time when the Big Bang occurred was 13.7 billion years ago, the formation of the Earth occurred about 4.5 billion years ago. Therefore, taking 1 EFU as 4.5 billion years (by definition from the question), there were $\frac{13.7}{4.5}$ or about 3 EFUs back to the Big Bang.

34. c. Meteorites formed along with the Earth at the beginning of the solar system. But on Earth, no rocks go back that far. The dates from meteorites give us the best estimate of the origin of our solar system.

35. d. Mercury is the nearest planet. The asteroids are between Mars and Jupiter. Phobos is a moon of Mars.

36. b. Of the possibilities, the only one in space right now is the international space station. Hopefully, the space shuttles will be put back into active service, but it's Russian rockets that are taking new astronauts to the space station at this time.

37. b. In July, 1969, Neil Armstrong set foot on the Moon and pronounced, "One small step for man, one giant leap for mankind."

38. b. In 2004, rovers on the surface of Mars discovered types of minerals that, as far as we know, could only have been formed with the activity of water. Also, previously, channels on Mars had been seen that looked much like the branching slow patterns of Earth's rivers.

39. c. Jupiter comes before the planet with rings, Saturn. Answers **a** and **d** are planets farther away than Saturn. And obviously, Saturn itself (**b**) makes no sense.

40. d. The spins of galaxies cannot be explained by the amount of known, ordinary matter. Something out there (the "dark matter") is creating more gravity than we can account for with the known, ordinary matter.

41. b. 73% of the universe is dark energy.

42. c. Carbon is made by fusion reactions in stars. Therefore, before stars and supernovas can disperse that carbon, there would have been no carbon in the earliest planets (in fact, planets as solid bodies could not have formed either). Life is so dependent on carbon that without carbon is seems likely there could not have been life.

43. d. The continental slope is still part of the continent, but it does head downward to the ocean floor itself.

44. a. The word *atom* came from the Greek word that meant indivisible. Though atoms are now known to have parts (they are divisible), they still are the fundamental units of any element.

45. d. Carbon-14 is the radioactive form of carbon (the most common form is carbon-12). Carbon-14 is formed in the atmosphere when cosmic rays hit nitrogen and convert small amounts of it (by changing a proton to a neutron—a nuclear change). Using its half-life decay rate, we can measure the amount of carbon-14 in ancient wood to determine the dates of wood architecture of ancient peoples as well as their campfires and even bones.

46. c. Quarks are the constituents of protons and neutrons.

47. d. Neutrons and protons are the parts of the nucleus of an atom.

48. b. The unit of resistance is the ohm.

49. c. An important topic in physics is the angular properties of objects that spin or turn in arcs. Angular momentum is one such property.

50. c. Electromagnetism governs interactions between charged particles, the situation that occurs when atoms possessing different numbers of valence electrons interact.

Section 5: Biology

1. d. Guanine is a purine. Thymine, cytosine, and uracil are the major pyrimidines.

2. d. The lining of the uterus, shed during menstruation, is referred to as the endometrium. Fimbria are found at the ends the Fallopian tubes in mammals. The cervix is the narrow neck of the uterus. The myometrium is the layer of smooth muscles of the uterine wall.

3. c. The prefix *dys-* means abnormal; *plasis* is Greek for formation.

4. a. Retinol is vitamin A. Thiamin is vitamin B_1. Tocopherol is vitamin E. Ascorbic acid is vitamin C.

5. d. A capsid is the protein coating of a virus. The myelin sheath covers the axons of nerve cells in most vertebrates.

6. b. The loop of Henle is a component of the nephron of the kidney, the excretory organ in vertebrates.

7. d. All animals except mammals and birds are cold-blooded or ectotherms.

8. a. The following are the SI units: 10^{-1} = *deci*; 10^{-2} = *centi*; 10^{-3} = *milli*; 10^{-6} = *micro*; 10^{-9} = *nano*; 10^{-12} = *pica*; 10^{-15} = *femto*; $^{l}0^{-18}$ = *atto*.

9. b. A compartment filled with air or watery fluid in the cytoplasm is referred to as a vacuole. Centrioles and centrosomes are associated with the process of cell division.

10. c. Chloroplasts contain chlorophyll and are found only in plant cells.

11. b. Iron is a necessary component of hemoglobin. It is the iron that binds oxygen for transport within red blood cells.

12. a. Prophase is the first phase of mitosis, or cell division. Telophase is the fourth stage.

13. a. A gamete is a unique cell because it is haploid—that is, it contains only one set of chromosomes instead of the two sets that are found in most somatic cells, which are diploid.

14. c. In a human cell that has resulted from mitosis, there are 23 pairs of chromosomes or a total of 46 chromosomes.

15. c. All of the plants will be **Tt**, or tall, because **T** is dominant.

16. d. The figure is a nerve cell. Note the long extensions (axons and dendrites) unique to neurons. Blood, fat, and muscle cells have very different shapes.

17. c. Hepatitis is a disease marked by a inflammation of the liver, as indicated by the Greek roots *hepato* meaning liver and *itis* meaning inflammation.

18. b. Tissues, such as bone and skin, are made from cells. Organs, such as the heart and lungs, are made from tissues. One example of a system is the digestive system, which involves organs such as the stomach, which is made up of smooth muscle plus epithelial and connective tissues.

19. a. The primary function of a blood platelet is to aid in the blood clotting process. Platelets scrape against the rough edges of broken tissue and release a substance to promote clotting. Red blood cells carry oxygen. Antibodies are produced by B lymphocytes. Phagocytic cells include neutrophils and macrophages (monocytes).

20. d. An expressed trait is determined by two alleles. A phenotype is the physical or visual expression of the genotype.

21. b. With the genotype **Bb**, the color will be black because black is dominant and requires only one allele for expression. With the genotype **rr**, the coat will be smooth because the necessary two copies of the recessive allele are present.

22. a. When a mutation occurs, a gene is changed.

23. c. Since it has the proper complementary bases—including the use of U instead of T as the compliment to A in RNA—the other choices are either nonsense or they use T and not U.

24. d. Incomplete dominance is a condition in which the heterozygous genotype for certain alleles gives rise to a phenotype intermediate between dominant and recessive traits because both traits are expressed.

25. a. The female organ of a flower is a long, vase-shaped structure called the pistil. The pistil is divided into three parts: the stigma, the style, and the ovary. The stamen is the male organ of a flower.

26. c. Kelp is a brown algae; the others are fungi.

27. c. Viruses are noncellular, and they must enter a living cell to replicate. However, not all viruses are disease-causing; many viruses do no apparent harm.

28. b. Bacteria can be placed in three groups (cocci, bacilli, spirilla) based on their shape.

29. c. Malaria is caused by *Plasmodium*, which is a protist. The others are viruses.

30. c. All bacteria are prokaryotes, meaning that they lack a nucleus. Eukaryotes contain a nucleus and other organelles. Some eukaryotes are single-celled (protists).

31. c. Birds and humans are the only animals that can stand erect and move around on two legs. *Bi-* is a combining form meaning *two*. *Ped* is the combining form for *foot*.

32. d. Translocation is a type of mutation in which a section of a chromosome breaks off and joins with another. In aneuploidy, one has an abnormal number of chromosomes. Transcription is the process in which genetic information is transferred from DNA to mRNA. Translation is a process used in the synthesis of new proteins on ribosomes.

33. b. A zygote is the product of a sperm nucleus fused with an ovum nucleus. A zoospore is found in certain fungi. Ova is the plural of ovum, a female egg, while an oocyte is a cell in the ovary that produces an ovum after undergoing meiosis.

34. b. A section of the male part of a flower is the stamen, consisting of the anther and filament. The stigma and style are both parts of the carpel.

35. a. When there is a shortage of oxygen in muscle tissue, pyruvic acid produces lactic acid to be converted to glucose by the liver. Lactose is milk sugar. Adrenaline is a hormone produced in the adrenal medulla that stimulates the sympathetic nervous system, while serotonin, also a hormone, is produced in many parts of the body.

36. c. The large intestine's main functions are water absorption and feces production. The large intestine consists of the rectum, colon, and caecum. Almost all the digestion and absorption of nutrients occur in the small intestine. The liver has numerous functions including the metabolism of carbohydrates, lipids, and proteins, as well as the removal of drugs and hormones and the production of bile. The stomach is the holding reservoir in which saliva, food, and gastric juices mix prior to continuing the digestive process in the small intestine.

37. a. Calcium ions are released in the interim between the time when a stimulus is received and a response occurs in muscle tissue.

38. a. Beriberi, most common in countries where white rice is the main food source, is caused by a lack of vitamin B_1. Deficiencies in vitamin C can cause scurvy and deficiencies in vitamin D can cause rickets. Hemolytic anemia is a possible consequence of vitamin E deficiency.

39. b. The quadriceps femoris join at the base of the femur. The triceps brachii extends the forearm, the biceps femoris is one of the hamstring muscles that flexes the leg and extends the thigh, and the gastrocnemius flexes the leg and foot.

40. d. Anaphylaxis is an immune system response such as that which occurs in a person who gets stung by a bee and is allergic to the venom. Hypertension is another term for high blood pressure.

41. a. The correct answer is analgesic. Anesthetics block perception of *all* sensory stimuli either generally (all over) or locally (in a specific area). Acetycholine is a neurotransmitter.

42. b. The hollow, four-chambered heart consists primarily of cardiac muscle or myocardium. Pericardium is a membranous sac that surrounds the heart. There is no smooth muscle or cartilage in the heart.

43. d. Kupffer cells remove red blood cells, otherwise known as erythrocytes, and other degenerating matter from the liver. Leukocytes and eosinophils are white blood cells.

44. b. In the past decade, geneticists have manipulated the chromosomes of countless fruit flies.

45. c. Down's syndrome is also known as trisomy 21 syndrome.

46. d. Ethanol or ethyl alcohol depresses the CNS, thereby affecting the neural activity of the consumer. Isopropyl alcohol is for external use only and is found in cosmetics. Methanol is wood alcohol used as a solvent. Methionine is an organic compound used in dietary supplements.

47. b. *Hepatic* means of or relating to the liver. For instance, *hepatitis* is a liver disease.

48. a. Warts are usually insignificant growths caused by a virus. Sarcomas are malignant tumors arising from connective tissue, while adenomas are glandlike benign tumors. A cold sore is a lesion caused by the herpes simplex virus.

49. c. Rhodopsin or visual purple is the light-sensitive pigment in vertebrate eyes. Cytochrome is a respiratory enzyme, hemoglobin is the oxygen-bearing protein in red blood cells that gives them their red color, and melanin is the dark pigment found in skin, hair, and the retina.

50. b. People suffering from high blood pressure, or hypertension, have an increased risk of stroke and heart attack. Cardiomyopathy is a form of muscle damage that leads to heart failure.

Section 6: Chemistry

1. b. It is very important for blood to be close to neutral, as variance outside a small pH range can cause death. Ammonia is a well-known base, while lemon juice and vinegar contain citric and acetic acids, respectively, giving them low pH.

2. c. Cl^-, Na^+, and K^+ all interact to form various cellular potentials that are important in the conduction of nerve impulses. Mg^{+2} is not involved in this process.

3. c. NH_2 is an amino group, which gives an amino acid the first part of its name. It is found in 19 of the 20 amino acids. The other prevalent group is carboxylic acid, or COOH, which is not one of the answer choices.

4. a. When two amino acids come together, the carboxylic acid group of one reacts with the amine group of the other. An OH from the carboxylic acid combines with an H from the amine group to form H_2O. The remaining C=O of the carboxylic acid then bonds with the remaining N-H of the amine to form a peptide bond.

5. d. Choice **d** describes primary structure. Choice **a** describes quaternary structure, choice **b** tertiary structure, and choice **c** secondary structure.

6. a. Radio waves are at the low energy end of the electromagnetic spectrum, while gamma rays are at the high energy end.

7. a. A catalyst is a substance that increases the rate of a reaction without being consumed in the reaction. It decreases the amount of energy necessary for the reaction to occur.

8. b. The number of neutrons in an atom can be found by subtracting the atomic number from the mass number.

9. c. This is the only choice where all atoms have a full octet and no formal charges. The other three choices have either or both, and unfilled octets and formal charges are undesirable in a stable molecule.

10. d. A butane is an alkane with four carbon atoms. The *t* in *t*-butane stands for a tertiary carbon. The central carbon of choice **d** is tertiary because it has three other carbon atoms bonded to it. Choice **a** is also a butane molecule, but it is *n*-butane. Choices **b** and **c** are not butanes.

11. a. This is an acid-base reaction. The water molecule is the acid and donates a proton to the ethyl amine molecule, the base. Water breaks into H^+ and OH^- ions upon dissociation, and the H^+ ion is attracted to the nucleophilic lone pair of the ethyl amine molecule.

12. c. A Lewis base is defined as a species that has a nonbonding pair or pairs of electrons that it can donate to form new bonds. Sodium is the only choice that does not have at least one lone pair of electrons.

13. b. Combustion is a reaction in which an alkane burns in excess oxygen to give carbon dioxide and water. Hydrogen gas, present in all three incorrect equations, is not a participant in combustion reactions.

14. d. The configuration of a chlorine atom in the ground state is $[Ne]3s^23p^5$. A Cl^- ion has an additional electron, giving it the same electron configuration as an argon atom in the ground state, which can also be written as $[Ne]3s^23p^6$.

15. d. The carbon atom in methane has four sigma bonds around it, meaning that it uses its s atomic orbital and all three p atomic orbitals to form four sp^3 molecular orbitals. The number of atomic orbitals combining always equals the number of molecular orbitals formed.

16. c. Electronegativity is a measure of the ability of an atom to attract shared electrons to itself. It increases across rows of the periodic table to the right and decreases going down columns of the table. Na, S, and Cl are all in the same row of the table, with Cl being rightmost. Cl is also above Br, so it is the most electronegative atom.

17. b. This is the definition of the boiling point. At temperatures higher than the boiling point, the vapor pressure of the liquid is greater than external pressure and molecules begin to escape in the gaseous phase.

18. b. Because the question is written with (II) after cobalt, the Co ion must be +2. Since the nitride ion is always –3, the formula must be Co_3N_2 to have a balanced compound.

19. a. The empirical formula of a compound is the formula written with the simplest form possible. $C_2H_6O_2$ has one molecule of both C and O for every three molecules of H, so the empirical formula is CH_3O.

20. b. The key to this problem is that 1 ml is equal to 1 cm^3. Multiplying 110 ml by $\frac{0.997\ g}{cm^3}$ gives approximately 110 grams.

21. d. The complete chemical symbol includes two numbers. The lower number is the atomic number, or the number of protons in the nucleus. The upper number is the mass number, or the sum of the protons and neutrons in the nucleus. Therefore, the answer is $^{33}_{16}S^{2-}$, because there are 18 electrons present.

22. b. Nonmetal oxides (SO_3) and bases (KOH) react to form salts and water. The solution in choice **a** forms an acid and that in choice **c** forms a salt, but such a reaction would not give off oxygen.

23. b. According to the periodic table, the molar mass of Al is 26.98, or approximately 27 grams. Therefore, there are 2 moles (54 divided by 27) of Al.

24. d. This problem is simply an equation-balancing problem. The number of molecules of each element must be the same on each side of the equation. Choice **d** has 8 carbons, 20 hydrogens, and 26 oxygens on each sicle of the equation.

25. a. The molar mass of the compound NaCl is approximately 58.4 g/mol; 29.2 grams is one-

half the molar mass of NaCl, so the solution is 0.5 M because there is one liter of the solution. Molarity is moles/liter.

26. d. The equation $M_1V_1 = M_2V_2$ must be used; $2.0\ (V_1) = 0.5(100)$; $V_1 = 25$ ml.

27. c. The sum of the oxidation numbers must be equal to the net charge on the compound, so the sum must be equal to zero. The charge on the cation is the same as its oxidation number, so the oxidation number of Na is +1 and the oxidation number for S_2O_3 is –2. Oxygen almost always has an oxidation number of –2, so the oxidation number of sulfur must be +2.

28. b. The formula $P_1V_1 = P_2V_2$ must be used. Solving $2(2\text{ l}) = P_2(0.5\text{ l})$ for P_2 gives 8 atm.

29. d. The sum of the partial pressures is the total pressure, or in this case the air pressure. Since the sample is 21% oxygen, and there is a total pressure of 800 torr, the partial pressure is 800×0.21, or 170 torr.

30. a. Thirty-six is the atomic number of krypton. The atomic mass of krypton is 83.80, and the electronic configuration is represented by the numbers listed on the left. The group number of VIII refers to the element's placement on a vertical column on the periodic table.

31. d. As a general rule, first ionization energy increases as you go up and to the right in the periodic table. Sr is the farthest up and to the right.

32. b. The molecules move faster when heated, causing more collisions, which in turn increases the pressure.

33. a. The formula q = (specific heat) × (mass of water) × ΔT is used. Because the units in the specific heat involve grams, the mass is left as grams instead of changed to kilograms; $(100\text{ g})(4.2\text{ J/g-K})(75\text{ K}) = 3.2 \times 10^4$ J.

34. a. Metals are usually malleable; nonmetals are usually brittle.

35. c. Ion-dipole forces act between an ion and a polar molecule. Dipole-dipole forces act between two polar molecules. Because K^+ is an ion, this can be ruled out. Hydrogen bonds are a special type of dipole-dipole interaction. London forces are generally weak.

36. a. This question refers to the ideal gas law, or the equation PV = nRT. Solving for P gives P = nRT/V. Therefore, pressure is inversely proportional to volume.

37. b. Compounds are solids in the upper left portion of the diagram.

38. c. To sublime is to go directly from the solid to the gas state. The gas state is the farthest down on the phase diagram.

39. a. NH_3 and O_2 form NO. Choice **a** is the only equation that is balanced.

40. b. 36 grams of O_2 are needed; the molar mass of O_2 is 32 g/mol.

$$1.5\text{ mole Al} \times \frac{3\text{ moles O}_2}{4\text{ moles Al}} \times \frac{32\text{ g O}_2}{\text{mole O}_2} = 36\text{ g O}_2$$

41. d. If an equation is

$$aA + bB \rightleftharpoons cC + dD,\ K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

42. d. The other definition, the Brönsted-Lowry definition, defines an acid to be an H^+ donor. Because BF_3 does not have any H in it, it cannot be a Brönsted-Lowry acid. Therefore, it is acidic by the Lewis definition only.

43. c. Electronegativity increases up and to the right on the periodic table.

44. c. 0.04 moles of acid are needed to titrate the NaOH: $0.4\text{ M} \times 0.100\text{ l} = 0.04$ moles.

45. a. LiF is the only ionic crystal. SiO_2 (glass) is a covalent crystal, while the other two are molecular.

46. c. Reactivity with water increases down and to the left on the periodic table.

47. d. Group IIA elements tend to lose two electrons, giving a net charge of 2+.

48. a. Calcium ions convert prothrombin to thrombin, which causes fibrinogen to convert to fibrin. Fibrin causes coagulation of the blood.

49. b. The ferrous ions (Fe^{2+}) in hemoglobin have two hundred times more affinity for CO than O_2. This is the cause of carbon monoxide poisoning; the hemoglobin is unable to carry oxygen.

50. c. The definition of a saturated fatty acid is a fatty acid with no double bonds.

▶ Scoring

Your score on each section is reported both as a raw score, the number of questions you got right in that section, and as a percentile, a number that indicates what percent of other test takers scored lower than you did on this section. No total score is reported, only scores for individual sections. Furthermore, there is no such thing as a "passing" raw or percentile score. Individual schools set their own standards.

For purposes of comparison, you'll work with raw scores in this book. So the first thing you should do is count up the number of questions you got right in each section, and record them in the following blanks.

Section 1: _____ of 50 questions right
Section 2: _____ of 45 questions right
Section 3: _____ of 50 questions right
Section 4: _____ of 50 questions right
Section 5: _____ of 50 questions right
Section 6: _____ of 50 questions right

Your purpose in taking this first practice exam—in addition to getting practice in answering the kinds of questions found on health occupations entrance exams—is to identify your strengths and weaknesses. In order to do so, convert your raw scores above into percentages. (Note that this *percentage* is not the same as the *percentile* that will appear on your score report. The percentage is simply the number you would have gotten right if there had been 100 questions in the section; it will enable you to compare your raw scores among the various sections. The percentile compares your score with that of other candidates.)

To get percentages for the sections with 50 questions, simply multiply your raw score by two. (Since each section has 50 questions, your percentage is twice your raw score.)

For section 2, divide your raw score by 45, and then move the decimal point two places to the right to arrive at a percentage.

Now that you know what percentage of the questions on each section you got right, you're ready to outline your study plan. The sections on which you got the lowest percentages are the ones you should plan on studying hardest. Sections on which you got higher percentages may not need as much of your time. However, unless you scored over 95% on a given section, you can't afford to skip studying that section altogether. After all, you want the highest score you can manage in the time left before the exam.

Use your percentage scores in conjunction with the Health Occupations Entrance Exam Planner in Chapter 1 of this book to help you devise a study plan. Then turn to the chapters that follow this one, which cover each of the areas tested on the health occupations entrance exam. These chapters contain valuable information on each section of the exam, along with study and test-taking tips and lots of practice questions, to help you score your best.

CHAPTER

4 Verbal Ability

CHAPTER SUMMARY

In order to be successful in the health profession of your choice, you have to be able to express ideas clearly and accurately. Because written expression is also an important part of your ability to communicate, your health occupations entrance exam will contain a spelling section. In a spelling test, you will not be required to spell out words, but rather, you will be asked to *identify* the correct spelling of a word from four choices.

THIS CHAPTER IS designed to help you refresh your spelling skills by teaching you the rules you need to know to spell your best. You'll learn strategies to help you spell words with tricky letter combinations, unusual plurals, prefixes, and hyphenated and compound words.

▶ What Spelling Questions Are Like

On the spelling part of the verbal ability section of your exam, your capacity to spell correctly and recognize properly and improperly spelled words will be tested. You may be given a set of differently spelled versions of the same word and asked to find the word that is spelled correctly. For example:

1. Select the correctly spelled word.
- **a.** peice
- **b.** piece
- **c.** peece
- **d.** peise

The correct answer is **b**, *piece*. Knowing the rules for when to use *ie* or *ei* could have helped you answer this question if you weren't sure of the answer. Read on to learn the rule.

Your exam might also present you with a set of different words and ask you to pick out the one word that is spelled incorrectly. For example:

2. Choose the misspelled word.
- **a.** destructive
- **b.** decisive
- **c.** distinguished
- **d.** There is no misspelled word.

If your spelling skills are sharp, you know that the correct answer is **d**; all three choices are spelled correctly. Other versions of this question type may ask to find the *correctly* spelled word from a group of misspelled words. When you are taking your exam, always be sure to read each question carefully.

▶ How to Prepare for Spelling Questions

Reading as much as you can, using your eyes to look at words carefully, visualizing the words, listening for the sounds of words, learning the most common prefixes, suffixes, and roots—these are all simple and effective ways to naturally improve your spelling skills. But if you want to ensure that you ace the spelling portion of your entrance exam, nothing beats learning the rules.

▶ Spelling Rules

Most of the spelling questions found on your health occupations entrance exam will test your knowledge of spelling rules, so getting a good grasp on these rules is essential. Following are the most common rules you'll likely be tested on.

IE and *EI*

If you've never heard the old rhyme, "*I* before *e* except after *c,* or when sounding like *a* as in *neighbor* or *weigh*," be sure to learn it now because it works. Another way to think about *ie* vs. *ei* is to remember that you use *ie* to make a long *e* sound and *ei* to make a long *a* sound. Words with the long *e* sound include: *wield, fierce*, and *cashier.* Words with the long *a* sound include: *eight, vein,* and *deign.*

3. Choose the correctly spelled word.
- **a.** yeild
- **b.** mischeivous
- **c.** achieve
- **d.** percieve

If you remember the rhyme and the rule above, it's easy to see the correct answer is **c**, *achieve*.

But beware! There are some words that are exceptions to this rule; be sure to memorize them:

friend	*piety*	*fiery*
quiet	*notoriety*	*society*
science	*ancient*	*deficient*
conscience	*either*	*seize*
weird	*sheik*	*seizure*
leisure	*height*	*sleight*
stein	*seismology*	*heifer*
their	*foreign*	*forfeit*
neither	*protein*	*Fahrenheit*
Codeine		

IA and *AI*

Use *ai* when the vowel combination makes the sound "uh," like the word *villain*. Use *ia* when each vowel is pronounced separately, like the word *median*.

4. Which of the following words is misspelled?
- **a.** guardain
- **b.** Britain
- **c.** controversial
- **d.** There is no misspelled word.

Choice **a** is spelled incorrectly. In the word *guardian*, the *i* and *a* are pronounced separately—*guard-I-An*. Therefore, *ia* is used.

Other Two-Vowel Combinations

Another grade-school rhyme will help you here: "When two vowels go walking, the first one does the talking." This holds true most of the time. Let's break down the rhyme to fully understand it. "When two vowels go walking" refers to a two-vowel combination in a word. For example, abst*ai*n, ch*ea*p, f*oe,* and r*ui*n. "The first one does the talking" is stating that in the two-vowel combinations, only the first vowel is pronounced, and the second one is silent. In the case of our examples, you hear the long *a* in *abstain,* but not the *i.* In *cheap,* you hear the long *e* but not the *a.* Similarly, in *foe,* you hear the long *o* but not the *e,* and in *ruin,* you hear the long *u* but not the *i.*

Here are some more examples of words that follow the two-vowels rule:

plead	*float*
woe	*repeat*
boat	*gear*
treat	*suit*
steal	*read*
chaise	*lead*
moat	*heat*

5. Choose the correctly spelled word.
- **a.** nuisance
- **b.** niusance
- **c.** nuicanse
- **d.** niucanse

The correct answer is **a**, *nuisance*. Say this word out loud. It sounds like *new-sance*, right? You hear the long *u*, but not the *i*, The first vowel is doing the talking here, so it must be *ui.*

When to Drop a Final *E*

Drop a final *e* before adding any ending that begins with a vowel, such as *-ed, -ing,* and *-able.* Keep a final *e* when adding endings that begin with consonants, such as *-ly* or *-ful.*

There are a few exceptions to this rule. You keep a final *e* when adding an ending that begins with a vowel if:

1. The *e* follows a soft *c* or *g.* This keeps the soft sound for those letters. (Remember: A soft *c* sounds like an *s*; a soft *g* sounds like a *j.*)
2. You need to protect pronunciation (show that a preceding vowel should be long, for example, as in *hoe* + *ing* = *hoeing* not *hoing*).

You will drop a final *e* when adding an ending that begins with a consonant if:

- The *e* follows a *u* or *w*.

6. Choose the misspelled word.
- **a.** changing
- **b.** peaceable
- **c.** truely
- **d.** There is no misspelled word.

The misspelled word is found in choice **c**, *truely.* The correct spelling is *truly.* This word is an example of an exception to the rule. Usually, when adding an ending that begins with a consonant (in this case, *-ly*), you keep the final *e,* unless it follows a *u* or *w.* In the word *true,* the letter *e* does indeed follow the letter *u,* so when adding *true* + *ly,* drop the final *e: truly.*

When to Keep a Final *Y* or Change it to *I*

When a final *y* follows a consonant, change the *y* to *i* when adding any ending, except *-ing.* When the final *y* follows a vowel, it does not change. This rule applies to **all** endings, even plurals.

Change the *y* to an *i*:

early—earlier
party—partied, partier, parties
sorry—sorrier
worry—worried, worrier, worries
fly—flier, flies
weary—wearied, wearies
pretty—prettier, prettiness
try—tried, tries

Remember to keep the *y* when adding *-ing:*

fly—flying
weary—wearying
try—trying
party—partying
worry—worrying

When the final *y* is preceded by a vowel, you do not change it to an *i.* For example:

enjoy—enjoyed, enjoying, enjoys
pray—prayed, praying, prays
employ—employed, employing, employs
delay—delayed, delaying, delays

7. Find the misspelled word.
a. holiness
b. queasyness
c. spying
d. There is no misspelled word.

The rule states that when a final *y* follows a consonant, you must change the *y* to *i* when adding any ending (except *-ing*). The final *y* in *queasy* is preceded by a consonant (letter *s*), so when the ending *-ness* is added, the *y* changes to *i*: *queasiness*. Therefore, choice **b** contains the spelling error.

Adding Endings to Words That End with a *C*

Add a *k* after a final *c* before any ending that begins with *e*, *i*, or *y*. All other endings do not require a *k*.

For example:

traffic + *-er* = trafficker
traffic + *-able* = trafficable

Other examples of when to add a *k* are:

panic—panicking, panicked, panicky
mimic—mimicking, mimicked, mimicker
picnic—picnicking, picnicked, picnicker

8. Choose the correctly spelled word.
a. trafficer
b. panicy
c. historical
d. havoced

Only choice **c**, *historical,* is spelled correctly. Remember, a *k* is required after a final *c* when an ending that begins with *e, i,* or *y* is added. So the other choices should be *trafficker*, *panicky*, and *havocked.*

One of the difficulties of spelling in English is the making of plurals. Unfortunately, you can't always simply add the letter *-s* to the end of the word to signal more than one.

When to Use *-S* or *-ES* to Form Plurals

There are two simple rules that govern most plurals.

1. Most nouns add *-s* to make plurals.
2. If a noun ends in a sibilant sound (*s, ss, z, ch, x, sh*), add *-es*.

The following are some examples of plurals:

cars
computers
books
skills
faxes
indexes
lunches
dishes
dresses
churches
guesses
buzzes

Exceptions

Remember from the last lesson that when a word ends in a *y* preceded by a consonant, the *y* changes to *i* when you add *-es.*

SINGULAR	PLURAL
fly	flies
rally	rallies

Plurals for Words That End in *O*

There is just one quick rule that governs a few words ending in *o.*

If a final *o* follows another vowel, it takes *-s.*

Here are some examples:

patios	*radios*
studios	*videos*

When the final *o* follows a consonant rather than a vowel, there is no rule to guide you in choosing *-s* or *-es.* You just have to learn the individual words.

The following words form a plural with *-s* alone:

albinos	*pianos*
altos	*silos*
banjos	*sopranos*
logs	*broncos*

The following words take *-es*

heroes	*tomatoes*
potatoes	*vetoes*

When in doubt about whether to add *-s* or *-es*, look it up in the dictionary.

Plurals That Don't Use *-S* or *-ES*

There are many words that don't simply use *-s* or *-es* to form plurals. These are usually words that still observe the rules of the languages from which they were adopted. Most of these plurals are part of your reading, speaking, and listening vocabularies. You can see that there are patterns that will help you. For instance, in Latin words, *-um* becomes *-a*, *-us* becomes *-i*, and in Greek words, *-sis* becomes *-ses.* A good way to remember these plurals is by saying the words aloud, because for the most part, they do not change form and you may remember them more easily if you listen to the sound of the spelling.

SINGULAR	PLURAL
child	children
deer	deer
goose	geese
man	men
mouse	mice
ox	oxen
woman	women
alumnus	alumni
curriculum	curricula
datum	data
fungus	fungi
medium	media
stratum	strata
analysis	analyses
axis	axes
basis	bases
oasis	oases
parenthesis	parentheses
thesis	theses

9. Chose the correctly spelled word.
- **a.** pianoes
- **b.** mosquitos
- **c.** deers
- **d.** spies

Only choice **d**, *spies*, is spelled correctly. The correct spelling of choices **a** and **b** is *pianos* and *mosquitoes*. These words belong to the group of plurals that has to be learned individually. The choice **c** is an exception. It belongs to the group of plurals that do not use *-s*/*-es* endings. The plural form of *deer* is *deer*.

▶ Homonyms

Homonyms are words that sound the same but are spelled differently. Many of these words have just one change in the vowel or vowel combination. There's no rule about these words so you'll simply have to memorize them. Here are some examples of word pairs that can be troublesome. Sometimes, it helps to learn each word in terms of the job it will do in a sentence. Often, the two words in a homophone pair are a different part of speech. Take a look at the following examples:

affect/effect	*led/lead*
altar/alter	*minor/miner*
bare/bear	*passed/past*
bloc/block	*peal/peel*
cite/site	*piece/peace*
cord/chord	*sheer/shear*
coarse/course	*stationery/stationary*
descent/dissent	*weak/week*
dual/duel	*which/witch*
heal/heel	*write/right*

Since the meanings of these homonyms are different, context is probably the best way to differentiate between these words.

Examples in Context

He led a **dual** (*adjective*) life as a spy.
He fought a **duel** (*noun*) with his great enemy.

He had to **alter** (*verb*) his clothes after he lost weight.
The bride smiled as she walked toward the **altar** (*noun*).

▶ Prefixes

Generally, when you add a prefix to a root word, neither the root nor the prefix changes spelling:

un- + prepared = unprepared
mal- + nutrition = malnutrition
sub- + traction = subtraction
mis- + informed = misinformed

This rule applies even when the root word begins with the same letter as the prefix. Generally, you use both consonants, but let your eye be your guide. If it looks funny, it's probably not spelled correctly. The following are some examples:

dissatisfied	*irreverent*
disservice	*misspelled*
illegible	*misstep*
irrational	*unnatural*

10. Choose the correctly spelled word.
- **a.** ilogical
- **b.** illogicall
- **c.** illogicle
- **d.** illogical

Only choice **d**, *illogical* is spelled correctly. Remember when you add a prefix to a root word (*il-* + logical), neither the root nor the prefix changes spelling, even when the root word begins with the same letter as the prefix.

Practice Questions

Here are some practice spelling questions. Answers follow.

Choose the correctly spelled word in questions 11–15.

11. **a.** magically
b. magickelly
c. majicelly
d. magicaly

12. **a.** beleif
b. bilief
c. belief
d. beleaf

13. **a.** nieghbor
b. neihbor
c. niehbor
d. neighbor

14. **a.** eficient
b. eficeint
c. efficient
d. efficeint

15. **a.** collaborate
b. colaborate
c. collaborat
d. colabarate

Find the misspelled word in questions 16–20.

16. **a.** women
b. people
c. babys
d. There is no misspelled word.

17. **a.** radios
b. leaves
c. alumni
d. There is no misspelled word.

18. **a.** anouncement
b. advisement
c. description
d. There is no misspelled word.

19. **a.** omission
b. aisle
c. litrature
d. There is no misspelled word.

20. **a.** oases
b. tomatoes
c. heroes
d. gooses

Answers to Practice Questions

11. **a.** magically
12. **c.** belief
13. **d.** neighbor
14. **c.** efficient
15. **a.** collaborate
16. **c.** babies
17. **d.** There is no misspelled word.
18. **a.** announcement
19. **c.** literature
20. **d.** geese

▶ Tips for Answering Verbal Ability Questions

- **Practice** using the sample questions in this chapter.
- **Read widely** to improve your general vocabulary and spelling.
- **Say the words** silently to yourself.
- **Dissect the words** to find their roots, prefixes, and suffixes.
- **Learn the rules** of spelling and memorize words that are exceptions.

▶ Additional Resources

If you'd like to improve your verbal ability, your best resource is your public or college library. Any challenging reading will improve your vocabulary and spelling, but here are some LearningExpress books specifically about building those skills.

- *Vocabulary and Spelling Success, 3rd Edition*
- *1001 Vocabulary and Spelling Questions*
- *Goof-Proof Spelling*
- *501 Synonym and Antonym Questions*

CHAPTER

5 Reading Comprehension

CHAPTER SUMMARY

Because reading is such a vital skill, many health occupations entrance exams include a reading comprehension section that tests your ability to understand what you read. The tips and exercises in this chapter will help you improve your comprehension of written passages so that you can increase your score in this area.

As a health services professional, you will do a lot of reading—memos, policies, and manuals, as well as medical and technical reports, charts, and procedures. Understanding written material is a key part of the job. Reading comprehension is also an essential skill for students of health education programs—most likely, you will need to read and understand scientific and medical textbooks as part of the training for your career. As a result, health occupations entrance exams attempt to measure how well applicants understand what they read.

The reading comprehension section of your test will look much like reading comprehension segments you have encountered before on other standardized tests. You read a passage from one to five paragraphs long, usually scientific in nature, and then answer one or more questions based on what you have read. You do not need to have any prior or specific knowledge to answer the questions—you need only the information presented in the passage. You *will* be asked to interpret passages, identify the author's purpose, look at how ideas are organized and presented, and draw conclusions based on the information in the passage.

▶ Types of Reading Comprehension Questions

As a test taker, you have two advantages when answering multiple-choice questions about reading passages:

1. You don't have to know anything about the topic of the passage.
2. You're being tested only on the information the passage provides.

The disadvantage is that you have to know where and how to find that information quickly in an unfamiliar text. This makes it easy to fall for one of the wrong answer choices, especially since they are designed to mislead you.

The best way to do well on this passage/question format is to be very familiar with the kinds of questions that are typically asked on the test. Questions most frequently ask you to:

- Identify a specific **fact or detail** in the passage.
- Note the **main idea** of the passage.
- Make an **inference** based on the passage.
- Define a **vocabulary** word from the passage.

Facts and details are the specific pieces of information that support the passage's **main idea**. The main idea is the thought, opinion, or attitude that governs the whole passage. Generally speaking, facts and details are indisputable—things that don't need to be proven, like statistics (18 million people) or descriptions (a green overcoat). Let's say, for example, you read a sentence that says *"After the department's reorganization, workers were 50% more productive."* A sentence like this, which gives you the **fact** that 50% of workers were more productive, might support a **main idea** that says, *"Every department should be reorganized."* Notice that this main idea is not something indisputable; it is an opinion. The writer thinks all departments should be reorganized, and because this is his opinion (and not everyone shares it), he needs to support his opinion with facts and details.

An **inference**, on the other hand, is a conclusion that can be drawn based on facts or evidence. For example, you can infer—based on the fact that workers became 50% more productive after the reorganization, which is a dramatic change—that the department had not been efficiently organized. The fact sentence, "After the department's reorganization, workers were 50% more productive," also implies that the reorganization of the department was the reason workers became more productive. There may, of course, have been other reasons, but we can infer only one from this sentence.

As you might expect, **vocabulary** questions ask you to determine the meaning of particular words. Often, if you have read carefully, you can determine the meaning of such words from their context, that is, how the word is used in the sentence or paragraph.

Because most of the texts you will read as a health occupations student and professional are scientific in nature, you are most likely to find fact or detail and vocabulary questions on your entrance exam. However, because all four types of questions are important to reading comprehension (because not all scientific texts are objective fact, and because analysis and interpretation are important parts of the scientific process), you will find main idea and inference questions on the tests as well.

The following is a sample test passage, followed by four questions. Read the passage carefully, and then answer the questions, based on your reading of the text, by circling your choice. Note under your answer which type of question has been asked (fact or detail, main idea, inference, or vocabulary). Correct answers appear immediately after the questions.

Practice Passage 1: Using the Four Question Types

The immune system, which protects the body from infections, diseases, and other injuries, is composed of the lymphatic system and the skin. Lymph nodes, which measure about 1 to 25 centimeters across, and small vessels called lymphatics compose the lymphatic system. The nodes are located in the groin, armpits, throat, and trunk, and are connected by the lymphatics. The nodes work with the body's immune system to fight off infectious agents like bacteria and fungus. When infected, the lymph nodes are often swollen and sensitive. The skin, the largest organ of the human body, is also considered part of the immune system. Hundreds of small nerves in the skin send messages to the brain to communicate pressure, pain, and other sensations. The skin encloses the organs to prevent injuries and forms a protective barrier that repels dirt and water and stops the entry of most harmful chemicals. Sweat glands in the skin help regulate the body's temperature, and other glands release oils that can kill or impede the growth of certain bacteria. Hair follicles in the skin also provide protection, especially of the skull and groin.

1. Lymph nodes are connected by
- **a.** blood vessels.
- **b.** smaller nodes.
- **c.** nerves.
- **d.** small vessels.

Question type: _____

2. According to the passage, pain in the lymph nodes most likely indicates that the
- **a.** skin is dirty or saturated with water.
- **b.** nodes are battling an infection.
- **c.** brain is not responding properly to infection.
- **d.** lymphatics are not properly connected to the nodes.

Question type: _____

3. Which of the following best expresses the main idea of the passage?
- **a.** The immune system is very sensitive and registers minute sensations.
- **b.** The skin and its glands are responsible for preventing most infections.
- **c.** The lymphatic system and the skin work together to protect the body from infection.
- **d.** Communication between the lymphatic system and the brain is essential in preventing and fighting infection.

Question type: _____

4. As it is used in this passage, the word *compose* most nearly means
- **a.** create, construct.
- **b.** arrange, put in order.
- **c.** control, pull together.
- **d.** form, constitute.

Question type: _____

Answers and Explanations for Practice Passage 1

Don't just look at the right answers and move on. The explanations are the most important part, so read them carefully. Use these explanations to help you understand how to tackle each kind of question the next time you come across it.

1. d. Question type: fact or detail. The third sentence of the passage says that the nodes *are connected by the lymphatics*, which are defined in the second sentence as *small vessels.* You may know that nerves and blood vessels make a web of connections in our bodies, but the passage specifically states that lymphatics—*small* vessels, not *blood* vessels—connect the nodes.

2. b. Question type: inference. The passage says that when lymph nodes are infected, they are *often swollen and sensitive.* Thus, if nodes are

painful, they are probably swollen and sensitive, and they are swollen and sensitive because they are fighting an infection. This is also the best answer because none of the other answers are clearly connected to pain in the lymph nodes. Dirty or saturated skin (choice **a**) may indeed result in infection, but that is not what the question is asking. Answers **c** and **d** describe malfunctions of the immune system, a subject that is not discussed in the passage.

3. c. Question type: main idea. The idea that the lymphatic system and the skin work together to protect the body from infection is the only answer that can serve as a "net" for the whole passage. The other three answers are limited to specific aspects of the immune system and therefore are too restrictive to be the main idea. For example, answer **b** refers only to the skin, so it does not encompass all of the ideas in the passage.

4. d. Question type: vocabulary. Although all of the answers can mean *compose* in certain circumstances, answer **d** is the only meaning that really works in the context of the passage, which says that the lymph nodes and the lymphatics "*compose* the lymphatic system." The passage makes it clear that the lymph nodes and the lymphatics are the two parts of the lymphatic system. Thus, they *form* or *constitute* the lymphatic system. They don't create it, arrange it, or control it; they are it.

▶ Detail and Main Idea Questions

Detail or fact questions and main idea questions both ask you for information that is right there in the passage. All you have to do is find it.

Detail or Fact Questions

In detail or fact questions, you have to identify a specific item of information from the text. This is usually the simplest kind of question. You just have to be able to separate important information from less important information. However, the choices may often be very similar, so you must be careful not to get confused.

Be sure you read the passage and questions carefully. In fact, it is usually a good idea to read the questions first, *before* you even read the passage, so you will know what details to look out for.

Main Idea Questions

The main idea of a passage, like that of a paragraph or a book, is what it is *mostly* about. The main idea is like an umbrella that covers all of the ideas and details in the passage, so it is usually something general, not specific. For example, in Practice Passage 1, question 3 asked about the main idea, and the correct answer was the choice that said that the skin and the lymphatic system work together to prevent infection. This is the best answer because it is the only one that includes both the skin and the lymphatic system, both of which are discussed in the passage.

Sometimes, the main idea is stated clearly, often in the first or last sentence of the passage. The main idea is expressed in the first sentence of Practice Passage 1, for example. The sentence that expresses the main idea is often referred to as the **topic sentence**.

At other times, the main idea is not stated in a topic sentence but is *implied* in the overall passage, and you will need to determine the main idea by inference. Because there may be much information in the passage, the trick is to understand what all that information adds up to—the gist of what the author wants you to know. Often, some of the wrong answers on main idea questions are specific facts or details from the passage. A good way to test yourself is to ask, "Can this answer serve as a *net* to hold the whole passage together?" If not, chances are you have chosen a fact or detail, not a main idea.

Practice answering main idea and detail questions by working on the questions that follow this passage. Circle the answers to the questions, and then check your answers against the key that appears immediately after the questions.

Practice Passage 2: Detail and Main Idea Questions

Because the body responds differently to different allergens, allergic reactions have been divided into four categories. Type I allergies, the most common, are characterized by the production of immunoglobulin E (IgE), a type of antibody the immune system releases when it thinks a substance is a threat to the body. IgE releases chemicals called mediators, like histamine, which cause blood vessels to dilate and release fluid into the surrounding tissues, usually resulting in a runny nose and sneezing. Type I allergies include allergic asthma and hay fever as well as reactions to insect stings and dust. Type II allergies, far more rare, are usually reactions to medications and can cause liver and kidney damage or anemia. The body sends immunoglobulin M (IgM) and immunoglobulin G (IgG) to the site to fight the infection. Type III allergies are usually caused by reactions to drugs like penicillin. The body releases IgM and IgG, but these allergens cause IgM and IgG to bind away from cell surfaces. This creates clumps of allergens and antibodies that get caught in the tissues and cause swelling, which can affect the kidneys, joints, and skin. Type IV allergies cause the release of mediators that create swelling as well as itchy rashes. These are usually skin reactions to irritants like poison ivy, soaps, cosmetics, and other contact allergens.

1. Which type(s) of allergic reactions result in swelling?
- **a.** Types I and III
- **b.** Types III and IV
- **c.** Type III only
- **d.** Types II and IV

2. IgE, IgG, and IgM can be classified as
- **a.** allergens.
- **b.** mediators.
- **c.** antibodies.
- **d.** medications.

3. Which of the following would be the best title for this passage?
- **a.** "Preventing Allergic Reactions"
- **b.** "Determining the Causes of Allergies"
- **c.** "Allergens and the Human Body"
- **d.** "Four Types of Allergic Reactions"

4. Which of the following best expresses the main idea of the passage?
- **a.** Allergies cause different responses in the body.
- **b.** People should avoid things that may cause allergic reactions.
- **c.** Type I allergies affect the most people.
- **d.** Mediators play an important role in allergic reactions.

Answers and Explanations for Practice Passage 2

1. b. The passage says that both Type III and Type IV allergic reactions cause swelling. In Type III allergies, IgM and IgG *bind away from cell surfaces. This creates clumps of allergens and antibodies that . . . cause swelling.* Type IV allergies also *cause the release of mediators that create swelling as well as itchy rashes.*

2. c. The passage says that immunoglobulin E (IgE) is *a type of antibody the immune system releases.* The Ig in IgE, IgG, and IgM stands for

immunoglobulin; all three are different types of immunoglobulin and therefore different types of antibodies. The immunoglobulins then release the mediators, like histamine, so choice **b** is incorrect. Further, immunoglobulins are produced in response to allergens, so choice **a** cannot be correct. And the passage clearly indicates that immunoglobulins are produced by the body, so choice **d** is also incorrect.

3. d. Titles generally reflect the main idea of a passage and must therefore be general enough to cover everything in that passage. The passage does not discuss how to prevent allergic reactions, so choice **a** is not a good answer. The passage does discuss what causes allergic reactions, but that is only part of what the passage covers, and it does not discuss how to determine the specific causes of a reaction, so choice **b** is incorrect. Choice **c** is not right because the passage does not focus on allergens; in fact, specific allergens aren't even mentioned for Type II allergies. Finally, it is clear that choice **d** is the best answer because the first sentence in the passage is a topic sentence: *Because the body responds differently to different allergens, allergic reactions have been divided into four categories.* This indicates that the passage is about the four types of allergic reactions and not about allergens.

4. a. This choice best expresses the main idea of the passage because it restates the topic sentence, which tells us the body *responds differently* to different allergens. Choice **b** is not a good answer because the passage does not discuss ways to avoid allergic reactions, and although choices **c** and **d** are mentioned in the passage, they are too specific to encompass the whole passage. Remember, the main idea should be general enough to include all of the ideas in the passage.

▶ Inference and Vocabulary Questions

Questions that ask you about the meaning of vocabulary words in the passage and those that ask what the passage *suggests* or *implies* (inference questions) are different from detail or main idea questions. In vocabulary and inference questions, you usually have to pull ideas from the passage, sometimes from more than one place in the passage.

Inference Questions

Inference questions can be the most difficult to answer because they require you to draw meaning from the text when that meaning is implied rather than directly stated. Inferences are conclusions that we draw based on the clues the writer has given us. When you draw inferences, you have to be something of a detective, looking for clues such as word choice, tone, and specific details that suggest a certain conclusion, attitude, or point of view. You have to read between the lines in order to make a judgment about what an author was implying in the passage.

A good way to test whether you have drawn an acceptable inference is to ask, "What evidence do I have for this inference?" If you can't find any, you probably have the wrong answer. You need to be sure that your inference is logical and that it is based on something that is suggested or implied in the passage itself—not by what you or others might think. Like a good detective, you need to base your conclusions on evidence—facts, details, and other information—not on random hunches or guesses.

Vocabulary Questions

There are generally two types of vocabulary questions. The first tests to see how carefully you have read a passage that may contain a number of new or technical terms and definitions. If you see that a passage has a number of unfamiliar terms, mark each term as it is

defined. This will make it easier for you to go back and find the right answer.

The second type of vocabulary question is designed to measure how well you can figure out the meaning of a word from its context. *Context* refers to how the word is used in the sentence—how it works with the words and ideas that surround it. If the context is clear enough, you should be able to substitute a nonsense word for the one being sought, and you would still make the right choice because you could determine meaning strictly from the sense of the sentence. For example, you should be able to determine the meaning of the following italicized nonsense word based on its context:

The speaker noted that it gave him great *terivinix* to announce the winner of the Outstanding Leadership Award.

In this sentence, *terivinix* most likely means

a. pain.
b. sympathy.
c. pleasure.
d. anxiety.

Clearly, the context of an award makes **c,** *pleasure,* the best choice. Awards don't usually bring pain, sympathy, or anxiety.

When confronted with an unfamiliar word, try substituting a nonsense word and see if the context gives you the clue. If you are familiar with prefixes, suffixes, and word roots, you can also use this knowledge to help you determine the meaning of an unfamiliar word.

More often, however, you will be asked about how familiar words or phrases are used in context. These questions can be very tricky because words often have more than one acceptable meaning. Your job is to figure out which meaning makes the most sense in the context of the sentence. For example, the word *manipulate* can mean either (**a**) *to handle* or *manage skillfully* or (**b**) *to arrange* or *influence cleverly or craftily.* The meaning of this word depends entirely upon the context in which it is used, as you can see from the following sentences.

a. The patient *manipulated* the wheelchair around the obstacles.
b. The media's *manipulation* of the facts has a powerful effect on politics.

Sentence **a** uses the first definition of the word, while sentence **b** uses the second.

When confronted with this type of question, your best bet is to take each possible answer and substitute it for the word in question in the sentence. Whichever answer makes the most sense in the context of the sentence should be the correct answer.

The questions that follow this passage are strictly vocabulary and inference questions. Circle the answers to the questions, and then check your answers against the key that appears immediately after the questions.

Practice Passage 3: Inference and Vocabulary Questions

The rise of science in the seventeenth century ushered in the modern world. Four men are primarily responsible for the discoveries that form the foundation of scientific and philosophical thought today: Copernicus, Kepler, Galileo, and Newton. Copernicus overthrew the geocentric notion of the universe which held that the earth—and therefore humanity—was at the center of the universe and showed that the planets revolve around the Sun. Kepler, the first major astronomer to adopt Copernicus's heliocentric theory, discovered three laws of planetary motion that helped validate Copernicus's theory. Galileo revealed the role of acceleration in dynamics and established the law of falling bodies. Finally, Newton's studies of motion—made possible only by the work of the three scientists before him—led to his laws of motion and the universal

law of gravitation: "Everybody attracts every other body with a force directly proportional to the product of their masses and inversely proportional to the square of the distance between them." It is these theories upon which much of modern science is based.

1. As it is used in the passage, the word "adopt" most nearly means to
   a. take and use as one's own.
   b. approve or accept.
   c. make suitable for a new situation.
   d. take guardianship for.

2. From the passage, which of the following can be inferred about Copernicus's heliocentric theory?
   a. It supported the religious doctrine of the time.
   b. It was accepted only because of Kepler.
   c. It went against established ideas.
   d. It revealed the laws of planetary motion.

3. Information contained in the passage supports which of the following statements about the four scientists?
   a. Their scientific discoveries contributed to the philosophical and social turmoil of the seventeenth century.
   b. Of the four, Newton's theories have been most instrumental in modern science.
   c. Their primary goal was to refute the theory that the Earth was the center of the universe.
   d. They recognized that their achievements were based on the achievements of those before them.

4. As it is used in the passage, the word *established* most nearly means
   a. instituted or ordained by law or agreement.
   b. set up permanently, brought into existence.
   c. settled in a place or position.
   d. introduced and secured acceptance of.

Answers and Explanations for Practice Passage 3

1. b. Look at how *adopt* is used in the sentence: *Kepler, the first major astronomer to* adopt *Copernicus's heliocentric theory, discovered three laws of planetary motion that helped validate Copernicus's theory.* Because Kepler helped validate this theory, choice **a** can't be correct, and neither can choice **d**; the passage clearly indicates that it's Copernicus's theory, not Kepler's. Furthermore, there's no indication from the context that Kepler changed the theory to make it suitable for another situation, so choice **c** cannot be correct either.

2. c. We can infer that Copernicus's theory went against established ideas because the passage says that Copernicus *overthrew* the notion that humanity was at the center of the universe, suggesting that the geocentric theory was the accepted theory of the time and that Copernicus's idea was revolutionary. There is no suggestion in the passage that Copernicus's theory supported the religious doctrine of the time, so choice **a** cannot be correct. Furthermore, the passage says that Kepler's discovery *helped* validate Copernicus's theory, but this does not imply that it was accepted only because of Kepler (choice **b**). Finally, the laws of planetary motion were discovered by Kepler, not Copernicus, so choice **d** cannot be correct.

3. a. The passage discusses scientific discoveries that challenged and changed the way human beings saw themselves in the universe and how the motion of bodies on Earth and in the universe was understood. We can thus infer that these discoveries greatly altered ideas in both philosophy and, of course, in science. Again, the word *overthrew* suggests upheaval, so choice **a** is the best answer. Choice **b** cannot be correct because the passage does not favor one scientist over the others; in fact, the passage tells us that Newton could not have done

his work without those who came before him. Furthermore, although these men did refute the theory that the Earth was the center of the universe, there's no indication in this passage that that was what the men were out to prove, as in choice **c**. Finally, while the *writer* of the passage recognizes that the achievements of these men were based only on the achievements of the others before them, there is no indication here of what the men themselves thought, so choice **d** cannot be correct.

4. d. If you insert the possible answers into the sentence, it should be clear that choice **d** makes the most sense in the context of the sentence. Galileo *"established* the law of falling bodies"—a law of gravity and motion in the universe—so he could not have instituted these laws by law or agreement (choice **a**), set them up or brought them into existence (choice **b**), or settled them in a place or position (choice **c**). Instead, he introduced them and secured acceptance of them by revealing the role of acceleration in dynamics (choice **d**).

If English Is Not Your First Language

When non-native speakers of English have trouble with reading comprehension tests, it's often because they lack the cultural, linguistic, and historical frame of reference that native speakers enjoy. People who have not lived in or been educated in the United States often don't have the background information that comes from reading American newspapers, magazines, and textbooks.

A second problem for non-native English speakers is difficulty in recognizing vocabulary and idioms (expressions like "chewing the fat") that assist comprehension. In order to read with good understanding, it's important to have an immediate grasp of as many words as possible in the text. Test takers need to be able to recognize vocabulary and idioms immediately so that the ideas those words express are clear.

The Long View

Read newspapers, magazines, and other periodicals that deal with current events and matters of local, state, and national importance. Pay special attention to articles related to the career you want to pursue.

Be alert to new or unfamiliar vocabulary or terms that occur frequently in the popular press. Use a highlighter pen to mark new or unfamiliar words as you read. Keep a list of those words and their definitions. Review them for 15 minutes each day. Though at first, you may find yourself looking up a lot of words, don't be frustrated—you will look up fewer and fewer as your vocabulary expands.

During the Test

When you are taking the test, make a picture in your mind of the situation being described in the passage. Ask yourself, "What did the writer mostly want me to think about this subject?"

Locate and underline the topic sentence that carries the main idea of the passage. Remember that the topic sentence—if there is one—may not always be the first sentence. If there doesn't seem to be one, try to determine what idea summarizes the whole passage.

▶ Review: Putting It All Together

A good way to solidify what you have learned about reading comprehension questions is for *you* to write the questions. Here is a passage, followed by space for you to write your own questions. Write one question of each of the four types: fact or detail, main idea, inference, and vocabulary.

In the years since it was first proposed, the free radical theory of aging has gained wide acceptance. But hypotheses that attempt to explain exactly how free radicals are involved in the aging process are troubled by the lack of a clear definition of aging. Is aging a programmed stage of cellular differentiation, or is it the result of physiological processes impaired by free radical or other damage to cells? Despite the want of a clear definition, few question that free radical damage to cell nucleic acids and lipids are an important factor in aging. A recent study shows that oxygen free radicals cause approximately 10,000 DNA base modifications per cell per day. Perhaps the accumulation of unrepaired damage of this type accounts for the deterioration of physiological function. A new theory, however, indicates that free radicals also damage cell proteins and that the accumulation of oxidized protein is an important factor in aging.

1. Detail question: _____

_____

a.
b.
c.
d.

2. Main idea question: _____

_____

a.
b.
c.
d.

3. Inference question: _____

_____

a.
b.
c.
d.

4. Vocabulary question: _____

_____

a.
b.
c.
d.

Possible Questions

Here is one question of each type based on the passage above. Your questions may be very different, but these will give you an idea of the kinds of questions that could be asked.

1. Detail: DNA modification can occur
- **a.** 10,000 times in the life of a cell.
- **b.** 1,000 times every second.
- **c.** thousands of times a day.
- **d.** once a day.

2. Main idea: Which sentence best sums up this passage?
- **a.** There are many theories, but no one knows how free radicals really affect aging.
- **b.** Free radicals are deadly.
- **c.** Scientists need a clearer definition of aging.
- **d.** Free radicals will lead scientists to the fountain of youth.

3. Inference: The passage suggests which of the following about the aging process?
   a. A clear definition of aging must be found in order to determine the cause of aging.
   b. DNA controls the aging process.
   c. Free radical damage to proteins increases with aging.
   d. Aging is somehow related to free radical damage to cells.

4. Vocabulary: The phrase *want of* as used in the fourth sentence most nearly means
   a. desire for.
   b. lack of.
   c. requirement of.
   d. falling short of.

Answers

1. c.
2. a.
3. d.
4. b.

▶ Additional Resources

Here are some other ways you can build the vocabulary and knowledge that will help you do well on reading comprehension questions.

- Practice asking the four sample question types about passages you read for information or pleasure.
- Using a computer search engine such as Google or Yahoo!, search out articles and forums related to the career you would like to pursue. Exchange views with others on the Internet. All of these exchanges will help expand your knowledge of job-related material that may appear in a passage on the test.
- Begin now to build a broad knowledge of your potential profession. Get in the habit of reading articles in newspapers and magazines on job-related issues. Keep a clipping file of those articles. This will help keep you informed of trends in the profession and familiarize you with pertinent vocabulary.
- Consider reading or subscribing to professional journals. They are usually available for a reasonable annual fee. They may also be available in your library.
- If you need more help building your reading skills and taking reading comprehension tests, consider *Reading Comprehension Success,* 3rd edition, published by LearningExpress.

CHAPTER

6 Math Review

CHAPTER SUMMARY

This chapter gives you important tips for dealing with math questions on your health occupations entrance exam and reviews some of the most commonly tested concepts. If you have forgotten most of your high school math or have math anxiety, this chapter is for you.

THE MATH SECTION of health occupations entrance exams covers concepts that you probably studied in high school, with an emphasis on arithmetic, algebra, and geometry, often using word problems. Health professionals need to be comfortable with numbers and be able to compute sums quickly. Both your ability to learn the scientific concepts that form the foundation of your work as well as your on-the-job performance will depend on your ability to reason logically using numbers.

For an entrance exam to the educational program of your choice, you need to know how to work not only with whole numbers, but also with fractions and decimals. You will have to be able to figure percentages, solve algebraic equations, and work with geometric figures. The tests assume that you know some basic terminology—words such as sum and perimeter—and some basic formulas, such as the area of a square or circle. Some admissions tests have a separate analytical reasoning section that measures your ability to recognize relationships between shapes or objects through visualization. This chapter will also prepare you for these types of questions.

Before you review those concepts, however, take a look at some strategies you can use to help you answer multiple-choice math questions.

▶ Math Strategies

- **Don't work in your head! Use your test book or scratch paper to take notes, draw pictures, and calculate.** Although you might think that you can solve math questions more quickly in your head, that's a good way to make mistakes. Write out each step.
- **Read a math question in *chunks* rather than straight through from beginning to end.** As you read each chunk, stop to think about what it means and make notes or draw a picture to represent that chunk.
- **When you get to the actual question, circle it.** This will keep you more focused as you solve the problem.
- **Glance at the answer choices for clues.** If they're fractions, you probably should do your work in fractions; if they're decimals, you should probably work in decimals; etc.
- **Make a plan of attack to help you solve the problem.**
- **If a question stumps you, try one of the backdoor approaches explained in the next section.** These are particularly useful for solving word problems.
- **When you get your answer, reread the circled question to make sure you've answered it.** This helps avoid the careless mistake of answering the wrong question.
- **Check your work after you get an answer.** Test takers get a false sense of security when they get an answer that matches one of the multiple-choice answers. Here are some good ways to check your work *if you have time*:
  - Ask yourself if your answer is reasonable, if it makes sense.
  - Plug your answer back into the problem to make sure the problem holds together.
  - Do the question a second time, but use a different method.
- **Approximate when appropriate.** For example:
  - $5.98 + $8.97 is a little less than $15. (Add: $6 + $9)
  - $.9876 \times 5.0342$ is close to 5. (Multiply: 1×5)
- **Skip hard questions and come back to them later.** Mark them in your test book so you can find them quickly.

Backdoor Approaches for Answering Questions That Puzzle You

Remember those word problems you dreaded in high school? Many of them are actually easier to solve by backdoor approaches. The two techniques that follow are terrific ways to solve multiple-choice word problems that you don't know how to solve with a straightforward approach. The first technique, *nice numbers*, is useful when there are unknowns (like x) in the text of the word problem, making the problem too abstract for you. The second technique, *working backward*, presents a quick way to substitute numeric answer choices back into the problem to see which one works.

Nice Numbers

1. When a question contains unknowns, like x, plug nice numbers in for the unknowns. A nice number is easy to calculate with and makes sense in the problem.
2. Read the question with the nice numbers in place. Then solve it.
3. If the answer choices are all numbers, the choice that matches your answer is the right one.
4. If the answer choices contain unknowns, substitute the same nice numbers into **all** the answer choices. The choice that matches your answer is the right one. If more than one answer matches, do the problem again with different nice numbers. You'll only have to check the answer choices that have already matched.

Example:

Judi went shopping with p dollars in her pocket. If the price of shirts was s shirts for d dollars, what is the maximum number of shirts Judi could buy with the money in her pocket?

a. psd

b. $\frac{ps}{d}$

c. $\frac{pd}{s}$

d. $\frac{ds}{p}$

To solve this problem, let's try these nice numbers: $p = \$100$, $s = 2$; $d = \$25$. Now reread it with the numbers in place:

Judi went shopping with **$100** in her pocket. If the price of shirts was **2** shirts for **$25**, what is the maximum number of shirts Judi could buy with the money in her pocket?

Since 2 shirts cost $25, that means that 4 shirts cost $50, and 8 shirts cost $100. So our answer is 8. Let's substitute the nice numbers into all four answers:

a. $100 \times 2 \times 25 = 5{,}000$

b. $\frac{100 \times 2}{25} = 8$

c. $\frac{100 \times 25}{2} = 1{,}250$

d. $\frac{25 \times 2}{100} = \frac{1}{2}$

The answer is **b** because it is the only one that matches our answer of **8**.

Working Backward

You can frequently solve a word problem by plugging the answer choices back into the text of the problem to see which one fits all the facts stated in the problem. The process is faster than you think because you'll probably only have to substitute one or two answers to find the right one.

This approach works only when:

- All of the answer choices are numbers.
- You're asked to find a simple number, not a sum, product, difference, or ratio.

Here's what to do:

1. Look at all the answer choices and begin with the one in the middle of the range. For example, if the answers are 14, 8, 2, 20, and 25, begin by plugging 14 into the problem.
2. If your choice doesn't work, eliminate it. Determine if you need a bigger or smaller answer.
3. Plug in one of the remaining choices.
4. If none of the answers works, you may have made a careless error. Begin again or look for your mistake.

Example:

Juan ate $\frac{1}{3}$ of the jelly beans. Maria then ate $\frac{3}{4}$ of the remaining jelly beans, which left 10 jelly beans. How many jelly beans were there to begin with?

a. 60

b. 80

c. 90

d. 120

Starting with the middle answer, let's assume there were 90 jelly beans to begin with:

Since Juan ate $\frac{1}{3}$ of them, that means he ate 30 ($\frac{1}{3} \times 90 = 30$), leaving 60 of them ($90 - 30 = 60$). Maria then ate $\frac{3}{4}$ of the 60 jelly beans, or 45 of them ($\frac{3}{4} \times 60 = 45$). That leaves 15 jelly beans ($60 - 45 = 15$).

Glossary of Terms

Denominator	the bottom number in a fraction. *Example*: 2 is the denominator in $\frac{1}{2}$.
Difference	subtract. The difference of two numbers means subtract one number from the other.
Divisible by	a number is divisible by a second number if that second number divides evenly into the original number. *Example*: 10 is divisible by 5 ($10 \div 5 = 2$, with no remainder). However, 10 is not divisible by 3. (See *multiple of*)
Even Integer	integers that are divisible by 2, like . . . –4, –2, 0, 2, 4, . . . (See *integer*)
Integer	numbers along the number line, like . . . –3, –2, –1, 0, 1, 2, 3, . . . Integers include the whole numbers and their opposites. (See *whole number*)
Multiple of	a number is a multiple of a second number if that second number can be multiplied by an integer to get the original number. *Example*: 10 is a multiple of 5 ($10 = 5 \times 2$); however, 10 is not a multiple of 3. (See *divisible by*)
Negative Number	a number that is less than zero, like . . . –1, –18.6, $-\frac{3}{4}$, . . .
Numerator	the top part of a fraction. *Example*: 1 is the numerator of $\frac{1}{2}$.
Odd Integer	integers that aren't divisible by 2, like . . . –5, –3, –1, 1, 3, . . .
Positive Number	a number that is greater than zero, like . . . 2, 42, $\frac{1}{2}$, 4.63, . . .
Prime Number	an integer that is divisible only by 1 and itself, like . . . 2, 3, 5, 7, 11, . . .
Product	multiply. The product of two numbers means the numbers are multiplied together.
Quotient	the answer you get when you divide. *Example*: 10 divided by 5 is 2; the quotient is 2.
Real Number	all the numbers you can think of, like . . . 17, –5, $\frac{1}{2}$, –23.6, 3.4329, 0, . . . Real numbers include the integers, fractions, and decimals. (See *integer*)
Remainder	the number left over after division. *Example*: 11 divided by 2 is 5, with a remainder of 1.
Sum	add. The sum of two numbers means the numbers are added together.
Whole Number	numbers you can count on your fingers, like . . . 1, 2, 3, . . . All whole numbers are positive.

The problem states that there were **10** jelly beans left, and we wound up with **15** of them. That indicates that we started with too big a number. Thus, 90, 120, and 140 are all wrong! With only two choices left, let's use common sense to decide which one to try. The next lower answer is only a little smaller than 90 and may not be small enough. So, let's try 60:

Since Juan ate $\frac{1}{3}$ of them, that means he ate 20 ($\frac{1}{3} \times 60 = 20$), leaving 40 of them ($60 - 20 = 40$). Maria then ate $\frac{3}{4}$ of the 40 jelly beans, or 30 of them ($\frac{3}{4} \times 40 = 30$). That leaves 10 jelly beans ($40 - 30 = 10$).

Because this result of 10 jelly beans left agrees with the problem, the right answer is **a**.

▶ Word Problems

Many of the math problems on tests are word problems. A word problem can include any kind of math, including simple arithmetic, fractions, decimals, percentages, even algebra and geometry.

The hardest part of any word problem is translating English into math. When you read a problem, you can frequently translate it *word for word* from English statements into mathematical statements. At other times, however, a key word in the word problem hints at the mathematical operation to be performed. Here are the translation rules:

EQUALS key words: is, are, has

English	*Math*
Bob **is** 18 years old.	$b = 18$
There **are** 7 hats.	$n = 7$
Judi **has** 5 books.	$f = 5$

ADDITION key words: sum; more, greater, or older than; total; altogether

English	*Math*
The **sum** of two numbers is 10.	$x + y = 10$
Karen has $5 **more than** Sam.	$k = 5 + s$
The base is 3" **greater than** the height.	$b = 3 + h$
Judi is 2 years **older than** Tony.	$j = 2 + t$
The **total** of three numbers is 25.	$a + b + c = 25$
How much do Joan and Tom have **altogether**?	$j + t = ?$

SUBTRACTION key words: difference; fewer, less, or younger than; remain; left over

English	*Math*
The **difference** between two numbers is 17.	$x - y = 17$
Mike has 5 **fewer** cats **than** twice the number Jan has.	$m = 2j - 5$
Jay is 2 years **younger than** Brett.	$j = b - 2$
After Carol ate 3 apples, r apples **remained**.	$r = a - 3$

MULTIPLICATION key words: of, product, times, each, at

English	*Math*
20% **of** the samples	$0.20 \times s$
Half **of** the bacteria	$\frac{1}{2} \times b$
The **product** of two numbers is 12.	$a \times b = 12$

DIVISION key word: per

English	*Math*
15 drops **per** teaspoon	$\frac{15 \text{ drops}}{\text{teaspoon}}$
22 miles **per** gallon	$\frac{22 \text{ miles}}{\text{gallon}}$

DISTANCE FORMULA: *DISTANCE = RATE × TIME*

The key words are movement words like: plane, train, boat, car, walk, run, climb, or swim.

- How far did the **plane** travel in 4 hours if it averaged 300 miles per hour?
  $D = 300 \times 4$
  $D = 1{,}200$ miles
- Ben **walked** 20 miles in 4 hours. What was his average speed?
  $20 = r \times 4$
  5 miles per hour = r

Solving a Word Problem Using the Translation Table

Remember the problem at the beginning of this chapter about the jelly beans?

Juan ate $\frac{1}{3}$ of the jelly beans. Maria then ate $\frac{3}{4}$ of the remaining jelly beans, which left 10 jelly beans. How many jelly beans were there to begin with?

a. 60
b. 80
c. 90
d. 120

We solved it by *working backward*. Now let's solve it using our translation rules.

Assume Juan started with J jelly beans. If Juan ate $\frac{1}{3}$ **of** them, that means there were $\frac{2}{3}$ of them left, or $\frac{2}{3} \times J$ jelly beans. Maria ate a fraction of the **remaining** jelly beans, which means we must **subtract** to find out how many are left: $J - \frac{1}{3} \times J = \frac{2}{3} \times J$. Maria then ate $\frac{3}{4}$, leaving $\frac{1}{4}$ **of** the $\frac{2}{3} \times J$ jelly beans, or $\frac{1}{4} \times \frac{2}{3} \times J$ jelly beans. Multiplying out $\frac{1}{4} \times \frac{2}{3} \times J$ gives $\frac{1}{6}J$ as the number of jelly beans left. The problem states that there were 10 jelly beans left, meaning that we set $\frac{1}{6} \times J$ **equal** to 10:

$$\frac{1}{6} \times J = 10$$

Solving this equation for J gives $\boldsymbol{J = 60}$. Thus, the right answer is **a** (the same answer we got when we *worked backward).* As you can see, both methods—working backward and translating from English to math—work. You should use whichever method is more comfortable for you.

Practice Word Problems

You will find word problems using fractions, decimals, and percentages in those sections of this chapter. For now, practice using the translation table on problems that just require you to work with basic arithmetic. Answers are at the end of the chapter.

_____ **1.** Joan went shopping with $100 and returned home with only $18.42. How much money did she spend?

a. $81.58
b. $72.68
c. $72.58
d. $71.68
e. $71.58

_____ **2.** Each of five physical therapists at the therapy center works six hours per day. Each therapist can work with three patients per hour. In total, how many patients can be seen each day at the center?

a. 18
b. 30
c. 60
d. 75
e. 90

_____ **3.** The office secretary can type 80 words per minute on his word processor. How many minutes will it take him to type a report containing 760 words?

a. 8
b. $8\frac{1}{2}$
c. 9
d. $9\frac{1}{2}$
e. 10

_____ **4.** Mr. Wallace is writing a budget request to upgrade his personal computer system. He wants to purchase a cable modem, which will cost $100, two new software programs at $350 each, a color printer for $249, and an additional color cartridge for $25. What is the total amount Mr. Wallace should write on his budget request?

a. $724
b. $974
c. $1,049
d. $1,064
e. $1,074

▶ Fraction Review

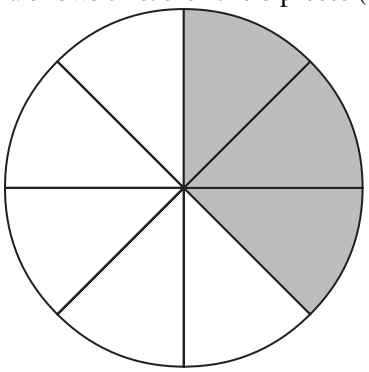
Problems involving fractions may be straightforward calculation questions, or they may be word problems. Typically, they ask you to add, subtract, multiply, divide, or compare fractions.

Working with Fractions

A fraction is a part of something.

Example:

Let's say that a pizza was cut into 8 equal slices and you ate 3 of them. The fraction $\frac{3}{8}$ tells you what part of the pizza you ate. The following pizza shows this: 3 of the 8 pieces (the ones you ate) are shaded.



Three Kinds of Fractions

Proper fraction: The top number is less than the bottom number:
$\frac{1}{2}; \frac{2}{3}; \frac{4}{9}; \frac{8}{13}$
The value of a proper fraction is less than 1.

Improper fraction: The top number is greater than or equal to the bottom number:
$\frac{3}{2}; \frac{5}{3}; \frac{14}{9}; \frac{12}{12}$
The value of an improper fraction is 1 or more.

Mixed number: A fraction written to the right of a whole number:
$3\frac{1}{2}; 4\frac{2}{3}; 12\frac{3}{4}; 24\frac{3}{4}$
The value of a mixed number is more than 1: It is the sum of the whole number plus the fraction.

Changing Improper Fractions into Mixed or Whole Numbers

It's easier to add and subtract fractions that are mixed numbers rather than improper fractions. To change an improper fraction, say $\frac{13}{2}$, into a mixed number, follow these steps:

1. Divide the bottom number (2) into the top number (13) to get the whole number portion (6) of the mixed number:

$$\begin{array}{r} 6 \\ 2\overline{)13} \\ \underline{12} \\ 1 \end{array}$$

2. Write the remainder of the division (1) over the old bottom number (2): $6\frac{1}{2}$
3. Check: Change the mixed number back into an improper fraction (see steps that follow).

Changing Mixed Numbers into Improper Fractions

It's easier multiply and divide fractions when you're working with improper fractions rather than mixed numbers. To change a mixed number, say $2\frac{3}{4}$, into an improper fraction, follow these steps:

1. Multiply the whole number (2) by the bottom number (4): $2 \times 4 = 8$
2. Add the result (8) to the top number (3): $8 + 3 = 11$
3. Put the total (11) over the bottom number (4): $\frac{11}{4}$
4. Check: Reverse the process by changing the improper fraction into a mixed number. If you get back the number you started with, your answer is right.

Reducing Fractions

Reducing a fraction means writing it in *lowest terms*, that is, with the smallest numbers possible. For instance, 50¢ is $\frac{50}{100}$ of a dollar, or $\frac{1}{2}$ of a dollar. In fact, if you have 50¢ in your pocket, you say that you have half a dollar. Reducing a fraction does not change its value.

Follow these steps to reduce a fraction:

1. Find a whole number that divides *evenly* into both numbers that make up the fraction.
2. Divide that number into the top of the fraction, and replace the top of the fraction with the quotient (the answer you got when you divided).
3. Do the same thing to the bottom number.
4. Repeat steps 1–3 until you can't find a number that divides evenly into both numbers of the fraction.

For example, let's reduce $\frac{8}{24}$. We could do it in two steps $\frac{8 \div 4}{24 \div 4} = \frac{2}{6}$; then $\frac{2 \div 2}{6 \div 2} = \frac{1}{3}$. Or we could do it in a single step $\frac{8 \div 8}{24 \div 8} = \frac{1}{3}$.

Shortcut: When the top and bottom numbers both end in zeroes, cross out the same number of zeroes in both numbers to begin the reducing process. For example $\frac{300}{4{,}000}$ reduces to $\frac{3}{40}$ when you cross out two zeroes in both numbers.

Whenever you do arithmetic with fractions, reduce your answer. On a multiple-choice test, don't panic if your answer isn't listed. Try to reduce it and then compare it to the choices.

Reduce these fractions to lowest terms.

_____ **5.** $\frac{3}{12}$

_____ **6.** $\frac{14}{35}$

_____ **7.** $\frac{27}{72}$

Raising Fractions to Higher Terms

Before you can add and subtract fractions, you have to know how to raise a fraction to higher terms. This is actually the opposite of reducing a fraction.

Follow these steps to raise $\frac{2}{3}$ to 24ths:

1. Divide the old bottom number (3) into the new one (24): $3\overline{)24} = 8$

2. Multiply the answer (8) by the old top number (2): $2 \times 8 = 16$

3. Put the answer (16) over the new bottom number (24): $\frac{16}{24}$

4. Check: Reduce the new fraction to see if you get back the original one: $\frac{16 \div 8}{24 \div 8} = \frac{2}{3}$

Raise these fractions to higher terms:

_____ **8.** $\frac{5}{12} = \frac{}{24}$

_____ **9.** $\frac{2}{9} = \frac{}{27}$

_____ **10.** $\frac{2}{5} = \frac{}{500}$

Adding Fractions

If the fractions have the same bottom numbers, just add the top numbers together and write the total over the bottom number.

Examples:

$\frac{2}{9} + \frac{4}{9} = \frac{2+4}{9} = \frac{6}{9}$ Reduce the sum: $\frac{2}{3}$.

$\frac{5}{8} + \frac{7}{8} = \frac{12}{8}$. Change the sum to a mixed number: $1\frac{4}{8}$; then reduce: $1\frac{1}{2}$.

There are a few extra steps to add mixed numbers with the same bottom numbers, say $2\frac{3}{5} + 1\frac{4}{5}$:

1. Add the fractions: $\frac{3}{5} + \frac{4}{5} = \frac{7}{5}$

2. Change the improper fraction into a mixed number: $\frac{7}{5} = 1\frac{2}{5}$

3. Add the whole numbers: $2 + 1 = 3$

4. Add the results of steps 2 and 3: $1\frac{2}{5} + 3 = 4\frac{2}{5}$

Finding the Least Common Denominator

If the fractions you want to add don't have the same bottom number, you will have to raise some or all of the fractions to higher terms so that they all have the same bottom number, called the **common denominator**. All of the original bottom numbers divide evenly into the common denominator. If it is the smallest number that they all divide evenly into, it is called the **least common denominator** (**LCD**).

Here are a few tips for finding the LCD, the smallest number that all the bottom numbers evenly divide into:

- See if all the bottom numbers divide evenly into the biggest bottom number.
- Inspect multiples of the largest bottom number until you find a number that all the other bottom numbers evenly divide into.
- When all else fails, multiply all the bottom numbers together.

Example: $\frac{2}{3} + \frac{4}{5}$

1. Find the LCD. Multiply the bottom numbers: $3 \times 5 = 15$

2. Raise each fraction to 15ths:

$$\frac{2}{3} = \frac{10}{15}$$
$$+ \frac{4}{5} = \frac{12}{15}$$

3. Add as usual: $\frac{22}{15}$

Try these addition problems:

_____ **11.** $\frac{3}{4} + \frac{1}{6}$

_____ **12.** $\frac{7}{8} + \frac{2}{3} + \frac{3}{4}$

_____ **13.** $4\frac{1}{3} + 2\frac{3}{4} + \frac{1}{6}$

Subtracting Fractions

If the fractions have the same bottom numbers, just subtract the top numbers and write the difference over the bottom number.

Example: $\frac{4}{9} - \frac{3}{9} = \frac{4-3}{9} = \frac{1}{9}$

If the fractions you want to subtract don't have the same bottom number, you will have to raise some or all of the fractions to higher terms so that they all have the same bottom number, or LCD. If you forgot how to find the LCD, just read the section on adding fractions with different bottom numbers.

Example: $\frac{5}{6} - \frac{3}{4}$

1. Raise each fraction to 12ths because 12 is the LCD, the smallest number that 6 and 4 both divide into evenly:

$$\frac{5}{6} = \frac{10}{12}$$
$$- \frac{3}{4} = \frac{9}{12}$$

2. Subtract as usual: $\frac{1}{12}$

Subtracting mixed numbers with the same bottom number is similar to adding mixed numbers.

Example: $4\frac{3}{5} - 1\frac{2}{5}$

1. Subtract the fractions: $\frac{3}{5} - \frac{2}{5} = \frac{1}{5}$
2. Subtract the whole numbers: $4 - 1 = 3$
3. Add the results of steps 1 and 2: $\frac{1}{5} + 3 = 3\frac{1}{5}$

Sometimes, there is an extra "borrowing" step when you subtract mixed numbers with the same bottom numbers, say $7\frac{3}{5} - 2\frac{4}{5}$:

1. You can't subtract the fractions the way they are because $\frac{4}{5}$ is bigger than $\frac{3}{5}$. So you borrow 1 from the 7, making it 6, and change that 1 to $\frac{5}{5}$ because 5 is the bottom number: $7\frac{3}{5} = 6\frac{5}{5} + \frac{3}{5}$
2. Add the numbers from step 1: $6\frac{5}{5} + \frac{3}{5} = 6\frac{8}{5}$
3. Now you have a different version of the original problem: $6\frac{8}{5} - 2\frac{4}{5}$
4. Subtract the fractional parts of the two mixed numbers: $\frac{8}{5} - \frac{4}{5} = \frac{4}{5}$
5. Subtract the whole number parts of the two mixed numbers: $6 - 2 = 4$
6. Add the results of the last two steps together: $4 + \frac{4}{5} = 4\frac{4}{5}$

Try these subtraction problems:

_____ **14.** $\frac{4}{5} - \frac{2}{3}$

_____ **15.** $\frac{7}{8} - \frac{1}{4} - \frac{1}{2}$

_____ **16.** $4\frac{1}{3} - 2\frac{3}{4}$

Now let's put what you have learned about adding and subtracting fractions to work in some real-life problems.

_____ **17.** Visiting nurse Alan drove $3\frac{1}{2}$ miles to the office to check his assignments for the day. Then he drove $4\frac{3}{4}$ miles to his first patient. When he left there, he drove 2 miles to his next patient. Then he drove $3\frac{2}{3}$ miles back to the office for a meeting. Finally, he drove $3\frac{1}{2}$ miles home. How many miles did he travel in total?

a. $17\frac{5}{12}$

b. $16\frac{5}{12}$

c. $15\frac{7}{12}$

d. $15\frac{5}{12}$

e. $13\frac{11}{12}$

_____ **18.** Before leaving the hospital, the ambulance driver noted that the mileage gauge on Ambulance 2 registered $4{,}357\frac{4}{10}$ miles. When he arrived at the scene of the accident, the mileage gauge then registered $4{,}400\frac{1}{10}$ miles. How many miles did he drive from the hospital to the accident?

a. $42\frac{3}{10}$

b. $42\frac{7}{10}$

c. $43\frac{7}{10}$

d. $47\frac{2}{10}$

Multiplying Fractions

Multiplying fractions is actually easier than adding them. All you do is multiply the top numbers and then multiply the bottom numbers.

Examples: $\frac{2}{3} \times \frac{5}{7} = \frac{2 \times 5}{3 \times 7} = \frac{10}{21}$ $\quad \frac{1}{2} \times \frac{3}{5} \times \frac{7}{4} = \frac{1 \times 3 \times 7}{2 \times 5 \times 4} = \frac{21}{40}$

Sometimes, you can *cancel* before multiplying. Canceling is a shortcut that makes the multiplication go faster because you're multiplying with smaller numbers. It's very similar to reducing: If there is a number that divides evenly into a top number and bottom number, do that division before multiplying. If you forget to cancel, you will still get the right answer, but you will have to reduce it.

Example: $\frac{5}{6} \times \frac{9}{20}$

1. Cancel the 6 and the 9 by dividing 3 into both of them: $6 \div 3 = 2$ and $9 \div 3 = 3$. Cross out the 6 and the 9: $\frac{5}{\cancel{6}_{2}} \times \frac{\overset{3}{\cancel{9}}}{20}$
2. Cancel the 5 and the 20 by dividing 5 into both of them: $5 \div 5 = 1$ and $20 \div 5 = 4$. Cross out the 5 and the 20: $\frac{\overset{1}{\cancel{5}}}{\underset{2}{\cancel{6}}} \times \frac{\overset{3}{\cancel{9}}}{\underset{4}{\cancel{20}}}$
3. Multiply across the new top numbers and the new bottom numbers: $\frac{1 \times 3}{2 \times 4} = \frac{3}{8}$

Try these multiplication problems:

_____ **19.** $\frac{1}{5} \times \frac{2}{3}$

_____ **20.** $\frac{2}{3} \times \frac{4}{7} \times \frac{3}{5}$

_____ **21.** $\frac{3}{4} \times \frac{8}{9}$

To multiply a fraction by a whole number, first rewrite the whole number as a fraction with a bottom number of 1.

Example: $5 \times \frac{2}{3} = \frac{5}{1} \times \frac{2}{3} = \frac{10}{3}$ (Optional: Convert $\frac{10}{3}$ to a mixed number: $3\frac{1}{3}$)

To multiply with mixed numbers, it's easier to change them to improper fractions before multiplying.

Example: $4\frac{2}{3} \times 5\frac{1}{2}$

1. Convert $4\frac{2}{3}$ to an improper fraction: $4\frac{2}{3} = \frac{4 \times 3 + 2}{3} = \frac{14}{3}$

2. Convert $5\frac{1}{2}$ to an improper fraction: $5\frac{1}{2} = \frac{5 \times 2 + 1}{2} = \frac{11}{2}$

3. Cancel and multiply the fractions: $\frac{\overset{7}{\cancel{14}}}{3} \times \frac{11}{\underset{1}{\cancel{2}}} = \frac{77}{3}$

4. Optional: Convert the improper fraction to a mixed number: $\frac{77}{3} = 25\frac{2}{3}$

Now try these multiplication problems with mixed numbers and whole numbers:

_____ **22.** $4\frac{1}{3} \times \frac{2}{5}$

_____ **23.** $2\frac{1}{2} \times 6$

_____ **24.** $3\frac{3}{4} \times 4\frac{2}{5}$

Here are a few more real-life problems to test your skills:

_____ **25.** After driving $\frac{2}{3}$ of the 15 miles to work, Dr. Stone received an emergency call from the hospital. How many miles had he driven when he got the call?

a. 5
b. $7\frac{1}{2}$
c. 10
d. 12
e. $15\frac{2}{3}$

_____ **26.** If Henry spent $\frac{3}{4}$ of a 40-hour week learning to use new laboratory equipment, how many hours did he spend in training?

a. $7\frac{1}{2}$
b. 10
c. 20
d. 25
e. 30

_____ **27.** Technician Chin makes $14.00 an hour. When she works more than 8 hours a day, she gets overtime pay of $1\frac{1}{2}$ times her regular hourly wage for the extra hours. How much did she earn for working 11 hours in one day?

a. $77
b. $154
c. $175
d. $210
e. $231

Dividing Fractions

To divide one fraction by a second fraction, invert the second fraction (that is, flip the top and bottom numbers, called the reciprocal) and then multiply. That's all there is to it!

Example: $\frac{1}{2} \div \frac{3}{5}$

1. Invert the second fraction ($\frac{3}{5}$): $\frac{5}{3}$

2. Change the division sign ($\div$) to a multiplication sign ($\times$): $\frac{1}{2} \times \frac{5}{3}$

3. Multiply the first fraction by the new second fraction: $\frac{1}{2} \times \frac{5}{3} = \frac{1 \times 5}{2 \times 3} = \frac{5}{6}$

To divide a fraction by a whole number, first change the whole number to a fraction by putting it over 1. Then follow the division steps above.

Example: $\frac{3}{5} \div 2 = \frac{3}{5} \div \frac{2}{1} = \frac{3}{5} \times \frac{1}{2} = \frac{3 \times 1}{5 \times 2} = \frac{3}{10}$

When the division problem has a mixed number, convert it to an improper fraction and then divide as usual.

Example: $2\frac{3}{4} \div \frac{1}{6}$

1. Convert $2\frac{3}{4}$ to an improper fraction: $2\frac{3}{4} = \frac{2 \times 4 + 3}{4} = \frac{11}{4}$

2. Divide $\frac{11}{4}$ by $\frac{1}{6}$: $\frac{11}{4} \div \frac{1}{6} = \frac{11}{4} \times \frac{6}{1}$

3. Flip $\frac{1}{6}$ to $\frac{6}{1}$, change $\div$ to $\times$, cancel, and multiply: $\frac{11}{\cancel{4}_{2}} \times \frac{\cancel{6}^{3}}{1} = \frac{11 \times 3}{2 \times 1} = \frac{33}{2}$

Here are a few division problems to try.

_____ **28.** $\frac{1}{3} \div \frac{2}{3}$

_____ **29.** $2\frac{3}{4} \div \frac{1}{2}$

_____ **30.** $\frac{3}{5} \div 3$

_____ **31.** $3\frac{3}{4} \div 2\frac{1}{3}$

Let's wrap this up with some real-life problems.

_____ **32.** If Dr. McCarthy's four assistants evenly divided $6\frac{1}{2}$ pounds of candy, how many pounds of candy did each assistant get?

a. $\frac{8}{13}$

b. $1\frac{5}{8}$

c. $1\frac{1}{2}$

d. $1\frac{5}{13}$

e. 4

_____ **33.** How many $2\frac{1}{2}$-pound chunks of cheese can be cut from a single 20-pound piece of cheese?

a. 2

b. 4

c. 6

d. 8

e. 10

_____ **34.** Ms. Goldbaum earned $36.75 for working $3\frac{1}{2}$ hours. What was her hourly wage?

a. $10.00

b. $10.50

c. $10.75

d. $12.00

e. $12.25

▶ Decimals

What Is a Decimal?

A decimal is a special kind of fraction. You use decimals every day when you deal with money—$10.35 is a decimal that represents 10 dollars and 35¢. The decimal point separates the dollars from the cents. Because there are 100¢ in one dollar, 1¢ is $\frac{1}{100}$ of a dollar, or $.01.

Each decimal digit to the right of the decimal point has a name:

Examples: .1 = 1 tenth = $\frac{1}{10}$

.02 = 2 hundredths = $\frac{2}{100}$

.003 = 3 thousandths = $\frac{3}{1{,}000}$

.0004 = 4 ten-thousandths = $\frac{4}{10{,}000}$

When you add zeroes after the rightmost decimal place, you don't change the value of the decimal. For example, 6.17 is the same as all of these:

6.170
6.1700
6.17000000000000000

If there are digits on both sides of the decimal point (like 10.35), the number is called a **mixed decimal**. If there are digits only to the right of the decimal point (like .53), the number is called a decimal. A whole number (like 15) is understood to have a decimal point at its right (15.). Thus, 15 is the same as 15.0, 15.00, 15.000, and so on.

Changing Fractions to Decimals

To change a fraction to a decimal, divide the bottom number into the top number after you put a decimal point and a few zeroes on the right of the top number. When you divide, bring the decimal point up into your answer.

Example: Change $\frac{3}{4}$ to a decimal.

1. Add a decimal point and 2 zeroes to the top number (3): 3.00

2. Divide the bottom number (4) into 3.00:

$$
\begin{array}{r}
.75 \\
4\overline{)3.00} \\
\underline{2\,8} \\
20 \\
\underline{20} \\
0
\end{array}
$$

3. The quotient (result of the division) is the answer: .75

Some fractions may require you to add many decimal zeroes in order for the division to come out evenly. In fact, when you convert a fraction like $\frac{2}{3}$ to a decimal, you can keep adding decimal zeroes to the top number forever because the division will never come out evenly. As you divide 3 into 2, you will keep getting 6's:

$$2 \div 3 = .6666666666 \text{ etc.}$$

This is called a *repeating decimal* and it can be written as $.66\overline{6}$ or as $.66\frac{2}{3}$. You can approximate it as .67, .667, .6667, and so on. When a bar is written above a digit or digits in a repeating decimal, it is those numbers that repeat (for example, $.\overline{42}$ means .42424242 . . .).

Changing Decimals to Fractions

To change a decimal to a fraction, write the digits of the decimal as the top number of a fraction and write the decimal's name as the bottom number of the fraction. Then reduce the fraction, if possible.

Example: .018

1. Write 18 as the top of the fraction: $\frac{18}{\ }$

2. Three places to the right of the decimal means *thousandths,* so write 1,000 as the bottom number: $\frac{18}{1{,}000}$

3. Reduce by dividing 2 into the top and bottom numbers: $\frac{18 \div 2}{1{,}000 \div 2} = \frac{9}{500}$

Change these decimals or mixed decimals to fractions:

_____ **35.** .005

_____ **36.** 3.48

_____ **37.** 123.456

Comparing Decimals

Because decimals are easier to compare when they have the same number of digits after the decimal point, tack zeroes onto the end of the shorter decimals. Then all you have to do is compare the numbers as if the decimal points weren't there:

Example: Compare .08 and .1

1. Tack one zero at the end of .1: .10

2. To compare .10 to .08, just compare 10 to 8.

3. Since 10 is larger than 8, .1 is larger than .08.

Adding and Subtracting Decimals

To add or subtract decimals, line them up so their decimal points are aligned. You may want to tack on zeroes at the end of shorter decimals so you can keep all your digits lined up evenly. Remember, if a number doesn't have a decimal point, then put one at the right end of the number.

Example: 1.23 + 57 + .038

1. Line up the numbers like this:

```
 1.230
57.000
+ .038
```

2. Add: 58.268

Example: 1.23 – .038

1. Line up the numbers like this:

$$\begin{array}{r} 1.230 \\ \underline{-\ .038} \end{array}$$

2. Subtract:

$$1.192$$

Try these addition and subtraction problems:

_____ **38.** .905 + .02 + 3.075

_____ **39.** .005 + 8 + .3

_____ **40.** 3.48 – 2.573

_____ **41.** 123.456 – 122

_____ **42.** James drove 3.7 miles to his physical therapist's office. He then walked 1.6 miles on the treadmill to strengthen his legs. He got back into the car, drove 2.75 miles to his radiology appointment, and then drove 2 miles back home. How many miles did he drive in total?

a. 8.05
b. 8.45
c. 8.8
d. 10
e. 10.05

_____ **43.** The average number of emergency room visits at City Hospital fell from 486.4 per week to 402.5 per week. By how many emergency room visits per week did the average fall?

a. 73.9
b. 83
c. 83.1
d. 83.9
e. 84.9

Multiplying Decimals

To multiply decimals, ignore the decimal points and just multiply the numbers. Then count the total number of decimal digits (the digits to the *right* of the decimal point) in the numbers you are multiplying. Count off that number of digits in your answer beginning at the right side and put the decimal point to the *left* of those digits.

Example: 215.7 × 2.4

1. Multiply 2157 times 24:

$$\begin{array}{r} 2{,}157 \\ \times\ 24 \\ \hline 8628 \\ 4314\ \ \\ \hline 51768 \end{array}$$

2. Because there are a total of 2 decimal digits in 215.7 and 2.4, count off 2 places from the right in 51768, placing the decimal point to the *left* of the last 2 digits: 517.68

If your answer doesn't have enough digits, tack zeroes on to the left of the answer.

Example: .03 × .006

1. Multiply 3 times 6: $3 \times 6 = 18$
2. You need 5 decimal digits in your answer, so tack on 3 zeroes: 00018
3. Put the decimal point at the front of the number (which is 5 digits in from the right): .00018

You can practice multiplying decimals with these:

_____ **44.** .05 × .6

_____ **45.** .053 × 6.4

_____ **46.** 38.1 × .0184

_____ **47.** Joe earns $14.50 per hour as an occupational therapist. Last week, he worked 37.5 hours. How much money did he earn that week?

a. $518.00
b. $518.50
c. $525.00
d. $536.50
e. $543.75

_____ **48.** Nuts cost $3.50 per pound. Approximately how much will 4.25 pounds of nuts cost?

a. $12.25
b. $12.50
c. $12.88
d. $14.50
e. $14.88

Dividing Decimals

To divide a decimal by a whole number, set up the division ($8\overline{).256}$) and immediately bring the decimal point straight up into the answer ($8\overline{)\dot{.}256}$). Then divide as you would normally divide whole numbers:

Example:

```
   .032
8)↑.256
  0
  25
  24
   16
   16
    0
```

To divide any number by a decimal, there is an extra step to perform before you can divide. Move the decimal point to the very right of the number you're dividing by, counting the number of places you're moving it. Then move the decimal point the same number of places to the right in the number you're dividing into. In other words, first change the problem to one in which you're dividing by a whole number.

Example: $.06\overline{)1.218}$

1. Because there are 2 decimal digits in .06, move the decimal point 2 places to the right in both numbers and move the decimal point straight up into the answer:

$$.06\overline{)1.21\dot{8}}$$

2. Divide using the new numbers:

```
   20.3
6)121.8
  12
  01
  00
   18
   18
    0
```

Under certain conditions, you have to tack on zeroes to the right of the last decimal digit in the number you are dividing into:

- If there aren't enough digits for you to move the decimal point to the right
- If the answer doesn't come out evenly when you do the division
- If you are dividing a whole number by a decimal. Then you will have to tack on the decimal point as well as some zeroes.

Try your skills on these division problems:

_____ **49.** $7\overline{)9.8}$

_____ **50.** $.0004\overline{).0512}$

_____ **51.** $.05\overline{)28.6}$

_____ **52.** $.14\overline{)196}$

_____ **53.** If James Worthington drove the mobile blood bank unit 92.4 miles in 2.1 hours, what was his average speed in miles per hour?

a. 41
b. 44
c. 90.3
d. 94.5
e. 194.04

_____ **54.** Mary Sanders walked a total of 18.6 miles in 4 days. On average, how many miles did she walk each day?

a. 4.15
b. 4.60
c. 4.65
d. 22.60
e. 74.40

▶ Percents

What Is a Percent?

A percent is a special kind of fraction or part of something. The bottom number (the *denominator*) is always 100. For example, 17% is the same as $\frac{17}{100}$. Literally, the word *percent* means *per 100 parts*. The root *cent* means 100: A *century* is 100 years; there are 100 *cents* in a dollar, etc. Thus, 17% means 17 parts out of 100. Because fractions can also be expressed as decimals, 17% is also equivalent to .17, which is 17 hundredths.

You come into contact with percents every day. Sales tax, interest, and discounts are just a few common examples.

If you're shaky on fractions, you may want to review the fraction section before reading further.

Changing a Decimal to a Percent and Vice Versa

To change a decimal to a percent, move the decimal point two places to the right and tack on a percent sign (%) at the end. If the decimal point moves to the very right of the number, you don't have to write the decimal point. If there aren't enough places to move the decimal point, add zeroes on the right before moving the decimal point.

To change a percent to a decimal, drop off the percent sign and move the decimal point two places to the left. If there aren't enough places to move the decimal point, add zeroes on the left before moving the decimal point.

Try changing these decimals to percents:

_____ **55.** .45

_____ **56.** .008

_____ **57.** $.16\frac{2}{3}$

Now, change these percents to decimals:

_____ **58.** 12%

_____ **59.** $87\frac{1}{2}\%$

_____ **60.** 250%

CONVERSION TABLE

DECIMAL	%	FRACTION
.25	25%	$\frac{1}{4}$
.50	50%	$\frac{1}{2}$
.75	75%	$\frac{3}{4}$
.10	10%	$\frac{1}{10}$
.20	20%	$\frac{1}{5}$
.40	40%	$\frac{2}{5}$
.60	60%	$\frac{3}{5}$
.80	80%	$\frac{4}{5}$
$.33\overline{3}$	$33\frac{1}{3}\%$	$\frac{1}{3}$
$.66\overline{6}$	$66\frac{2}{3}\%$	$\frac{2}{3}$

Changing a Fraction to a Percent and Vice Versa

To change a fraction to a percent, there are two techniques. Each is illustrated by changing the fraction $\frac{1}{4}$ to a percent:

Technique 1: Multiply the fraction by 100%.

Multiply $\frac{1}{4}$ by 100%:

$$\frac{1}{\cancel{4}_{1}} \times \frac{\cancel{100}^{25}\%}{1} = 25\%$$

Technique 2: Divide the fraction's bottom number into the top number; then move the decimal point two places to the right and tack on a percent sign (%).

Divide 4 into 1 and move the decimal point 2 places to the right:

$$4\overline{)1.00}\quad .25$$

$.25 = 25\%$

To change a percent to a fraction, remove the percent sign and write the number over 100. Then reduce if possible.

Example: Change 4% to a fraction.

1. Remove the % and write the fraction 4 over 100: $\frac{4}{100}$
2. Reduce: $\frac{4 \div 4}{100 \div 4} = \frac{1}{25}$

Here's a more complicated example: Change $16\frac{2}{3}\%$ to a fraction.

1. Remove the % and write the fraction $16\frac{2}{3}$ over 100: $\frac{16\frac{2}{3}}{100}$
2. Since a fraction means "top number divided by bottom number," rewrite the fraction as a division problem: $16\frac{2}{3} \div 100$
3. Change the mixed number ($16\frac{2}{3}$) to an improper fraction ($\frac{50}{3}$): $\frac{50}{3} \div \frac{100}{1}$
4. Flip the second fraction ($\frac{100}{1}$) and multiply:

$$\frac{\cancel{50}^{1}}{3} \times \frac{1}{\cancel{100}_{2}} = \frac{1}{6}$$

Try changing these fractions to percents:

_____ **61.** $\frac{1}{8}$

_____ **62.** $\frac{13}{25}$

_____ **63.** $\frac{7}{12}$

Now change these percents to fractions:

_____ **64.** 95%

_____ **65.** $37\frac{1}{2}\%$

_____ **66.** 125%

Sometimes it is more convenient to work with a percentage as a fraction or a decimal. Rather than have to *calculate* the equivalent fraction or decimal, consider memorizing the conversion table on page 125. Not only will this increase your efficiency on the math test, but it will also be practical for real-life situations.

Percent Word Problems

Word problems involving percents come in three main varieties:

- Find a percent of a whole.
  Example: What is 30% of 40?
- Find what percent one number is of another number.
  Example: 12 is what percent of 40?
- Find the whole when the percent of it is given.
  Example: 12 is 30% of what number?

While each variety has its own approach, there is a single shortcut formula you can use to solve each of these:

$$\frac{is}{of} = \frac{\%}{100}$$

The ***is*** is the number that usually follows or is just before the word *is* in the question.
The ***of*** is the number that usually follows the word *of* in the question.
The **%** is the number that is in front of the **%** or *percent* in the question.

Or you may think of the shortcut formula as:

$$\frac{part}{whole} = \frac{\%}{100}$$

To solve each of the three varieties, we're going to use the fact that the **cross products** are equal. The cross products are the products of the numbers diagonally across from each other. Remembering that *product* means *multiply*, here's how to create the cross products for the percent shortcut:

$$\frac{part}{whole} = \frac{\%}{100}$$
$$part \times 100 = whole \times \%$$

Here's how to use the shortcut with cross products:

- Find a percent of a whole.
  What is 30% of 40?
  30 is the % and 40 is the *of* number:
  Cross multiply and solve for *is*:

$$\frac{is}{40} = \frac{30}{100}$$
$$\boldsymbol{is} \times 100 = 40 \times 30$$
$$\boldsymbol{is} \times 100 = 1{,}200$$
$$\mathbf{12} \times 100 = 1{,}200$$

  Thus, **12 *is*** 30% of 40.

- Find what percent one number is of another number.
  12 is what percent of 40?
  12 is the *is* number and 40 is the *of* number:
  Cross multiply and solve for %:

$$\frac{12}{40} = \frac{\%}{100}$$
$$12 \times 100 = 40 \times \boldsymbol{\%}$$
$$1{,}200 = 40 \times \boldsymbol{\%}$$
$$1{,}200 = 40 \times \mathbf{30}$$

  Thus, 12 is **30%** of 40.

- Find the whole when the percent of it is given.
  12 is 30% of what number?
  12 is the *is* number and 30 is the *%*:
  Cross multiply and solve for the *of* number:

$$\frac{12}{of} = \frac{30}{100}$$
$$12 \times 100 = \boldsymbol{of} \times 30$$
$$1{,}200 = \boldsymbol{of} \times 30$$
$$1{,}200 = \mathbf{40} \times 30$$

  Thus, 12 is 30% ***of* 40**.

You can use the same technique to find the percent increase or decrease. The *is* number is the actual increase or decrease, and the *of* number is the original amount.

Example: If a merchant puts his \$20 hats on sale for \$15, by what percent does he decrease the selling price?

1. Calculate the decrease, the *is* number: $\$20 - \$15 = \$5$

2. The *of* number is the original amount, \$20.

3. Set up the equation and solve for *of* by cross multiplying:

$$\frac{5}{20} = \frac{\%}{100}$$
$$5 \times 100 = 20 \times \%$$
$$500 = 20 \times \%$$
$$500 = 20 \times \mathbf{25}$$

4. Thus, the selling price is decreased by **25%**.

If the merchant later raises the price of the hats from \$15 back to \$20, don't be fooled into thinking that the percent increase is also 25%! It's actually more, because the increase amount of \$5 is now based on a lower original price of only \$15:
Thus, the selling price is increased by **33%**.

$$\frac{5}{15} = \frac{\%}{100}$$
$$5 \times 100 = 15 \times \%$$
$$500 = 15 \times \%$$
$$500 = 15 \times \mathbf{33\frac{1}{3}}$$

Find a percent of a whole:

_____ **67.** 1% of 25

_____ **68.** 18.2% of 50

_____ **69.** $37\frac{1}{2}$ of 100

_____ **70.** 125% of 60

Find what percent one number is of another number:

_____ **71.** 10 is what % of 20?

_____ **72.** 4 is what % of 12?

_____ **73.** 12 is what % of 4?

Find the whole when the percent of it is given:

_____ **74.** 15% of what number is 15?

_____ **75.** $37\frac{1}{2}$% of what number is 3?

_____ **76.** 200% of what number is 20?

Now try your percent skills on some real-life problems:

_____ **77.** Last Monday, 20% of the 140–member nursing staff was absent. How many nurses were absent that day?

a. 14
b. 20
c. 28
d. 112
e. 126

_____ **78.** Forty percent of General Hospital's medical technologists are women. If there are 80 female medical technologists, how many medical technologists are male?

a. 32
b. 112
c. 120
d. 160
e. 200

_____ **79.** Of the 840 biopsies performed last month, 42 were positive. What percent of the biopsies were positive?

a. .5%
b. 2%
c. 5%
d. 20%
e. 50%

_____ **80.** Sam's Shoe Store put all of its merchandise on sale for 20% off. If Jason saved $10 by purchasing one pair of shoes during the sale, what was the original price of the shoes before the sale?

a. $12
b. $20
c. $40
d. $50
e. $70

▶ Averages

An **average**, also called an arithmetic mean, is a number that *typifies* a group of numbers, a measure of central tendency. You come into contact with averages on a regular basis: your bowling average, the average grade on a test, the average number of hours you work per week.

To calculate an average, add up the number of items being averaged and divide by the number of items.

Example: What is the average of 6, 10, and 20?

Solution: Add the three numbers together and divide by 3: $\frac{6 + 10 + 20}{3} = 12$

Shortcut

Here's a neat shortcut for some average problems.

- Look at the numbers being averaged. If they are equally spaced, like 5, 10, 15, 20, and 25, then the average is the number in the middle, or 15 in this case.
- If there are an even number of such numbers, say 10, 20, 30, and 40, then there is no middle number. In this case, the average is halfway between the two middle numbers. In this case, the average is halfway between 20 and 30, or 25.
- If the numbers are almost evenly spaced, you can probably estimate the average without going to the trouble of actually computing it. For example, the average of 10, 20, and 32 is just a little more than 20, the middle number.

Try these average questions:

_____ **81.** Bob's bowling scores for the last 5 games were 180,182,184,186, and 188. What was his average bowling score?

a. 182
b. 183
c. 184
d. 185
e. 186

_____ **82.** Ambulance Driver Conroy averaged 30 miles an hour for the two hours he drove in town and 60 miles an hour for the two hours he drove on the highway. What was his average speed in miles per hour?

a. 18
b. $22\frac{1}{2}$
c. 45
d. 60
e. 90

_____ **83.** There are 10 females and 20 males in the first aid course. If the females achieved an average score of 85 and the males achieved an average score of 95, what was the class average? (Hint: Don't fall for the trap of taking the average of 85 and 95; there are more 95s being averaged than 85s, so the average is closer to 95.)

a. $90\frac{2}{3}$
b. $91\frac{2}{3}$
c. 92
d. $92\frac{2}{3}$
e. 95

▶ Working with Length and Time Units

The United States uses the *English system* to measure length; however, most other countries use the *metric system*, which is also prevalent in scientific use in the United States. The English system requires knowing many different equivalences, but you're probably used to dealing with these equivalences on a daily basis. Mathematically, however, it's simpler to work in metric units because their equivalences are all multiples of 10. The meter is the basic unit of length, with all other length units defined in terms of the meter.

Length Conversions

Math questions on standardized tests, especially geometry word problems, may require conversions within a particular system. An easy way to convert from one unit of measurement to another is to multiply by an equivalence ratio. Such ratios don't change the value of the unit of measurement because each ratio is equivalent to 1.

Example: Convert 3 yards to feet.

Multiply 3 yards by the ratio $\frac{3\ ft.}{1\ yd.}$. Notice that we chose $\frac{3\ ft.}{1\ yd.}$ rather than $\frac{1\ yd.}{3\ ft.}$ because the yards cancel during the multiplication:

$$3\ yds. \times \frac{3\ ft.}{1\ yd.} = \frac{3\ \cancel{yds.} \times 3\ ft.}{1\ \cancel{yd.}} = \mathbf{9\ ft.}$$

Example: Convert 31 inches to feet and inches.

1. First, multiply 31 inches by the ratio $\frac{1\ ft.}{12\ in.}$: $31\ in. \times \frac{1\ ft.}{12\ in.} = \frac{31\ \cancel{in.} \times 1\ ft.}{12\ \cancel{in.}} = \frac{31}{12}\ ft. = 2\frac{7}{12}\ ft.$

2. Then change the $\frac{7}{12}$ portion of $2\frac{7}{12}$ ft. to inches: $\frac{7\ ft.}{12} \times \frac{12\ in.}{1\ ft.} = \frac{7\ \cancel{ft.} \times \cancel{12}\ in.}{\cancel{12} \times 1\ \cancel{ft.}} = 7\ in.$

3. Thus, 31 inches is equivalent to both $\mathbf{2\frac{7}{12}}$ **ft.** and **2 feet 7 inches**.

Convert as indicated.

_____ **84.** 2 ft. = _____ in.

_____ **85.** 3 cm = _____ mm

_____ **86.** 16 m = _____ cm

_____ **87.** 294 cm = _____ m

ENGLISH SYSTEM	
UNIT	**EQUIVALENCE**
foot (ft.)	1 ft. = 12 in.
yard (yd.)	1 yd. = 3 ft. 1 yd. = 36 in.
mile (mi.)	1 mi. = 5,280 ft. 1 mi. = 1,760 yds.

METRIC SYSTEM	
UNIT	**EQUIVALENCE**
meter (m)	Basic unit A giant step is about 1 meter long.
centimeter (cm)	100 cm = 1 m Your index finger is about 1 cm wide.
millimeter (mm)	10 mm = 1 cm; 1,000 mm = 1 m Your fingernail is about 1 mm thick.
kilometer (km)	1 km = 1,000 m Five city blocks are about 1 km long.

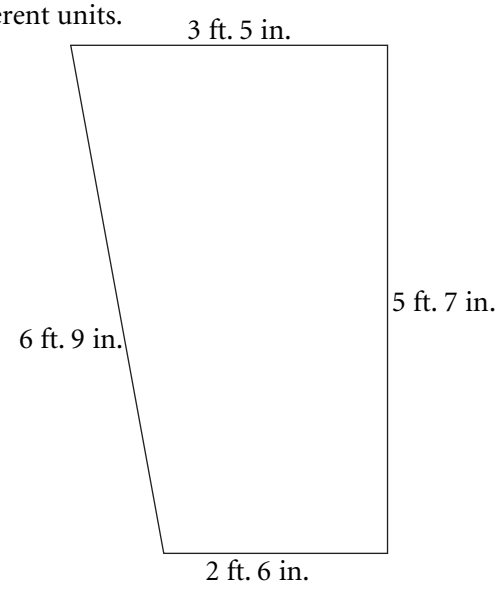
ENGLISH SYSTEM	
TO CONVERT BETWEEN	**MULTIPLY BY THIS RATIO**
inches and feet	$\frac{12\ in.}{1\ ft.}$ *or* $\frac{1\ ft.}{12\ in.}$
inches and yards	$\frac{36\ in.}{1\ yd.}$ *or* $\frac{1\ yd.}{36\ in.}$
feet and yards	$\frac{3\ ft.}{1\ yd.}$ *or* $\frac{1\ yd.}{3\ ft.}$
feet and miles	$\frac{5{,}280\ ft.}{1\ mi.}$ *or* $\frac{1\ mi.}{5{,}280\ ft.}$
yards and miles	$\frac{1{,}760\ yds.}{1\ mi.}$ *or* $\frac{1\ mi.}{1{,}760\ yds.}$

METRIC SYSTEM	
TO CONVERT BETWEEN	**MULTIPLY BY THIS RATIO**
millimeters and centimeters	$\frac{10\ mm}{1\ cm}$ *or* $\frac{1\ cm}{10\ mm}$
meters and millimeters	$\frac{1{,}000\ mm}{1\ m}$ *or* $\frac{1\ m}{1{,}000\ mm}$
meters and centimeters	$\frac{100\ cm}{1\ m}$ *or* $\frac{1\ m}{100\ cm}$
meters and kilometers	$\frac{1{,}000\ m}{1\ km}$ *or* $\frac{1\ km}{1{,}000\ m}$

Addition and Subtraction with Length Units

Finding the perimeter of a figure may require adding lengths of different units.

Example: Find the perimeter of the figure at right.



To add the lengths, add each column of length units separately:

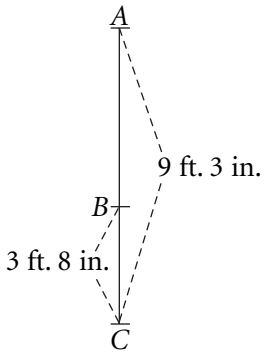
$$\begin{array}{rrr} 5 \text{ ft.} & 7 & \text{in.} \\ 2 \text{ ft.} & 6 & \text{in.} \\ 6 \text{ ft.} & 9 & \text{in.} \\ + \ 3 \text{ ft.} & 5 & \text{in.} \\ \hline \textbf{16 ft.} & \textbf{27} & \textbf{in.} \end{array}$$

Since 27 inches is more than 1 foot, the total of **16 ft. 27 in.** must be simplified:

- Convert 27 inches to feet and inches:
  $27\ in. \times \frac{1\ ft.}{12\ in.} = \frac{27}{12}\ ft. = 2\frac{3}{12}\ ft. = 2\ ft.\ 3\ in.$
- Add: 16 ft.
  + 2 ft. 3 in.
  18 ft. 3 in. Thus, the perimeter is **18 feet 3 inches**.

Finding the length of a line segment may require subtracting lengths of different units.

Example: Find the length of line segment *AB* below.



To subtract the lengths, subtract each column of length units separately, starting with the rightmost column.

$$\begin{array}{r} 9 \text{ ft. } 3 \text{ in.} \\ -\ 3 \text{ ft. } 8 \text{ in.} \\ \hline \end{array}$$

Warning: You can't subtract 8 inches from 3 inches because 8 is larger than 3! As in regular subtraction, you have to *borrow* 1 from the column on the left. However, borrowing *1 ft.* is the same as borrowing *12 inches;* adding the borrowed 12 inches to the 3 inches gives 15 inches. Thus:

$$\begin{array}{r} \overset{8}{\cancel{9}} \text{ ft. } \overset{12}{\cancel{3}}\overset{\nearrow 15}{} \text{ in.} \\ -\ 3 \text{ ft. } 8 \text{ in.} \\ \hline \textbf{5 ft. 7 in.} \end{array}$$

Thus, the length of $\overline{AB}$ is **5 feet 7 inches**.

Add and simplify.

88. $\begin{array}{r} 5 \text{ ft. } 3 \text{ in.} \\ +\ 2 \text{ ft. } 9 \text{ in.} \\ \hline \end{array}$

89. $\begin{array}{r} 7 \text{ km } 220 \text{ m} \\ 4 \text{ km } 180 \text{ m} \\ +\ 9 \text{ km } 770 \text{ m} \\ \hline \end{array}$

Subtract and simplify.

90. $\begin{array}{r} 4 \text{ ft. } 1 \text{ in.} \\ -\ 2 \text{ ft. } 9 \text{ in.} \\ \hline \end{array}$

91. $\begin{array}{r} 14 \text{ cm } 2 \text{ mm} \\ -\ 6 \text{ cm } 4 \text{ mm} \\ \hline \end{array}$

Time Conversions

Word problems involving time typically ask you to determine how long something takes. You might have to add together the amount of time several activities take in order to determine the total amount of time the entire process takes or calculate the elapsed time from the start to the finish of a particular activity.

Adding and subtracting time units is a lot like adding and subtracting length units. You have to make sure that you are adding hours to hours, minutes to minutes, and seconds to seconds. If the given information is in different time units, then you'll have to convert to a common time unit before you can proceed. Use the following conversion ratios:

- **To convert minutes to hours:** $\frac{1\ hour}{60\ minutes}$
- **To convert hours to minutes:** $\frac{60\ minutes}{1\ hour}$
- **To convert seconds to minutes:** $\frac{1\ minute}{60\ seconds}$
- **To convert minutes to seconds:** $\frac{60\ seconds}{1\ minute}$

Example: Convert $2\frac{1}{4}$ hours to seconds.

1. Convert hours to minutes: $2\frac{1}{4}\ \cancel{hr.} \times \frac{60\ min.}{1\ \cancel{hr.}} = 135\ min.$

2. Convert minutes to seconds: $135\ \cancel{min.}\ \frac{60\ sec.}{1\ \cancel{min.}} = 8{,}100\ sec.$

The hours and minutes cancel, giving an answer in seconds.

Calculating Elapsed Time

Calculating elapsed time when you're given the starting and ending time can be a bit tricky, depending on the starting and ending time. If the starting and ending times are both A.M. or both P.M. of the same day, you can calculate the elapsed time by simply subtracting the starting time from the ending time. However, you may have to "regroup," or "borrow."

Example: Radiology Associates opens at 6:45 A.M. and closes for lunch at 11:35 A.M. How long are they open in the morning?

1. Set up the subtraction:

2. You can't subtract 45 minutes from 35 minutes, so you have to "borrow" 1 hour from the 11 hours. Borrowing 1 hour from 11 hours is equivalent to borrowing 60 minutes. Thus, you're actually subtracting 45 minutes from 95 minutes (that is, 35 + 60 minutes).

$$\begin{array}{r} {\scriptstyle 10\ \ 9} \\ \cancel{11}{:}\cancel{3}5 \\ -\ 6{:}45 \\ \hline 4{:}50 \end{array}$$

Radiology Associates is open for 4 hours and 50 minutes in the morning.

If the starting time is A.M. and ending time is P.M. of the same day, you have to calculate the elapsed time in two steps and then add the step results together. Calculate the elapsed morning time by subtracting the starting time from noon. The elapsed afternoon time is equivalent to the ending time. So you add the elapsed morning time and the elapsed afternoon time to get the total elapsed time.

Example: If Radiology Associates opens at 7:15 A.M. and closes at 5:30 P.M., how long are they open?

1. Subtract the starting time from noon: (You'll have to "borrow" 60 minutes from 12.)

$$\begin{array}{r} {\scriptstyle 5} \\ {\scriptstyle 1\ \cancel{6}\ 10} \\ 1\cancel{2}{:}\cancel{00} \\ -\ 7{:}15 \\ \hline 4{:}45 \end{array}$$

Radiology Associates is open for 4 hours and 45 minutes in the morning.

2. Radiology Associates closes at 5:30 P.M. Thus, they're open for 5 hours and 30 minutes in the afternoon.

3. Add the results together:

$$\begin{array}{r} 4{:}45 \\ +\ 5{:}30 \\ \hline 9{:}75 \end{array}$$

4. The sum of 9 hours and 75 minutes needs to be adjusted because 75 minutes is more than an hour. There's a "carry" of 1 hour: the 75 minutes is equivalent to 1 hour and 15 minutes. Thus, 9 hours and 75 minutes is the same as 10 hours and 15 minutes.

You follow the same procedure when the starting time is P.M. of one day and the ending time is A.M. of the next day. Calculate the elapsed P.M. time by subtracting the starting time from midnight. Then add the elapsed A.M. time, which is equivalent to the ending time.

If the starting and ending times are on different days, you calculate the elapsed time in three steps: elapsed time on the starting day, elapsed time on the ending day, and the time of the intervening days. Then you add the results of the three steps together.

Example: Each week, Radiology Associates turns their computers on at 6:45 A.M. on Monday and turns them off for the weekend at 5:30 P.M. on Friday. How long are the computers on, in hours?

1. Starting day, Monday

a. For the A.M. hours, subtract the starting time from noon:

$$\begin{array}{r} {\scriptstyle 5} \\ 1\ \cancel{6}\ {\scriptstyle 10} \\ 1\cancel{2}{:}\cancel{00} \\ \underline{-\ 6{:}45} \\ 5{:}15 \end{array}$$

b. For the P.M. hours, there are 12 hours from noon until midnight.

c. Add the A.M. and P.M. hours to get the total hours on the starting day:

$$\begin{array}{r} 5{:}15 \\ \underline{+\ 12{:}00} \\ 17{:}15 \end{array}$$

On Monday, 17 hours and 15 minutes elapse.

2. Ending day, Friday

a. For the A.M. hours, there are 12 hours from midnight until noon: 12:00

b. For the P.M. hours, the ending time is the elapsed time: + 5:30

c. Add the A.M. and P.M. hours to get the total hours on the ending day: 17:30

On Friday, 17 hours and 30 minutes elapse.

3. The intervening days: Tuesday, Wednesday, and Thursday

3 days × 24 hours per day = 72 hours

4. Add the results of steps 1–3 together:

$$\begin{array}{r} 17{:}15 \\ 17{:}30 \\ \underline{+\ 72{:}00} \\ 106{:}45 \end{array}$$

The total elapsed time is 106 hours and 45 minutes.

5. Since the question asks for the amount of time the computers are on in hours, the 45 minutes portion of the answer must be converted to a fraction of an hour:

$$45\ \textit{minutes} \times \frac{1\ \textit{hour}}{60\ \textit{minutes}} = \frac{3}{4}\ \text{hour}$$

Thus, the computers were on for a total of $106\frac{3}{4}$ hours.

Now try these time problems:

_____ **92.** Jan ran three tests in the lab that each required 45 minutes. If she then ran a final test and all four tests required a total of $3\frac{1}{4}$ hours, how long did the final test take?

a. $\frac{1}{2}$ hour

b. $\frac{2}{3}$ hour

c. $\frac{3}{4}$ hour

d. 1 hour

e. $1\frac{1}{4}$ hours

_____ **93.** If each of eight radiology rooms is in use for 5 hours and 15 minutes per day, and a total of 84 procedures are performed, how long does each procedure take on average?

a. 20 minutes
b. 30 minutes
c. 40 minutes
d. 50 minutes
e. 1 hour

_____ **94.** Clara cultured a particular virus at 2:30 P.M. on Monday and stored the culture in the refrigerator until 11:30 A.M. on Wednesday. How long was the culture in the refrigerator?

a. 3 hours
b. 21 hours
c. 27 hours
d. 45 hours
e. 69 hours

▶ Algebra

Popular topics for algebra questions on health occupations exams include:

- Solving equations
- Positive and negative numbers
- Algebraic expressions

What Is Algebra?

Algebra is a way to express and solve problems using numbers and symbols. These symbols, called *unknowns* or *variables*, are letters of the alphabet that are used to represent numbers.

For example, let's say you are asked to find out what number, when added to 3, gives you a total of 5. Using algebra, you could express the problem as $x + 3 = 5$. The variable x represents the number you are trying to find.

Here's another example, but this one uses only variables. To find the distance traveled, multiply the rate of travel (speed) by the amount of time traveled: $d = r \times t$. The variable d stands for *distance*, r stands for *rate*, and t stands for *time*.

In algebra, the variables may take on different values. In other words, they *vary*, and that's why they're called *variables*.

Operations

Algebra uses the same operations as arithmetic: addition, subtraction, multiplication, and division. In arithmetic, we might say $3 + 4 = 7$, while in algebra, we would talk about two numbers whose values we don't know that add up to 7, or $x + y = 7$. Here's how each operation translates to algebra:

ALGEBRAIC OPERATIONS	
The sum of 2 numbers	$a + b$
The difference of 2 numbers	$a - b$
The product of 2 numbers	$a \times b$ or $a \cdot b$ or ab
The quotient of 2 numbers	$\frac{a}{b}$

Equations

An equation is a mathematical sentence stating that two quantities are equal. For example:

$$2x = 10$$
$$x + 5 = 8$$

The idea is to find a replacement for the unknown that will make the sentence true. That's called solving the equation. Thus, in the first example, $x = 5$ because $2 \times 5 = 10$. In the second example, $x = 3$ because $3 + 5 = 8$.

Sometimes you can solve an equation by inspection, as with the above examples. Other equations may be more complicated and require a step-by-step solution, for example:

$$\frac{n+2}{4} + 1 = 3$$

The general approach is to consider an equation like a balance scale, with both sides equally balanced. Essentially, whatever you do to one side, you must also do to the other side to maintain the balance. Thus, if you were to add 2 to the left side, you would also have to add 2 to the right side.

Let's apply this *balance* concept to our complicated equation above. Remembering that we want to solve it for n, we must somehow rearrange it so the n is isolated on one side of the equation. Its value will then be on the other side. Looking at the equation, you can see that n has been increased by 2 and then divided by 4 and ultimately added to 1. Therefore, we will undo these operations to isolate n.

Begin by subtracting 1 from both sides of the equation:

$$\frac{n+2}{4} + 1 = 3$$
$$\underline{\quad -1 \quad -1}$$
$$\frac{n+2}{4} = 2$$

Next, multiply both sides by 4:

$$4 \times \frac{n+2}{4} = 2 \times 4$$
$$n + 2 = 8$$

Finally, subtract 2 from both sides:

$$\underline{\quad -2 \quad -2}$$

This isolates n and solves the equation:

$$n = 6$$

Notice that each operation in the original equation was undone by using the inverse operation. That is, addition was undone by subtraction, and division was undone by multiplication. In general, each operation can be undone by its *inverse*.

ALGEBRAIC INVERSES

OPERATION	INVERSE	OPERATION	INVERSE
Addition	Subtraction	Subtraction	Addition
Multiplication	Division	Division	Multiplication
Square	Square Root	Square Root	Square

After you solve an equation, check your work by plugging the answer back into the original equation to make sure it balances. Let's see what happens when we plug 6 in for n:

$$\frac{6+2}{4} + 1 = 3 \quad ?$$
$$\frac{8}{4} + 1 = 3 \quad ?$$
$$2 + 1 = 3 \quad ?$$
$$3 = 3 \quad \checkmark$$

Solve each equation:

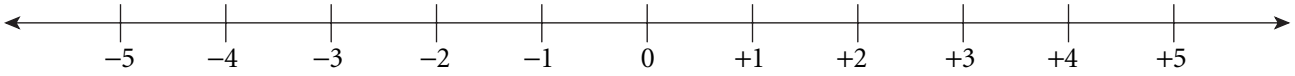
_____ **95.** $x + 5 = 12$

_____ **96.** $3x + 6 = 18$

_____ **97.** $\frac{1}{4}x = 7$

Positive and Negative Numbers

Positive and negative numbers, also known as *signed* numbers, are best shown as points along the number line:



Numbers to the left of (smaller than) 0 are *negative* and those to the right are *positive*. Zero is neither negative nor positive. If a number is written without a sign, it is assumed to be *positive*. Notice that when you are on the negative side of the number line, bigger numbers have smaller values. For example, –5 is *less than* –2. You come into contact with negative numbers more often than you might think; for example, very cold temperatures are recorded as negative numbers.

As you move to the right along the number line, the numbers get larger. Mathematically, to indicate that one number, say 4, is *greater than* another number, say –2, the *greater than* sign (>) is used:

$$4 > -2$$

On the other hand, to say that –2 is *less than* 4, we use the *less than* sign (<):

$$-2 < 4$$

Arithmetic with Positive and Negative Numbers

The table on the next page illustrates the rules for doing arithmetic with signed numbers. Notice that when a negative number follows an operation (as it does in the second example below), it is often enclosed in parentheses to avoid confusion.

When more than one arithmetic operation appears, you must know the correct sequence in which to perform the operations. For example, do you know what to do first to calculate $2 + 3 \times 4$? You're right if you said, "Multiply first." The correct answer is 14. If you add first, you'll get the wrong answer of 20! The correct sequence of operations is:

1. **P**arentheses
2. **E**xponents
3. **M**ultiplication or **D**ivision
   (whichever comes first when reading left to right)
4. **A**ddition or **S**ubtraction
   (whichever comes first when reading left to right)

} If you remember this saying, you'll know the order of operations: **P**lease **E**xcuse **M**y **D**ear **A**unt **S**ally.

Even when signed numbers appear in an equation, the step-by-step process works exactly as it does for positive numbers. You just have to remember the arithmetic rules for negative numbers. For example, let's solve $-14x + 2 = 5$.

1. Subtract 2 from both sides:

$$-14x + 2 = -5$$
$$\underline{\quad -2 \quad -2}$$

2. Divide both sides by −14:

$$\frac{-14x}{-14} = \frac{-7}{-14}$$
$$x = \frac{1}{2}$$

RULE	EXAMPLE
ADDITION	
If both numbers have the same sign, just add them. The answer has the same sign as the numbers being added.	$3 + 5 = 8$ $-3 + (-5) = -8$
If both numbers have different signs, subtract the smaller number from the larger. The answer has the same sign as the larger number.	$-3 + 5 = 2$ $3 + (-5) = -2$
If both numbers are the same but have opposite signs, the sum is zero.	$3 + (-3) = 0$
SUBTRACTION	
Change the subtraction sign to addition. Add as above.	$3 - 5 = 3 + (-5) = -2$ $-3 - 5 = -3 + (-5) = -8$ $-3 - (-5) = -3 + 5 = 2$
MULTIPLICATION	
Multiply the numbers together. If both numbers have the same sign, the answer is positive; otherwise, it is negative.	$3 \times 5 = 15$ $-3 \times (-5) = 15$ $-3 \times 5 = -15$ $3 \times (-5) = -15$
If one number (or both) is zero, the answer is zero.	$3 \times 0 = 0$
DIVISION	
Divide the numbers. If both numbers have the same sign, the answer is positive; otherwise, it is negative.	$15 \div 3 = 5$ $-15 \div (-3) = 5$ $15 \div (-3) = -5$ $-15 \div 3 = -5$
If the number to be divided (or the top number of a fraction) is zero, the answer is zero. You cannot divide by zero; thus, the bottom number of a fraction cannot be zero.	$3 \div 0$ is meaningless

Algebraic Expressions

An algebraic expression is a group of numbers, unknowns, and arithmetic operations, like: $3x - 2y$. This one may be translated as, "3 times some number minus 2 times another number." To *evaluate* an algebraic expression, replace each variable with its value. For example, if $x = 5$ and $y = 4$, we would evaluate $3x - 2y$ as follows:

$$3(5) - 2(4) = 15 - 8 = 7$$

Even when signed numbers appear in an equation, the step-by-step solution works exactly as it does for positive numbers. For example, let's solve $-14x + 2 = 5$.

1. Subtract 2 from both sides:

$$\begin{array}{r} -14x + 2 = -5 \\ \underline{\quad -2 \quad -2} \\ -14x = -7 \end{array}$$

2. Divide both sides by –14:

$$\begin{array}{r} -14x \div -14 = -7 \div -14 \\ x = \frac{1}{2} \end{array}$$

Now try these problems with signed numbers.

_____ **98.** $1 - 3\ (-4) = x$

_____ **99.** $-3x + 6 = -18$

_____ **100.** $-\frac{x}{4} + 3 = -7$

Evaluate these expressions.

_____ **101.** $4a + 3b$; $a = 2$ and $b = -1$

_____ **102.** $3mn - 4m + 2n$; $m = 3$ and $n = -3$

_____ **103.** $-2x - \frac{1}{2}y + 4z$; $x = 5$, $y = -4$, and $z = 6$

_____ **104.** The volume of a cylinder is given by the formula $V = \pi r^2 h$, where r is the radius of the base and h is the height of the cylinder. What is the volume of a cylinder with a base radius of 3 and height of 4? (Leave π in your answer.)

Squares and Square Roots

It's not uncommon to see squares and square roots on standardized math tests, especially on questions that involve right triangles.

To find the **square** of a number, multiply that number by itself. For example, the square of 4 is 16, because $4 \times 4 = 16$. Mathematically, this is expressed as:

$$4^2 = 16$$

4 squared equals 16.

To find the **square root** of a number, ask yourself, "What number times itself equals the given number?" For example, the square root of 16 is 4 because $4 \times 4 = 16$. Mathematically, this is expressed as:

$$\sqrt{16} = 4$$

The square root of 16 is 4.

Because certain squares and square roots tend to appear more often than others on standardized tests, the best course is to memorize the most common ones.

COMMON SQUARES AND SQUARE ROOTS

SQUARES			SQUARE ROOTS		
$1^2 = 1$	$7^2 = 49$	$13^2 = 169$	$\sqrt{1} = 1$	$\sqrt{49} = 7$	$\sqrt{169} = 13$
$2^2 = 4$	$8^2 = 64$	$14^2 = 196$	$\sqrt{4} = 2$	$\sqrt{64} = 8$	$\sqrt{196} = 14$
$3^2 = 9$	$9^2 = 81$	$15^2 = 225$	$\sqrt{9} = 3$	$\sqrt{81} = 9$	$\sqrt{225} = 15$
$4^2 = 16$	$10^2 = 100$	$16^2 = 256$	$\sqrt{16} = 4$	$\sqrt{100} = 10$	$\sqrt{256} = 16$
$5^2 = 25$	$11^2 = 121$	$20^2 = 400$	$\sqrt{25} = 5$	$\sqrt{121} = 11$	$\sqrt{400} = 20$
$6^2 = 36$	$12^2 = 144$	$25^2 = 625$	$\sqrt{36} = 6$	$\sqrt{144} = 12$	$\sqrt{625} = 25$

You can multiply and divide square roots, but you cannot add or subtract them:

$$\sqrt{a} + \sqrt{b} \neq \sqrt{a+b} \qquad \sqrt{a} \times \sqrt{b} = \sqrt{a \times b}$$
$$\sqrt{a} - \sqrt{b} \neq \sqrt{a-b} \qquad \sqrt{\frac{a}{b}} = \frac{\sqrt{a}}{\sqrt{b}}$$

Use the rules above to solve these problems in squares and square roots.

_____ **105.** $\sqrt{4} \times \sqrt{9} = ?$

_____ **106.** $\sqrt{\frac{1}{4}} = ?$

_____ **107.** $\sqrt{9} + \sqrt{16} = ?$

How to Solve an Equation

Example: $5 - 2(3x + 1) = 7x - 8$

1. Remove parentheses by distribution: $5 - 6x - 2 = 7x - 8$

2. If there are like terms on the same side of the equals sign, combine them: $3 - 6x = 7x - 8$

3. Decide where you want all of the x terms. Put all the x terms on one side by addition and subtraction:

$$\begin{array}{r} +6x = +6x \\ \hline 3 = 13x - 8 \end{array}$$

4. Get all the constants on the other side by addition and subtraction:

$$\begin{array}{r} 3 = 13x - 8 \\ +8 = +8 \\ \hline 11 = 13x \end{array}$$

5. Isolate the x by performing the opposite operation:

$$\frac{11}{13} = \frac{\cancel{13}x}{\cancel{13}}$$

$$\frac{11}{13} = x$$

_____ **108.** $\sqrt{9 + x} = 5$

_____ **109.** $(3 + x)^2 = 49$

▶ Geometry

Geometry questions cover points, lines, planes, angles, triangles, rectangles, squares, and circles. You may be asked to determine the area or perimeter of a particular shape, the size of an angle, the length of a line, and so forth. Some word problems may also involve geometry.

Points, Lines, and Planes

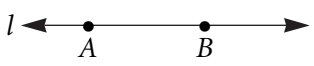
What Is a Point?

A point has position but no size or dimension. It is usually represented by a dot named with an uppercase letter: • A

What Is a Line?

A line consists of an infinite number of points that extend endlessly in both directions.

A line can be named in two ways:



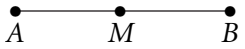
1. By a letter at one end (typically in lowercase): l

2. By two points on the line: $\overleftrightarrow{AB}$ or $\overleftrightarrow{BA}$

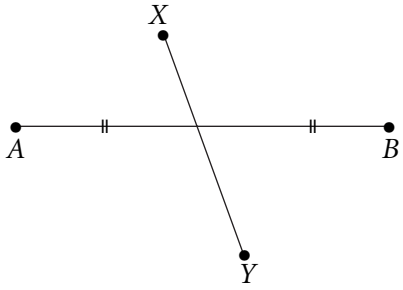
The following terminology is frequently used on math tests:

- Points are **collinear** if they lie on the same line. Points *J*, *U*, *D*, and *I* are collinear.

- A **line segment** is a section of a line with two endpoints. The line segment at right is indicated as $\overline{AB}$.



- The **midpoint** is a point on a line segment that divides it into two line segments of equal length. *M* is the midpoint of line segment *AB*. Two line segments of the same length are said to be **congruent**. Congruent line segments are indicated by the same mark on each line segment.

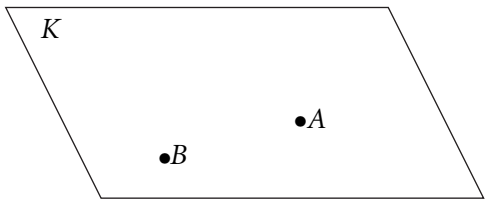


- A line segment (or line) that divides another line segment into two congruent line segments is said to ***bisect*** it. $\overline{XY}$ bisects $\overline{AB}$.

- A **ray** is a section of a line that has one endpoint. The ray at the right is indicated as $\overrightarrow{AB}$.

What Is a Plane?

A plane is like a flat surface with no thickness. Although a plane extends endlessly in all directions, it is usually represented by a four-sided figure and named by an uppercase letter in a corner of the plane: *K*.



Points are ***coplanar*** if they lie on the same plane. Points *A* and *B* are coplanar.

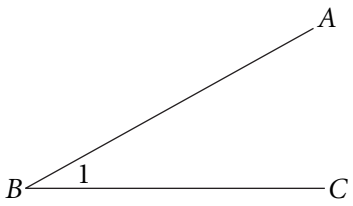
Angles

An angle is formed when two lines, segments, or rays meet at a point: The lines are called the **sides** of the angle, and the point where they meet is called the **vertex** of the angle.

The symbol used to indicate an angle is $\angle$.

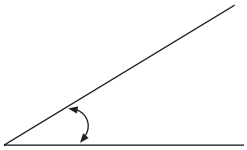
There are three ways to name an angle:

- By the letter that labels the vertex: $\angle B$
- By the three letters that label the angle: $\angle ABC$ or $\angle CBA$, with the vertex letter in the middle
- By the number inside the vertex: $\angle 1$



An angle's size is based on the opening between its sides. Size is measured in **degrees** (°). The smaller the angle, the fewer degrees it has. Angles are classified by size. Notice how the arc (↶) shows which of two angles is indicated:

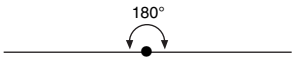
Acute angle: less than 90°



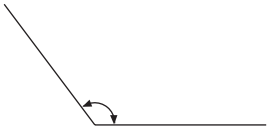
Right angle: exactly 90°

The little box indicates a right angle. A right angle is formed by two perpendicular lines.

Straight angle: exactly 180°

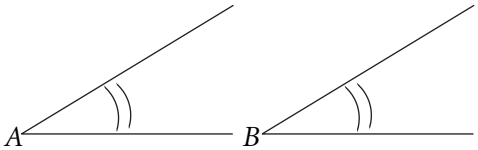


Obtuse angle: more than 90° and less than 180°



Special Angle Pairs

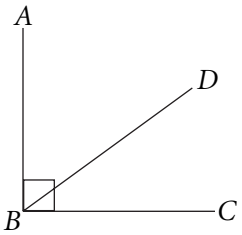
- **Congruent angles:** Two angles that have the same degree measure.



Congruent angles are marked the same way.

The symbol ≅ is used to indicate that two angles are congruent: $\angle A \cong \angle B$.

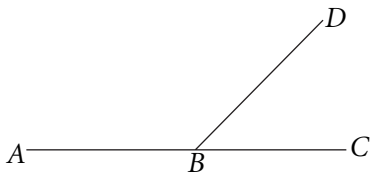
- **Complementary angles**: Two angles whose sum is 90°.



$\angle ABD$ and $\angle DBC$ are **complementary** angles.

$\angle ABD$ is the **complement** of $\angle DBC$, and vice versa.

■ **Supplementary angles:** Two angles whose sum is 180°.

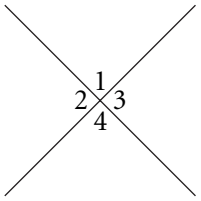


$\angle ABD$ and $\angle DBC$ are **supplementary** angles.

$\angle ABD$ is the **supplement** of $\angle DBC$, and vice versa.

Hook: To prevent confusing complementary and supplementary:
C comes before **S** in the alphabet, and 90 comes before 180.
Complementary: 90°
Supplementary: 180°

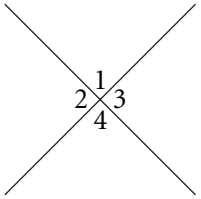
■ **Vertical angles:** Two angles that are opposite each other when two lines cross.



Two sets of vertical angles are formed:
$\angle 1$ and $\angle 4$
$\angle 2$ and $\angle 3$
Vertical angles are congruent.
When two lines cross, the **adjacent** angles are supplementary and the sum of all four angles is 360°.

Angle-pair problems tend to ask for an angle's complement or supplement.

Example: If the measure of $\angle 2 = 70°$, what are the measures of the other three angles?

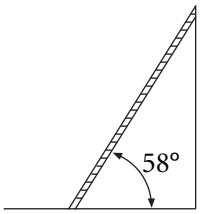


1. $\angle 2 \cong \angle 3$ because they're vertical angles.
Therefore, $\angle 3 =$ **70°**.
2. $\angle 1$ and $\angle 2$ are adjacent angles and therefore supplementary.
Thus, $\angle 1 =$ **110°** ($180° - 70° = 110°$).
3. $\angle 1 \cong \angle 4$ because they're also vertical angles.
Therefore, $\angle 4 =$ **110°**.
Check: Add the angles to be sure their sum is 360°.

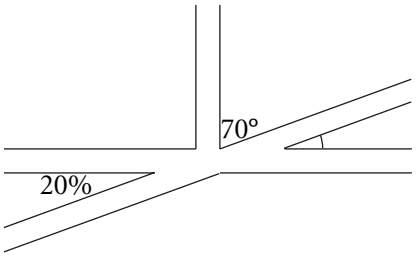
To solve geometry problems more easily, draw a picture if one is not provided. Try to draw the picture to scale. As the problem presents information about the size of an angle or line segment, label the corresponding part of your picture to reflect the given information. As you begin to find the missing information, label your picture accordingly.

These word problems require you to find the measures of angles.

_____**110.** In order to paint the second story of his house, Alex leaned a ladder against the side of his house, making an acute angle of 58° with the ground. Find the size of the obtuse angle the ladder made with the ground.



_____**111.** Confusion Corner is an appropriately named intersection that confuses drivers unfamiliar with the area. Referring to the street plan on the right, find the size of the marked angle.

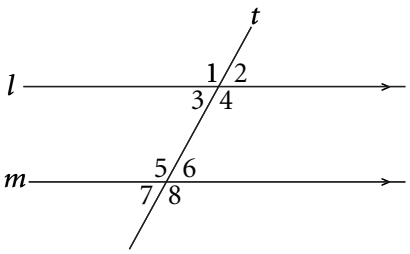


Special Line Pairs

Parallel Lines

Parallel lines lie in the same plane and don't cross at any point.

The arrowheads on the lines indicate that they are parallel. The symbol || is used to indicate that two lines are parallel: $l \parallel m$.



When two parallel lines are crossed by another line, two groups of four angles each are formed. One group consists of $\angle 1$, $\angle 2$, $\angle 3$, and $\angle 4$; the other group contains $\angle 5$, $\angle 6$, $\angle 7$, and $\angle 8$.

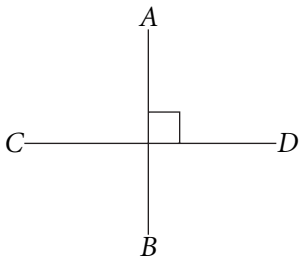
These angles have special relationships:

- The four obtuse angles are congruent: $\angle 1 \cong \angle 4 \cong \angle 5 \cong \angle 8$.
- The four acute angles are congruent: $\angle 2 \cong \angle 3 \cong \angle 6 \cong \angle 7$.
- The sum of any one acute angle and any one obtuse angle is 180° because the acute angles lie on the same line as the obtuse angles.

Don't be fooled into thinking two lines are parallel just because they look parallel. Either the lines must be marked with similar arrowheads or there must be an angle pair as just described.

Perpendicular Lines

Perpendicular lines lie in the same plane and cross to form four right angles.



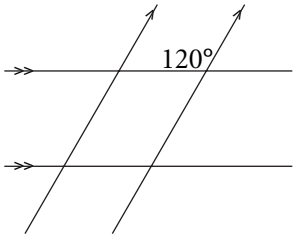
The little box where the lines cross indicates a right angle. Because vertical angles are equal and the sum of all four angles is 360°, each of the four angles is a right angle. However, only one little box is needed to indicate this.

The symbol ⊥ is used to indicate that two lines are perpendicular: $\overleftrightarrow{AB} \perp \overleftrightarrow{CD}$.

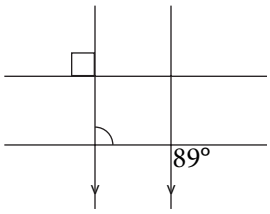
Don't be fooled into thinking two lines are perpendicular just because they look perpendicular. The problem must indicate the presence of a right angle (by stating that an angle measures 90° or by the little right angle box in a corresponding diagram), or you must be able to prove the presence of a 90° angle.

Determine the measure of the marked angles.

_____112.



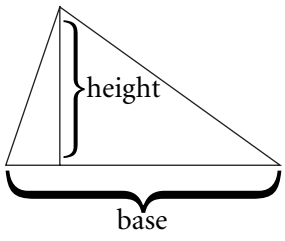
_____113.



Polygons

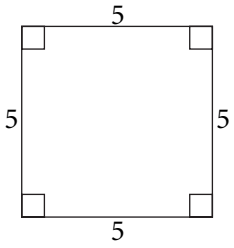
A polygon is a closed, plane (flat) figure formed by three or more connected line segments that don't cross each other. Familiarize yourself with the following polygons; they are the four most common polygons appearing on standardized tests—and in life.

Triangle



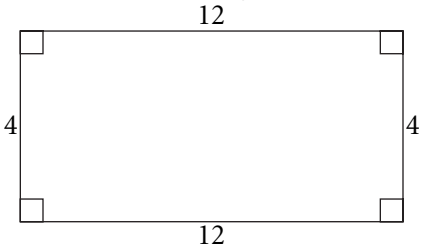
Three-sided polygon

Square



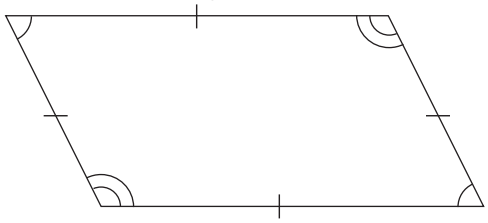
Four-sided polygon with four right angles; all sides are congruent (equal), and each pair of opposite sides is parallel.

Rectangle



Four-sided polygon with four right angles; each pair of opposite sides is parallel and congruent.

Parallelogram



Four-sided polygon; each pair of opposite sides is parallel.

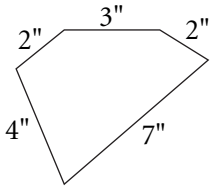
Perimeter

Perimeter is the distance around a polygon. The word *perimeter* is derived from *peri*, which means around (as in *peri*scope and *peri*pheral vision), and *meter*, which means *measure*. Thus *perimeter* is the *measure around* something. There are many everyday applications of perimeter. For instance, a carpenter measures the perimeter of a room to determine how many feet of ceiling molding she needs. A farmer measures the perimeter of a field to determine how many feet of fencing he needs to surround it.

Perimeter is measured in length units, like feet, yards, inches, meters, etc.

> To find the perimeter of a polygon, add the lengths of the sides.

Example: Find the perimeter of the polygon below:



Write down the length of each side and add:

3 inches
2 inches
7 inches
4 inches
+ 2 inches
18 inches

The notion of perimeter also applies to a circle; however, the perimeter of a circle is referred to as its **circumference**.

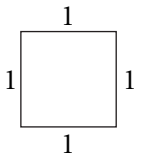
Find the perimeters for these word problems:

_____ **114.** Maryellen has cleared a 10–foot-by-6–foot rectangular plot of ground for her herb garden. She must completely enclose it with a chain-link fence to keep her dog out. How many feet of fencing does she need, excluding the 3–foot gate at the south end of the garden?

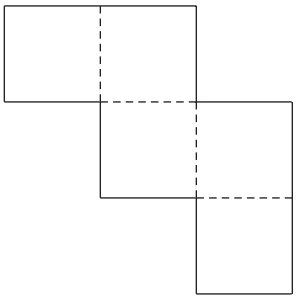
_____ **115.** Terri plans to hang a wallpaper border along the top of each wall in her square dressing room. Wallpaper border is sold only in 12–foot strips. If each wall is 8 feet long, how many strips should she buy?

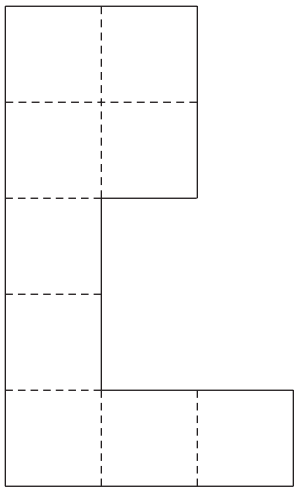
Area

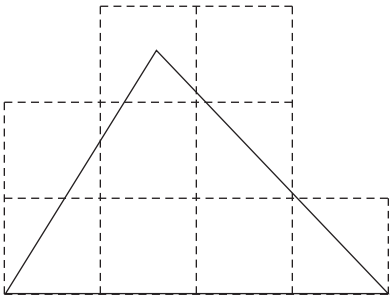
Area is the amount of space taken by a figure's surface. Area is measured in square units. For instance, a square that is 1 unit on all sides covers *1 square unit*. If the unit of measurement for each side is feet, for example, then the area is measured in *square feet;* other possibilities are units like square inches, square miles, square meters, and so on.

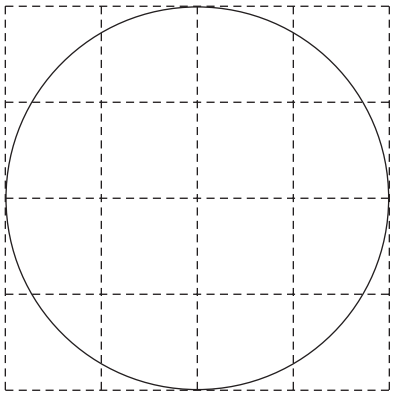


You could measure the area of any figure by counting the number of square units the figure occupies. The first two figures are easy to measure because the square units fit into them evenly, while the following two figures are more difficult to measure because the square units don't fit into them evenly.





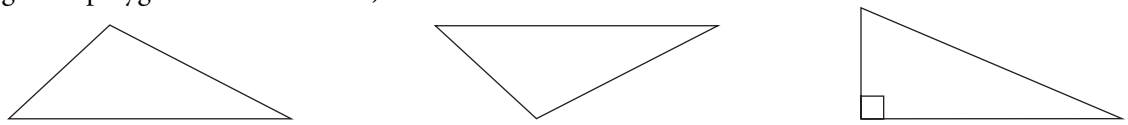




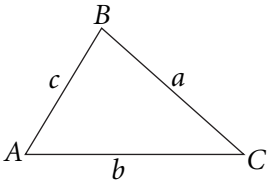
Because it's not always practical to measure a particular figure's area by counting the number of square units it occupies, an area formula is used. As each figure is discussed, you'll learn its area formula. Although there are perimeter formulas as well, you don't really need them (except for circles) if you understand the perimeter concept: It is merely the sum of the lengths of the sides.

Triangles

A triangle is a polygon with three sides, like those shown here:



The symbol used to indicate a triangle is $\triangle$. Each vertex—the point at which two lines meet—is named by a capital letter. The triangle is named by the three letters at the vertices, usually in alphabetical order: $\triangle ABC$.



There are two ways to refer to a side of a triangle:

- By the letters at each end of the side: *AB*
- By the letter—typically a lowercase letter—next to the side: *a*
  Notice that the name of the side is the same as the name of the angle opposite it, except the angle's name is a capital letter.

There are two ways to refer to an angle of a triangle:

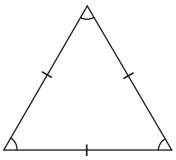
- By the letter at the vertex: $\angle A$
- By the triangle's three letters, with that angle's vertex letter in the middle: $\angle BAC$ or $\angle CAB$

Types of Triangles

A triangle can be classified by the size of its angles and sides.

Equilateral Triangle

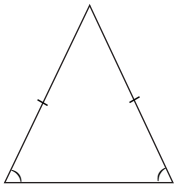
- 3 congruent angles, each 60°
- 3 congruent sides



Hook to help you remember: The word *equilateral* comes from *equi*, meaning *equal*, and *lat*, meaning *side*. Thus, *all equal sides*.

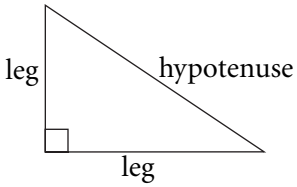
Isosceles Triangle

- 2 congruent angles, called *base angles*; the third angle is the *vertex angle.*
- Sides opposite the base angles are congruent.
- An equilateral triangle is also isosceles.



Right Triangle

- 1 right (90°) angle, the largest angle in the triangle
- The side opposite the right angle is the *hypotenuse*, the longest side of the triangle. (**Hook:** The word *hypotenuse* reminds us of *hippopotamus*, a very large animal.)
- The other two sides are called *legs*.



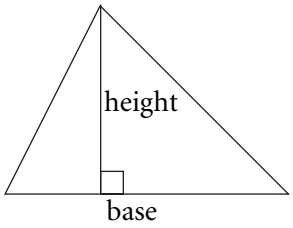
Area of a Triangle

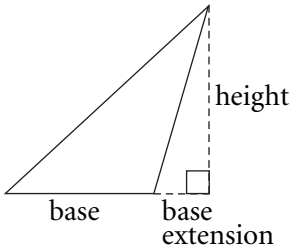
To find the area of a triangle, use this formula:

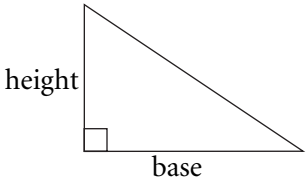
$$area = \frac{1}{2}(base \times height)$$

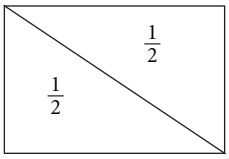
Although any side of a triangle may be called its **base**, it's often easiest to use the side on the bottom. To use another side, rotate the page and view the triangle from another perspective.

A triangle's **height** is represented by a perpendicular line drawn from the angle opposite the base to the base. Depending on the triangle, the height may be inside, outside, or on the triangle. Notice the height of the second triangle: We extended the base to draw the height perpendicular to the base. The third triangle is a **right** triangle: One leg may be its base and the other its height.



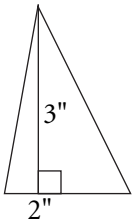






Hook: Think of a triangle as being half a rectangle. The area of that triangle is half the area of the rectangle.

Example: Find the area of a triangle with a 2-inch base and a 3-inch height.

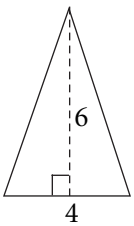


1. Draw the triangle as close to scale as you can.
2. Label the size of the base and height.
3. Write the area formula; then substitute the base and height numbers into it:
4. The area of the triangle is **3 square inches**.

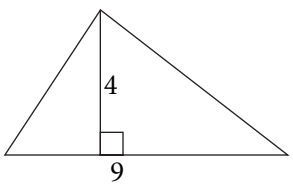
$area = \frac{1}{2}(base \times height)$
$area = \frac{1}{2}(2 \times 3) = \frac{1}{2} \times 6$
$area = \mathbf{3}$

Find the area of the triangles.

_____ **116.**



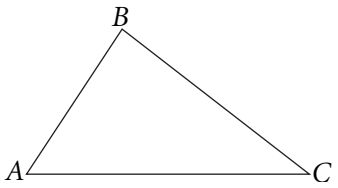
_____ **117.**



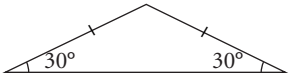
Triangle Rules

The following rules tend to appear more frequently on standardized tests than other rules. A typical test question follows each rule.

> The sum of the angles in a triangle is 180°:
> $\angle A + \angle B + \angle C = 180°$



Example: One base angle of an isosceles triangle is 30°. Find the vertex angle.

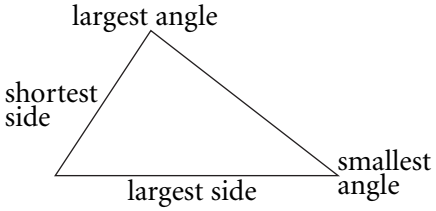


1. Draw a picture of an isosceles triangle. Drawing it to scale helps: Since it is an isosceles triangle, draw both base angles the same size (as close to 30° as you can) and make sure the sides opposite them are the same length. Label one base angle as 30°.
2. Since the base angles are congruent, label the other base angle as 30°.
3. There are two steps needed to find the vertex angle:
   - Add the two base angles together: $30° + 30° = 60°$
   - The sum of all three angles is 180°. To find the vertex angle, subtract the sum of the two base angles (60°) from 180°: $180° - 60° =$ **120°**

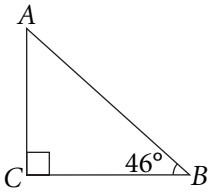
Thus, the vertex angle is **120°**.

Check: Add all 3 angles together to make sure their sum is 180°:
$30° + 30° + 120° = 180°$ ✔

> The longest side of a triangle is opposite the largest angle. This rule implies that the second-longest side is opposite the second-largest angle, and the shortest side is opposite the shortest angle.



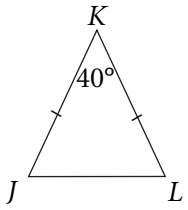
Example: In the triangle shown at the right, which side is the shortest?



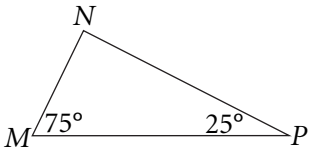
1. Determine the size of $\angle A$, the missing angle, by adding the two known angles and then subtracting their sum from 180°: Thus, $\angle A$ is 44°.
   $90° + 46° = 136°$
   $180° - 136° = 44°$
2. Since $\angle A$ is the smallest angle, side BC, which is opposite $\angle A$, is the shortest side.

Find the missing angles.

_____**118.**

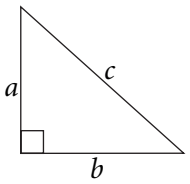


_____**119.**

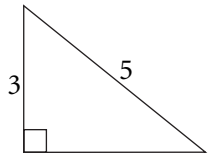


Right Triangles

To find the missing side of a RIGHT triangle, use the *Pythagorean theorem*:
$a^2 + b^2 = c^2$
(*c* is the hypotenuse)



Example: What is the perimeter of the triangle shown at the right?



1. Since the perimeter is the sum of the lengths of the sides, we must first find the missing side. Use the Pythagorean theorem: $a^2 + b^2 = c^2$

2. Substitute the given sides for two of the letters. Remember: Side *c* is always the hypotenuse:

$$3^2 + b^2 = 5^2$$

3. To solve this equation, subtract 9 from both sides:

$$\begin{array}{r} 9 + b^2 = 25 \\ \underline{-9 \qquad -9} \\ b^2 = 16 \end{array}$$

4. Then, take the square root of both sides.
Thus, the missing side has a length of **4** units:

$$\sqrt{b^2} = \sqrt{16}$$
$$b = \mathbf{4}$$

5. Adding the three sides yields a perimeter of **12**:

$$3 + 4 + 5 = \mathbf{12}$$

Simplifying Radicals

$$\text{Index } \sqrt[3]{48} \text{ Radical sign}$$
$$\text{Radicand}$$

A radical is **simplified** if there is no perfect square factor of the radicand. For example, $\sqrt{10}$ is simplified because 10 has no perfect square factors. But, $\sqrt{20}$ is not simplified because 20 has a perfect square factor of 4.

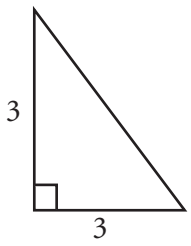
In order to simplify a radical, rewrite the radical as the product of two radicals, one of which is the largest perfect square factor of the radicand. The square root of a perfect square always simplifies to a rational number. Simplify the perfect square radical to get your final answer.

Example: Simplify $\sqrt{50}$.

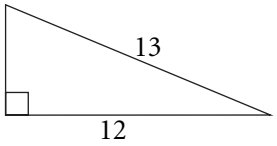
$$\sqrt{50} = \sqrt{25 \times 2} = \sqrt{25} \times \sqrt{2} = 5\sqrt{2}$$

Find the perimeter and area of each triangle. **Hint:** Use the Pythagorean theorem.

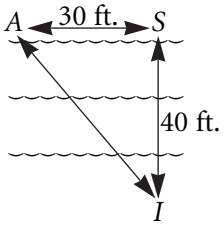
_____**120.**



_____**121.**



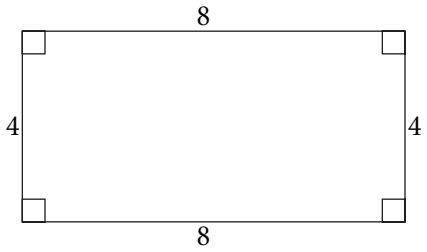
_____**122.** Irene is fishing at the edge of a 40–foot wide river, directly across from her friend Sam, who is fishing at the edge of the other side. Sam's friend Arthur is fishing 30 feet down the river from Sam. How far is Irene from Arthur?



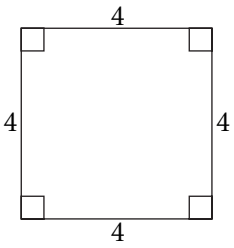
Quadrilaterals

A quadrilateral is a four-sided polygon. Here are three quadrilaterals that are most likely to appear on standardized tests (and in life):

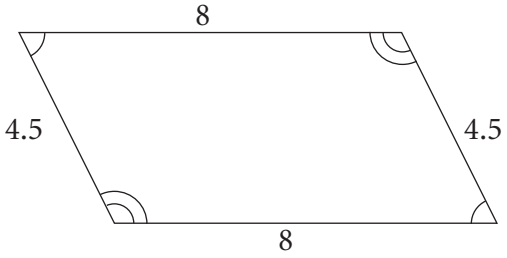
Rectangle



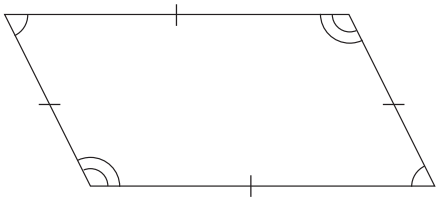
Square



Parallelogram

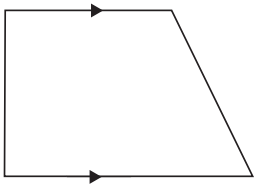


Rhombus



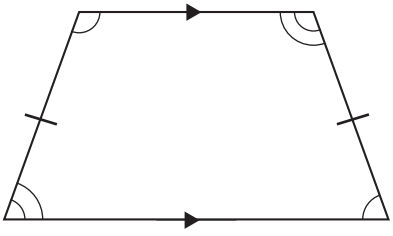
Four-sided polygon with each pair of opposite sides parallel, and all sides are congruent.

Trapezoid



Four-sided polygon with exactly one pair of opposite sides parallel.

Isosceles Trapezoid



Trapezoid whose nonparallel sides are congruent. Base angles are ≅.

These quadrilaterals have something in common beside having four sides:

- Opposite sides are the same size and parallel.
- Opposite angles are the same size.

However, each quadrilateral has its own distinguishing characteristics:

QUADRILATERALS			
	RECTANGLE	**SQUARE**	**PARALLELOGRAM**
SIDES	Adjacent sides are not necessarily the same length.	All four sides are the same size.	Adjacent sides are not necessarily the same length.
ANGLES	All the angles are right angles.	All the angles are right angles.	The opposite angles are the same size, but they don't have to be right angles. (A rectangle leaning to one side is a parallelogram.)

The naming conventions for quadrilaterals are similar to those for triangles:

- The figure is named by the letters at its four consecutive corners, usually in alphabetic order: rectangle *ABCD*.
- A side is named by the letters at its ends: side *AB*.
- An angle is named by its vertex letter: $\angle A$.

The sum of the angles of a quadrilateral is 360°:
$\angle A + \angle B + \angle C + \angle D = 360°$

Perimeter

To find the perimeter of a quadrilateral, follow this simple rule:

Perimeter = Sum of all four sides

Shortcut: Take advantage of the fact that the opposite sides of a rectangle and a parallelogram are equal: Just add two adjacent sides and double the sum. Similarly, multiply one side of a square by four.

Here are some word problems in perimeters of quadrilaterals:

_____**123.** What is the length of a side of a square room whose perimeter is 58 feet?

a. 8 feet
b. 14 feet
c. 14.5 feet
d. 29 feet
e. 232 feet

_____**124.** Find the dimensions of a rectangle with perimeter of 16 feet and whose long size is 3 times its short side.

a. 4 ft. by 4 ft.
b. 4 ft. by 12 ft.
c. 3 ft. by 5 ft.
d. 2 ft. by 6 ft.
e. 2 ft. by 8 ft.

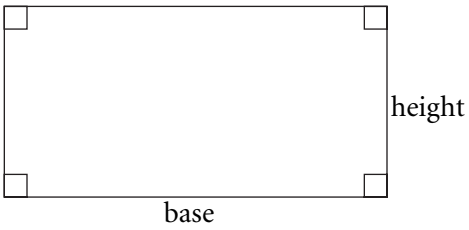
Area

To find the area of a rectangle, square, or parallelogram, use this formula:

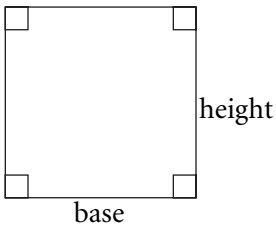
$$Area = base \times height$$

The **base** is the size of one of the sides. It is easiest if you call the side on the bottom the base, but any side can be a base. The **height** (or **altitude**) is the size of a perpendicular line drawn from the base to the side opposite it. The height of a rectangle and a square is the same as the size of its non-base side.

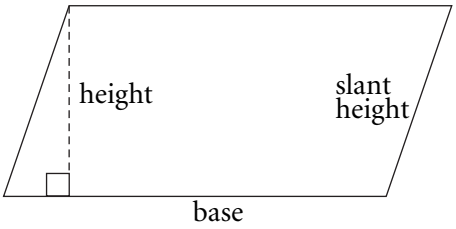
Rectangle



Square



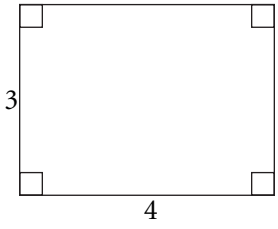
Caution: A parallelogram's height is not usually the same as the size connecting the base to its opposite side (called the *slant height*), but the size of a perpendicular line drawn from the base to the side opposite it.



Example: Find the area of a rectangle with a base of 4 meters and a height of 3 meters.

1. Draw the rectangle as close to scale as possible.
2. Label the size of the base and height.
3. Write the area formula; then substitute the base and height numbers into it: Thus, the area is **12 square meters**.

$A = b \times h$
$A = 4 \times 3 = \mathbf{12}$



Now try some area word problems:

_____**125.** Tristan is laying 12–inch by 18–inch tiles on the laboratory floor. If the lab measures 15 feet by 18 feet, how many tiles does Tristan need, assuming there's no waste? (Hint: Do *all* your work in either feet or inches.)

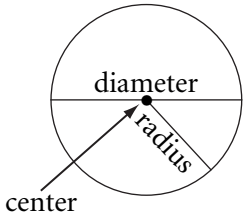
a. 12
b. 120
c. 180
d. 216
e. 270

_____**126.** What is the length in feet of a rectangular parking lot that has an area of 8,400 square feet and a width of 70 feet?

a. 12
b. 120
c. 1,200
d. 4,000
e. 4,130

Circles

We can all recognize a circle when we see one, but its definition is a bit technical. A **circle** is a set of points that are all the same distance from a given point called the **center**. That distance is called the **radius**. The **diameter** is twice the length of the radius; it passes through the center of the circle.



Circumference

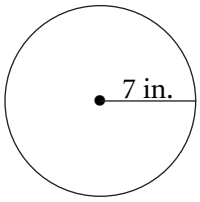
The **circumference** of a circle is the distance around the circle (it is the perimeter of the circle). To determine the circumference of a circle, use either of these two equivalent formulas:

$$\text{Circumference} = 2\pi r$$
$$\text{or}$$
$$\text{Circumference} = \pi d$$

- r is the radius
- d is the diameter
- π is approximately equal (denoted by the symbol $\approx$) to 3.14 or $\frac{22}{7}$

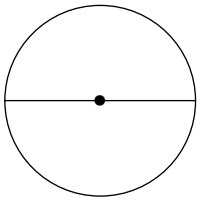
Note: Math often uses letters of the Greek alphabet, like π (pi). Perhaps that's what makes math seem like Greek to some people! In the case of the circle, you can use π as a hook to recognize a circle question: A *pie* is shaped like a circle.

Example: Find the circumference of a circle whose radius is 7 inches.



1. Draw this circle and write the radius version of the circumference formula (because you're given the radius): $C = 2\pi r$
2. Substitute 7 for the radius: $C = 2 \times \pi \times 7$
3. On a multiple-choice test, look at the answer choices to determine whether to leave π in your answer or substitute the *value of* π in the formula.
   If the answer choices don't include π, substitute $\frac{22}{7}$ or 3.14 for π and multiply: $C = 2 \times \frac{22}{7} \times 7$; $C \approx$ **44**
   $C = 2 \times 3.14 \times 7$; $C \approx$ **43.96**
   If the answer choices include π, just multiply: $C = 2 \times \pi \times 7$; $C =$ **14π**
   All the answers—**44 inches, 43.96 inches,** and **14π inches**—are considered correct.

Example: What is the diameter of a circle with a circumference of 62.8 centimeters? Use 3.14 for π.



1. Draw a circle with its diameter and write the diameter version of the circumference formula (because you're asked to find the diameter): $C = \pi d$
2. Substitute 62.8 for the circumference, 3.14 for π, and solve the equation: $62.8 = 3.14 \times d$
   The diameter is **20 centimeters**. $62.8 = 3.14 \times$ **20**

These word problems require you to find the circumference:

_____**127.** What is the circumference of a circular room whose diameter is 15 feet?

a. 7.5π ft.
b. 15π ft.
c. 30π ft.
d. 45π ft.
e. 225π ft.

_____**128.** What is the approximate circumference of a round tower whose radius is $3\frac{2}{11}$ feet?

a. 10 ft.
b. 20 ft.
c. 33 ft.
d. 40 ft.
e. 48 ft.

_____**129.** Find the circumference of a water pipe whose radius is 1.2 inches.

a. 1.2π in.
b. 1.44π in.
c. 2.4π in.
d. 12π in.
e. 24π in.

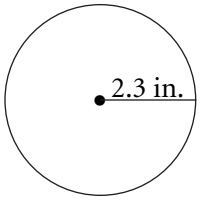
Area

The **area** of a circle is the space its surface occupies. To determine the area of a circle, use this formula:

$$Area = \pi r^2$$

Hook: To avoid confusing the area and circumference formulas, just remember that *area* is always measured in *square* units, like 12 *square yards* of carpeting. Thus, the *area* formula is the one with the *squared* term in it.

Example: Find the area of the circle at right, rounded to the nearest tenth:



1. Write the area formula: $A = \pi r^2$
2. Substitute 2.3 for the radius: $A = \pi \times 2.3 \times 2.3$
3. On a multiple-choice test, look at the answer choices to determine whether to use π or an approximate *value of* π (decimal or fraction) in the formula. If the answers don't include π, use 3.14 for π (because the radius is a decimal): $A = 3.14 \times 2.3 \times 2.3$

   $\boldsymbol{A = 16.6}$

   If the answers include π, multiply and round: $A = \pi \times 2.3 \times 2.3$

   $\boldsymbol{A = 5.3\pi}$

   Both answers—**16.6 square inches** and **5.3π square inches**—are correct.

Example: What is the diameter of a circle with an area of 9π square centimeters?

1. Draw a circle with its diameter (to help you remember that the question asks for the diameter); then write the area formula: $A = \pi r^2$
2. Substitute 9π for the area and solve the equation: $9\pi = \pi r^2$

$9 = r^2$

Since the radius is 3 centimeters, the diameter is **6 centimeters**. $3 = r$

Try these word problems on the area of a circle:

_____ **130.** What is the area in square inches of the bottom of a beaker with a diameter of 6 inches?

a. 6π
b. 9π
c. 12π
d. 18π
e. 36π

_____ **131.** James Band is believed to be hiding within a 5–mile radius of his home. What is the approximate area, in square miles, of the region in which he may be hiding?

a. 15.7
b. 25
c. 31.4
d. 78.5
e. 157

_____ **132.** If a circular parking lot covers an area of 2,826 square feet, what is the size of its radius? (Use 3.14 for π.)

a. 30 ft.
b. 60 ft.
c. 90 ft.
d. 450 ft.
e. 900 ft.

▶ Answers to Math Problems

Word Problems

1. a.
2. e.
3. d.
4. e.

Fractions

5. $\frac{1}{4}$
6. $\frac{2}{5}$
7. $\frac{3}{8}$
8. 10
9. 6
10. 200
11. $\frac{11}{12}$
12. $\frac{55}{24}$ or $2\frac{7}{24}$
13. $7\frac{1}{4}$
14. $\frac{2}{15}$
15. $\frac{1}{8}$
16. $\frac{19}{12}$ or $1\frac{7}{12}$
17. a.
18. b.
19. $\frac{2}{15}$
20. $\frac{8}{35}$
21. $\frac{2}{3}$
22. $\frac{26}{15}$ or $1\frac{11}{15}$
23. 15
24. $\frac{33}{2}$ or $16\frac{1}{2}$
25. c.
26. e.
27. c.
28. $\frac{1}{2}$
29. $5\frac{1}{2}$
30. $\frac{1}{5}$
31. $\frac{45}{28}$ or $1\frac{17}{28}$
32. b.
33. d.
34. b.

Decimals

35. $\frac{5}{1{,}000}$ or $\frac{1}{200}$
36. $3\frac{12}{25}$
37. $123\frac{456}{1{,}000}$ or $123\frac{57}{125}$
38. 4
39. 8.305
40. .907
41. 1.456
42. b.
43. d.
44. .03
45. .3392
46. .70104
47. e.
48. e.
49. 1.4
50. 128
51. 572
52. 1,400
53. b.
54. c.

Percents

55. 45%
56. .8%
57. $16.\overline{6}\%$ or $16\frac{2}{3}\%$
58. .12
59. .875
60. 2.5
61. 12.5% or $12\frac{1}{2}\%$
62. 52%
63. $58.\overline{3}\%$ or $58\frac{1}{3}\%$
64. $\frac{19}{20}$
65. $\frac{3}{8}$
66. $\frac{5}{4}$ or $1\frac{1}{4}$
67. $\frac{1}{4}$ or .25
68. 9.1
69. $37\frac{1}{2}$ or 37.5
70. 75
71. 50%
72. $33\frac{1}{3}\%$
73. 300%
74. 100
75. 8
76. 10
77. c.
78. c.
79. c.
80. d.

Averages

81. **c.**
82. **c.**
83. **b.**

Length and Time

84. 24
85. 30
86. 1,600
87. 2.94
88. 8 ft.
89. 21 km 170 m
90. 1 ft. 4 in.
91. 7 cm 8 mm
92. **d.**
93. **b.**
94. **d.**

Algebra

95. 7
96. 4
97. 28
98. 13
99. 8
100. 40
101. 5
102. –45
103. 16
104. 36π
105. 6
106. $\frac{1}{2}$
107. 7
108. 16
109. 4

Geometry

110. 122°
111. 20°
112. 60°
113. 91° (The horizontal lines are not parallel.)
114. 29 feet
115. 3 strips
116. 12 square units
117. 18 square units
118. $\angle J = \angle L = 70°$
119. $\angle N = 80°$
120. Perimeter = $6 + 3\sqrt{2}$ units
Area = 4.5 square units
121. Perimeter = 30 units
Area = 30 square units
122. 50 feet
123. **c.**
124. **d.**
125. **c.**
126. **b.**
127. **b.**
128. **b.**
129. **c.**
130. **b.**
131. **d.**
132. **a.**

CHAPTER

7 Biology Review

CHAPTER SUMMARY

This chapter reviews the key biology concepts tested by health occupations entrance exams. After surveying the important concepts and testing yourself with the sample questions in this chapter, you will know where to concentrate further studies.

▶ Biology Review: Important Concepts

I. General Introduction

A. Description of How Health Occupations Entrance Exams Test Biology

Health occupations entrance exams do not measure scientific knowledge in the same way. The natural sciences section of the Health Occupations Aptitude Exam (HOAE) is made up of approximately 65 multiple-choice questions, which can include biology questions. Other entrance exams, like the Health Occupations Basic Entrance Test (HOBET), require only that you can read and understand college-level scientific material and identify key scientific concepts. It does not contain a separate test section on biology.

The following subject areas are important for you to know for your entrance exam: cell biology, heredity, human structure and function, bacteria and viruses, and plants.

B. How to Use This Chapter

This chapter includes major biology concepts you will encounter on the exam. There is also a section on other content areas that will be helpful to you in taking the test: the scientific method, the origin of life, a brief description

of taxonomic classification systems, and the social behavior of animals. The general discussions in this chapter, lists of terms and concepts, and "You Should Review" sections are meant to guide you in your studies—*they are not exhaustive* and must be supplemented with a good college textbook, a reliable medical dictionary and dictionary of biology, and a fair amount of general reading on the subject. Suggested sources of study materials are found at the end of this chapter.

After each main subject heading in this chapter, you will find several sample questions that represent the content and level of difficulty of the questions that will appear on the test. You should first read through the outline and try to answer the sample questions, and then make notes on those areas in which you need more work. After that, you will want to go to your source material and review all subject areas, with special emphasis on those areas where you feel least confident.

Allow yourself plenty of time to prepare before the exam. Remember that thorough preparation is the most important factor in test-taking success. By studying and taking practice tests, you become familiar with subject areas and typical test questions, boosting your ability to do your best on the exam.

II. Main Topics

A. Cell Biology

1. Definition of a Cell

The cell is the structural and functional unit of life.

The Cell Doctrine, generally credited to Schleiden (1838) and Schwann (1839), maintains that:

- All living things are made up of cells and the products formed by cells.
- Cells are units of structure and function.
- All cells arise from preexisting cells.

2. Two Types of Cells

a. Prokaryotic Cells

Prokaryotic cells: cells found only in bacteria and cyanobacteria (formerly known as blue-green algae). These cells lack a true nucleus and organelles.

b. Eukaryotic Cells

Eukaryotic cells: cells found in all organisms except bacteria. These cells are differentiated by membranes into subcellular structures called organelles, including a nucleus.

3. Organization of a Cell

a. Prokaryotic Cells

Prokaryotes (bacteria and cyanobacteria) do not have:

- a nucleus (DNA is throughout the cell and in rings called *plasmids*.)
- mitochondria
- chloroplasts
- Golgi apparatus
- lysosomes
- vacuoles
- cilia or flagella
- centrioles

Prokaryotes do have:

- a cell membrane
- a cell wall
- single chromosome, with DNA only
- ribosomes

b. Eukaryotic Cells

Eukaryotes include animals and plants.

Animal cells do not have:

- a cell wall
- chloroplasts

Animal cells do have:

- a cell membrane
- a nucleus
- chromosomes (multiple, with DNA and protein)
- ribosomes
- mitochondria
- Golgi apparatus
- lysosomes (often)
- vacuoles (sometimes—they may be small or there may be none)
- cilia or flagella (often)
- centrioles

Plant cells do not have:

- cilia or flagella
- centrioles

Plant cells do have:

- a cell membrane
- a nucleus
- a cell wall
- chromosomes (multiple, with DNA and protein)
- ribosomes
- mitochondria
- chloroplasts (in photosynthetic cells)
- Golgi apparatus
- plastids
- lysosomes
- vacuoles (one large single vacuole in a mature cell)

4. Energy Transformation in a Cell

a. General Discussion of Energy

The two concepts most basic to science are **matter** and **energy**.

Matter: anything that has mass and takes up space (volume).

Energy: the capacity to do work; a more abstract concept that can be described only as it affects matter.

There are two types of energy: **kinetic** and **potential**.

b. Thermodynamics

Thermodynamics: the physics of what is and is not possible with regard to energy.

First law of thermodynamics: Energy can be transferred and transformed, but it cannot be created or destroyed (conservation of energy).

Second law of thermodynamics: Every energy transfer or transformation results in the release of heat from the system to the rest of the universe.

c. Cell Metabolism

Cell metabolism: energy management by a cell. The complex structure of a cell includes pathways along which metabolism proceeds, aided by enzymes.

Bioenergetics: the study of how organisms manage energy, including heat production and transfer; and regulation of body temperature (endothermy and ectothermy).

Metabolism: the totality of chemical reactions that take place in an organism.

Anabolism: the metabolic synthesis of proteins, fats, etc., from simpler molecules; requires energy in the form of adenosine triphosphate (ATP).

Catabolism: the metabolic breakdown of molecules (for example, respiration).

Cellular respiration: a catabolic pathway for the production of ATP, in which sometimes oxygen is consumed as a reactant along with an organic fuel (food). At other times, the process proceeds without atmospheric oxygen, but this is less efficient.

- **Anaerobic pathway of cellular respiration:** Food (especially carbohydrates) is partially oxidized and chemical energy is released; however, atmospheric oxygen is not involved in the process.
- **Aerobic pathway of cellular respiration:** Food is completely oxidized to carbon dioxide and water, and chemical energy is released; atmospheric oxygen is involved in the process. The Krebs cycle, electron-transport chain, and oxidative phosphorylation are important concepts here.

Photosynthesis: conversion of light energy into chemical energy, on which, directly or indirectly, all living things depend. Photosynthesis occurs in plants, algae, and certain prokaryotes.

d. Enzymology

Enzymology: the study of the speed of the process of transformation of energy in a cell; enzymes change the rate of a reaction without themselves being consumed by that reaction.

e. Movement of Molecules

Small molecules are steadily transported across the cell membrane. Types of transport include **diffusion** and **passive transport**; **osmosis** (a special case of passive transport); and **active transport**.

5. Cell Reproduction

a. General Discussion of Cell Reproduction

All cells arise from other cells. The basis of all biological reproduction is cell division. A single, intact chain of life extends backward from today to the first bacteria on Earth.

Prokaryotes often reproduce simply, by binary fission, or division into identical halves. Eukaryotes have much more complicated genomes, and therefore, the process of reproduction is more complex.

b. The Cell Cycle

The cell cycle describes the entire life cycle of a cell including reproduction that occurs in an orderly sequence. M phase—division of nucleus and cytoplasm.

- **Mitosis:** division of the nucleus; distribution of nuclear materials, particularly chromosomes. For descriptive purposes, mitosis is divided into phases: prophase, prometaphase, metaphase, anaphase, and telophase.
- **Cytokinesis:** division of the cytoplasm into two identical daughter cells, which occurs during the telophase stage of mitosis.

Interphase—cell grows and copies chromosomes.

- **G1 phase:** vegetative, nonreproductive functions. The "restriction point" is here, just before DNA synthesis—if "no-go," the cell exits from cell cycle and enters G0 phase.
- **S phase:** DNA of nucleus doubles.
- **G2 phase:** mitosis proper.
- Back to M phase.

c. Control of Cell Division

A certain timing and rate of division are necessary to normal growth. Cell division can be interfered with by lack of nutrients, poisons, lack of growth factors (for example, platelet-derived growth factor or PDGF), cell size, and density.

d. When Things Go Wrong

In abnormal cell division (e.g., cancer), cells do not heed the restriction point; they may divide excessively, invading surrounding tissue. If given enough nutrients, they may divide "forever" (see "immortal" or HeLa cells); or abnormal cells may stop dividing at any point in the cell cycle, not just at the restriction point.

You Should Review

- the structure and function of prokaryotic and eukaryotic cells; comparison of the two
- the composition, structure, and function of organelles: nucleus (chromosomes and nucleolus); ribosomes; rough endoplasmic reticulum; smooth endoplasmic reticulum; Golgi apparatus; lysosomes; peroxisomes; central vacuole in plants; mitochondria; chloroplasts in plants and some protists; cytoskeleton; cell wall in plants, fungi, and some protists; glycocalyx in animals; and intercellular junctions
- cell membrane structure and function
- major features of bioorganic molecules; makeup of amino acids; RNA genetic code showing base sequence
- why compartmental organization is important in eukaryotic cells and an understanding of the way in which the various compartments interrelate—i.e., how organelles "cooperate"
- biological membranes and the importance of their selective permeability; the fluid mosaic model of cell membrane structure; structure and function of lipids, proteins, and carbohydrates
- differences between organelles of cells found in organisms in the various kingdoms (For more on classification of living organisms, see page 192.)
- properties of energy
- heat production and transfer mechanisms in various species; regulation of body temperature
- ATP: structure and hydrolysis; how it performs; regeneration from ADP and phosphate; metabolic disequilibrium; ATP syntheses
- metabolic map—the catabolic and anabolic pathways
- control of metabolism: feedback inhibition
- how body size affects metabolic rate
- enzymes (most of which are proteins): six major groups (oxidoreductases, transferases, hydrolases, lyases, isomerases, ligases) and the ways in which the various classes work; molecular structure; how enzymes function as biological catalysts; types and shapes of active sites; response to environmental conditions; enzyme inhibitors
- coenzymes, especially vitamins: classifications and functions
- cellular respiration
- basic mechanisms of prokaryotic and eukaryotic cell reproduction
- the cell cycle
- how cell division is controlled
- main features of abnormal cell division
- the following terms and concepts (among others): genome, haploid nucleus, diploid nucleus, chromatin, chromosome, centriole, atrophy, karyolysis, nucleic acid (especially DNA and RNA), pyrimidines (cytosine, thymine, uracil), purines (guanine and adenine), nucleotide, transcription, translation, meiosis (do not confuse with mitosis), basal metabolic rate

Questions

1. Most of a cell membrane's specific functions are controlled by
- **a.** lipids.
- **b.** proteins.
- **c.** plasma.
- **d.** nitrogen.

2. The basic method by which chloroplasts and mitochondria generate ATP is
- **a.** oxidation.
- **b.** photorespiration.
- **c.** respiration.
- **d.** chemiosmosis.

3. Which of the following regions exists just outside the nuclear membrane of most animal cells?
- **a.** the centrosome
- **b.** the equatorial plane
- **c.** the organelle
- **d.** the pellicle

4. The decay of a leaf after it falls from a tree indicates an increase in its
- **a.** ecological efficiency.
- **b.** entropy.
- **c.** metabolic disequilibrium.
- **d.** estivation.

5. Alcoholic fermentation is a form of
- **a.** anaerobic respiration.
- **b.** aerobic respiration.
- **c.** cation exchange.
- **d.** absorption.

6. Phagocytosis is a form of
- **a.** hydrolysis.
- **b.** exocytosis.
- **c.** glycolysis.
- **d.** endocytosis.

7. In the structure of cells, in which of the following organisms would one find a cell wall?
- **a.** a dog
- **b.** a fruit fly
- **c.** a tulip
- **d.** a mackerel

8. Which of the following is the electron acceptor in fermentation?
- **a.** pyridoxine
- **b.** pyruvate
- **c.** pyrimidine
- **d.** pyrrole

9. The small spherical bodies within a cell where proteins are assembled according to genetic instructions are called
- **a.** mitochondria.
- **b.** ribosomes.
- **c.** Golgi apparatus.
- **d.** lysosomes.

10. Metastasis refers to the
- **a.** uncontrolled division of cancer cells.
- **b.** irregularity in shape of a cancer cell.
- **c.** spread of cancer cells to sites beyond their origin.
- **d.** transformation of a normal cell into a cancer cell.

Answers

1. b. Although a cell membrane's main fabric is made of lipids, its specific functions are largely determined by proteins.

2. d. Chemiosmosis is the term used for this process. It is important to cellular work, including ATP synthesis.

3. a. The centrosome (also called the microtubule-organizing center) is found in all eukaryotic cells and is important during cell division.

4. b. Entropy (symbol S) is the quantitative measure of a system's disorder or randomness. As systems—whether houses, people, leaves, or stars—break down and undergo irreversible changes, making less energy available to them, their entropy increases.

5. a. Alcoholic fermentation is the anaerobic catabolism of organic nutrients; one of its end products is ethanol.

6. d. Phagocytosis and pinocytosis are both forms of endocytosis, the process by which materials enter a cell without passing through the cell membrane.

7. c. The cell wall is one of the cell structures that help differentiate between plants and animals.

8. b. Pyruvate is the correct answer. Under anaerobic conditions, like fermentation, it is converted to lactate or ethanol.

9. b. The ribosome is the site of protein synthesis.

10. c. Metastasis refers to the spread of cancer cells to areas beyond their original site.

B. Heredity

1. Pre-Mendelian Concepts

Before Mendel's discoveries, theories included averages or blending of colors like the mixing of paints; physical characteristics carried only by the male; characteristics carried by blood; small human grown large; pangenesis; and others.

2. Mendelian Inheritance

a. Mendel's Experiments

Gregor Mendel, the father of classical genetics, was an Austrian monk who, in a small monastery, tended a little garden and did experiments on garden peas, which have great variety. He allowed pure strains (one with purple flowers, one with white) to either self-pollinate or cross pollinate, strictly controlling the parentage. Cross pollinated breeds (hybrids) of purple and white flowers showed all purple flowers in the first generation. But when the second generation self-pollinated, the white trait reappeared. Thus, the theory of dominant and recessive traits was formed.

b. Mendel's Major Discoveries

Mendel found that no averages or blendings take place; instead, particular characteristics are retained, which are either dominant or recessive. Today, we know the mechanisms: genes and chromosomes; and DNA.

3. Chromosomal Genetics

Not all of a eukaryotic cell's genes are located on nuclear chromosomes—some are found in cytoplasmic organelles.

a. Genes and Chromosomes

Gene: a discrete heritable unit of information located on the chromosomes and made up of DNA

Chromosome: a long threadlike structure carrying genes in a linear sequence, found in the nucleus of eukaryotic cells, consisting of DNA (which stores or contains genetic information) and protein. Human beings possess 46 chromosomes; the ovum and sperm each contain 23, of which 22 are autosomes and one is a sex chromosome.

Chromatin: the substance of which eukaryotic chromosomes are composed, consisting mostly of proteins, DNA, and RNA

Chromatid: a threadlike strand formed as a chromosome condenses during the early stages of cell division

Character (or trait): a heritable feature; for each character, an organism inherits two genes

Genome: all the genes contained in a single set of chromosomes; an organism's genetic material

Autosome: a chromosome not directly involved in determining sex

Alleles: alternative versions of a gene, one from each parent. The existence of alleles explains why there is variation in inherited traits. An expressed trait is determined by two alleles. A dominant allele is fully expressed in the organism's appearance; a recessive allele has no noticeable effect unless two recessive alleles are inherited, in which case, the recessive trait will be expressed. For some traits, there is incomplete dominance.

Phenotype: an organism's appearance; its observable, physical and physiological traits; often depends on environment as well as genes

Genotype: an organism's genetic makeup (which is not always apparent), its genetic composition; the combination of alleles it possesses

b. DNA and RNA

DNA (deoxyribonucleic acid): a double-stranded, helical nucleic acid molecule capable of replicating. DNA makes up the genetic material of most living organisms and plays a central role in determining heredity.

RNA (ribonucleic acid): a single-stranded nucleic acid molecule involved in protein synthesis, the structure of which is specified by DNA. Messenger RNA (mRNA) is responsible for carrying the genetic code transcribed from DNA to specialized sites within a cell (ribosomes) where the information is translated into protein composition.

4. Molecular and Human Genetics

a. Molecular Genetics

Molecular genetics is a specialized type of molecular biology, concerned with the analysis of genes. Perhaps the most famous molecule in the world is the double-stranded helix, DNA, the substance of genes.

b. Human Genetics

Because human beings are much more complex organisms than the ones Mendel studied, and because experimental breeding of humans is socially unacceptable, study of human genetics must be done by analyzing the results of matings that have already occurred. This is done by examining the pedigree of the subjects involved—the interrelationships of parents and children across generations—and constructing a pedigree chart to study both past and future. Through the study of pedigrees, one can analyze genetic traits, from harmless (such as eye color and texture of hair) to harmful or lethal (such as the diseases discussed below). Various tests for genetic defects are also useful in the study of human genetics.

5. Treatment of Genetic Diseases and Genetic Engineering

a. Genetic Diseases

Although most harmful alleles are recessive, some genetic combinations can lead to lethal conditions. Examples are Huntington's disease, Tay-Sachs disease, sickle-cell anemia, cystic fibrosis, and others, along with sex-linked disorders such as hemophilia. Two carriers of the same harmful allele may mate; the likelihood of this happening is increased in consanguineous ("same blood") mating—i.e., mating between two close relatives (for example, siblings or first cousins). However, consanguineous mating can also lead to concentration of favorable alleles.

In addition to simple Mendelian disorders, there are multifactorial disorders, resulting from effects of harmful alleles along with environmental factors—for example, heart disease, diabetes, cancer, alcoholism, schizophrenia, and bipolar disorder.

Genetic engineering (discussed next) may be important in the treatment of some genetic diseases. Already, genetic screening and counseling is being undertaken in many hospitals, using tests along with family history to compute the odds. Trait recognition is now possible through various tests, such as amniocentesis and chorionic villi sampling. Likewise, newborns can be screened for genetic disorders, most of which are untreatable, but a few of which—for example, phenylketonuria—can be treated.

b. Genetic Engineering

Begun in the 1970s, genetic engineering is the manipulation of genes—i.e., inserting new genes into DNA, removing existing genes, or changing part of a gene. Examples are:

- The gene for human insulin has been added to a common bacterium, so that the bacterium produces insulin; bacteria is grown in tanks and the insulin is then removed for treatment of diabetes.
- Human protein (hormones, enzymes, and other biological chemicals) made in the same manner can be used to treat hemophilia, multiple sclerosis, and other diseases previously untreatable.
- New genes can be introduced into farm animals to make them larger, or into plants to make them disease- or insect-resistant.

Scientists have set up regulating and ethics committees to regulate genetic engineering because of the worry that the process might set up dangerous new life forms.

You Should Review

- Mendel's experiments with garden peas—self-pollination and cross pollination; dominant and recessive characteristics
- meiosis versus mitosis
- the genetic basis of variation among individuals in a population
- how to use probability to determine inherited characteristics; the statistical nature of inheritance or inheritance as a game of chance; the rule of multiplication and the rule of addition
- the testcross: breeding of a recessive homozygote with an organism of dominant phenotype but unknown genotype
- inheritance patterns based on dominant and recessive alleles
- the "particulate model"—i.e., parents pass on discrete heritable units
- aneuploidy (chromosomal aberration); also, polyploidy (triploidy and tetraploidy), deletion, duplication, inversion, and translocation
- genomic imprinting
- mutation
- the Punnett square: a grid representing all possible genotypic combinations in the second generation produced by a male (gametes listed horizontally) and a female (gametes listed vertically) of the first generation
- the process of hybridization
- Mendel's Law of Segregation (named after the sorting of alleles into separate gametes)
- Mendel's Law of Independent Assortment
- segregation of genes during gamete production
- recessively inherited disorders and dominantly inherited disorders; multifactorial disorders
- Thomas Hunt Morgan's experiments with *Drosophila melanogaster* (the fruit fly)
- genetic mapping
- the process of transcribing DNA to mRNA
- discovery of the double helix by James Watson and Francis Crick and what the discovery has meant to the study of genetics
- processes of DNA replication and DNA repair
- process of protein synthesis
- the genetic code
- the basics of genetic engineering
- recombinant DNA and gene cloning
- the following terms and concepts (among others): homozygous and heterozygous; genotypic ratio; protein synthesis; transcription; translation; linked genes; crossing over; Barr body; karyotype; complete dominance, incomplete dominance, and codominance; pleiotropy; epistasis; quantitative characters; polygenetic inheritance; norm of reaction; gene sequencing; pedigree chart

Questions

11. The probabilities for all possible outcomes of an event must add up to

a. 0.1.

b. 1.

c. 10.

d. 100.

12. When a red snapdragon is crossed with a white one, all the F1 hybrids have pink flowers. This is an example of
a. inheritance of acquired characteristics.
b. the blending theory of inheritance.
c. incomplete dominance.
d. codominance.

13. While doing his experiments on garden peas, Gregor Mendel was unaware of the
a. laws of probability.
b. statistical nature of inheritance.
c. existence of particulate inheritance.
d. role of chromosomes in inheritance.

14. Which of the following is NOT a feature of Mendel's Law of Segregation?
a. The variation in inherited characters is caused by alternative versions of heritable factors.
b. For each character, an organism inherits two heritable factors, one from each parent.
c. The two heritable factors for each character segregate during gamete production.
d. When heritable factors cannot segregate, they must be linked together and then passed on.

15. Sometimes, a gene at one locus on the chromosome suppresses the phenotypic expression of a gene at a different locus. This is called
a. epistasis.
b. meiosis.
c. carrier recognition.
d. consanguinity.

16. Traits that are alternatives to the wild type (for example, white eyes in a fruit fly as opposed to the usual red) are called
a. point mutations.
b. mutant phenotypes.
c. missense mutations.
d. frameshift mutations.

17. When, in the 1960s, molecular biologists performed a series of experiments that showed the amino acid translations of each of the codons of nucleic acids, they
a. created a model for most later genetic studies.
b. called into question an important Mendelian law.
c. cracked the code of life.
d. established the first link between practical and applied genetics.

18. Lethal recessive mutations are perpetuated by the reproduction of carriers with normal
a. genotypes.
b. Barr bodies.
c. linked genes.
d. phenotypes.

19. In helping determine whether a genetic disorder is present in a fetus, which of the following is an alternative to amniocentesis?
a. chorionic villi sampling
b. carrier recognition testing
c. RFLP analysis
d. use of labeled DNA probes

20. Which of the following is NOT a sex-linked genetic disorder?
a. color-blindness
b. Duchenne's muscular dystrophy
c. syphilis
d. hemophilia

Answers

11. b. The probabilities for all possible outcomes of an event, added together, must equal 1. For example, in the toss of a two-headed coin, the probability of tossing tails is $\frac{1}{2}$ and of tossing heads $\frac{1}{2}$; in the throw of a six-sided die, the probability of rolling the number 3 is $\frac{1}{6}$, and the probability of rolling a number other than 3 is $\frac{5}{6}$.

12. c. Incomplete dominance is the correct answer. Characteristics acquired during an individual's lifetime (choice **a**)—for example, increased muscle mass in a runner's legs due to running—are not genetically controlled and are therefore not heritable. The blending theory of inheritance (choice **b**) is discredited by Mendel's experiments with garden peas. The blending theory would predict only pink offspring from this crossing, whereas the reality is that the red or white traits can appear in the next generation—that is, one can predict a phenotypic ratio of 1 red to 2 pink to 1 white. Codominance (choice **d**) arises when both alleles in a heterozygous organism are dominant and shown in the phenotype.

13. d. Until 1918, most biologists dismissed the importance of chromosomes in inheritance. Mendel died in 1884.

14. d. The discovery of linked heritable factors (now called genes) did not occur until after Mendel's death. The discovery was made by Bateson and Punnett of Cambridge University in 1906.

15. a. Epistasis (Greek for *standing still on*) is the correct answer.

16. b. Phenotypes are the observable physical and physiological traits of an organism. A trait alternative to the normal phenotypic character (the "wild type") is a mutant phenotype.

17. c. Cracking the genetic code was one of the most important steps taken in the field of molecular biology. Marshall Nirenberg, of the National Institutes of Health, deciphered the first codon in 1961.

18. d. Unlike lethal dominant alleles, lethal recessive alleles are masked in the heterozygous carriers.

19. a. Chorionic villi sampling is the suctioning off of a small amount of fetal tissue from the villi of the embryonic membrane. It yields more rapid results than amniocentesis, but its risks have not yet been fully assessed.

20. c. Syphilis is caused by infection by the bacterium *Treponema pallidum*.

C. Structure and Function of Human Systems

1. Integumentary System

a. Definition and Structure

The integument is the outermost covering of the body and is its largest organ. It consists of the epidermis (thinner, outermost layer) and dermis (thicker, innermost layer). It also includes specialized structures, the hair, and nails. Within the layers, there are also other structures. Beneath the skin is the subcutaneous tissue.

b. Function

The integumentary system has the following functions:

- In cooperation with the immune system, it provides protection for the body from injury, dehydration, and invasion by harmful agents such as bacteria.
- As a sense organ, it provides sensitivity to pain, temperature, and pressure.
- It aids in the regulation of body temperature.

2. Skeletal System

a. Definition and Structure

The skeleton is the chief structural system which, along with the skin, provides form and shape to the body. Comprised of 206 bones in adults, along with cartilage and ligaments, the skeletal system is rigid, yet flexible because of joints; the bones form levers that are moved by muscles. There are three types of bone:

- long, or cortical
- flat, or compact
- trabecular, which has features that fall somewhere between long and flat

The cartilage is the flexible but strong substance found in the joints, nose, and ears. The ligaments, comprised of softer, flexible tissue, attach bones to each other.

b. Function

The skeletal system has the following functions:

- It provides mechanical support.
- It protects vulnerable organs within the body.
- Along with the muscular system, it makes body movement possible.
- It stores calcium in the bones, which contain marrow for production of red and white blood cells and platelets.

3. Muscular System

a. Definition and Structure

The muscular system is made up of muscle tissue in sheets or bundles of cells. Muscles can only contract—expansion is passive—and are attached to the skeleton, generally in pairs that work against each other. There are three major types:

- voluntary (skeletal), which can be controlled by conscious thought
- involuntary (visceral, smooth), which cannot be controlled by the will
- cardiac (heart muscles, striated, and smooth), which are specialized and particular to the heart, contract spontaneously, and are regulated by nervous system intervention

b. Function

Along with the skeletal system, the muscular system is responsible for flexibility, movement, and tension.

4. Circulatory System

a. Definition and Structure

The circulatory system consists of the cardiovascular and lymphatic systems: the heart; blood vessels (tubes through which blood is carried to and from the heart, including arteries, arterioles, capillaries, venules, and veins); blood; lymphatic vessels and sinuses; and lymphs.

b. Function

The circulatory system distributes blood and associated chemicals throughout the body and underlies all aspects of function within the human body.

5. Immunological System

a. Definition and Structure

The immunological system is the body's protective mechanism. It consists of the lymphatic system; the white cells of the blood and bone marrow; the thymus gland; and the outer fortress, the skin. There are two types of immunity, inherited (natural or innate) and acquired (active and passive).

The basic characteristics of the immune system include the concepts of:

- **Specificity:** the immune system's capacity to recognize and get rid of antigens—harmful pathogens and molecules—by producing lymphocytes and antibodies (specific proteins). An antigen (literally meaning "antibody-

generating") can include anything "foreign" to the body, such as the molecules of viruses, bacteria, fungi, protozoans, parasitic worms, pollen, insect poison, and, unfortunately, tissue that has been transplanted from another person.

- **Diversity:** the immune system's capacity to respond to literally millions of invaders, due to the great variety of lymphocytes keyed to particular antigen markers.
- **Self/nonself recognition:** the immune system's ability to distinguish its own body's molecules ("self") from antigens ("nonself").
- **Memory:** the immunological system's capacity to remember formerly encountered antigens and react more quickly when exposed again—called acquired immunity. There are two kinds of acquired immunity: active, as a response by the individual's own immune system, either naturally or artificially acquired as through vaccines; and passive, as a response by antibodies transferred from one person to another—for example, a mother's passing antibodies to the fetus or the artificial introduction of antibodies from an immune animal or human.

b. Function

The immunological system protects the body from infection (invasion by pathologic agents—microorganisms or viruses), diseases, and injury-causing agents.

6. Respiratory System

a. Definition and Structure

The respiratory system consists of the organs responsible for the interchange of gases between body and atmosphere—the lungs (its center), the nose, pharynx, larynx, trachea, bronchi, and diaphragm.

b. Function

The respiratory system functions to take in oxygen and eliminate carbon dioxide.

7. Digestive (or Gastrointestinal) System

a. Definition and Structure

The digestive system includes the gastrointestinal tract (or alimentary canal), a tube with two openings, the mouth and anus, for intake of food and elimination of waste; as well as accessory structures and organs such as teeth, tongue, liver, pancreas, and gallbladder.

b. Function

The digestive system's function is to break down food for energy, reabsorb water and nutrients, and eliminate waste.

8. Renal System

a. Definition and Structure

The renal system consists of:

- two kidneys: compact, bean-shaped organs through which blood is cycled for removal of nitrogenous waste and other substances
- the nephrons or excretory tubules contained within the kidneys
- the blood vessels that serve the kidneys
- the structures that carry waste, in the form of urine, out of the body. Urine is 95% water and 5% solids in solution, including organic constituents (urea, hippuric acid, uric acid, creatinine) and inorganic constituents (mainly salts of sodium and potassium).

b. Function

The kidneys remove nitrogenous waste or toxic byproducts from the blood and maintain homeostasis of blood and body fluids.

9. Nervous System

a. Definition and Structure

The nervous system is one of two coordinating systems. (The other is the endocrine system, with which the nervous system interacts and cooperates.) It is made up of the nerves, brain, and sense organs for sight, sound, smell, taste, and touch. The nervous system is divided into two parts:

- the central nervous system: the brain and spinal cord
- the peripheral nervous system: the rest of the neural network—the cervical, thoracic, lumbar, and sacral nerves that branch from the spine

The brain is the nervous system's main control center and consists of three parts:

- the cerebral hemispheres, which are responsible for the higher functions, such as speech and hearing
- the cerebellum, which is responsible for subconscious activities and some balance functions
- the brain stem, which is responsible for necessary functions such as breathing and circulation

The cells of the nervous system consist of neurons and supporting cells.

b. Function

The nervous system controls the flow of information in the body between the sensory and motor cells and organs.

10. Endocrine System

a. Definition and Structure

The endocrine system is the internal system of chemical communication, involving:

- **Hormones:** substances that regulate growth or functioning of a specific tissue or organ in a distant part of the body—for example, insulin, sex hormones, corticosteroids, adrenaline, thyroxine, and growth hormone
- the ductless glands that secrete hormones directly into the interstitial spaces: the pituitary, adrenal, thyroid, parathyroid, ovary, testis, placenta, and part of the pancreas
- the molecular receptors on or in target cells that respond to hormones

b. Function

In concert with the nervous system, the endocrine system effects internal regulation and maintains homeostasis. Hormones affect the rate of metabolism and metabolism of specific substances, growth and developmental processes, development and functioning of reproductive organs and sexual characteristics, development of higher nervous functions (for example, personality), and the ability of the body to handle stress and resist disease.

11. Reproductive System

a. Definition and Structure

Reproduction is the method by which new individuals are created from existing ones. In humans, this involves two sets of organs, the internal reproductive organs and the external genitalia. Reproduction involves the fusion of two haploid gametes—the female ovum and the male spermatozoon—to form a diploid zygote.

The male reproductive system is made up of:

- the external genitalia: the scrotum and penis
- the internal reproductive organs: the gonads (testes) and hormones, accessory glands, and a set of ducts that carry sperm and glandular secretions

The female reproductive system is made up of:

- the external genitalia: the clitoris and two sets of labia
- the internal system: the fallopian tubes, ovaries, uterus, vagina, and related organs. The ovaries contain thousands of eggs. During a female's fertile years, an egg is released by one of the ovaries into the fallopian tube about once a month. If fertilization occurs, the egg attaches to the wall of the uterus and grows into a fetus.

b. Function

The reproductive system functions to create new individuals from existing ones and propagate the species.

c. Fertilization, Descriptive Embryology, and Developmental Mechanics

Fertilization (syngamy): the union of male and female gametes to form a zygote, in human sexual reproduction. Each gamete contains half the correct number of chromosomes; together, they form a full complement.

Embryology: the science that studies the development of the human embryo

The development of the embryo occurs roughly in the second through eighth week after fertilization. During the first week, the zygote is formed and enters the uterus, where implantation occurs. In the second through eighth weeks, the embryo develops and begins to show human form. The development of the embryo occurs in the following stages:

- **Cleavage:** zygote divides to form the blastula
- **Gastrulation:** cells become arranged into three primary germ layers
- **Organogenesis or organogeny:** further cell division and differentiation results in the formation of organs

At this point, we refer to the growing organism as a fetus. In the third to ninth months, the fetus develops until it comprises all the organs necessary for life outside the womb.

You Should Review

- the structure of the skin, including sweat pores, high and low temperature receptors, pain receptors, papillary region, hair and hair follicles, sebaceous glands, arrector pili, Meissner's corpuscle, stratum corneum, stratum granulosum, Malpighian layer, sweat glands and sweat ducts, blood capillaries, the Pacinian corpuscles (pressure receptors), sensory nerves, adipose (fat) tissue
- the way the skin functions in the immune system
- the main parts of the skeleton and a little about their individual functions, including the cranium and its parts, and the mandible, sternum, clavicle, rib cage, vertebrae, carpals, metacarpals, phalanges, femur, patella, tibia, fibula, metatarsals, tarsals, phalanges, scapula, humerus, iliac crest, ulna, radius, pelvis, coccyx, ischium
- the synovial joints, their structure and function: the ball-and-socket, ellipsoidal, gliding, hinged, pivot, saddle, sutures/immovable joints
- the way bones, muscle, and cartilage work together to support weight and enable movement
- axial versus appendicular skeletal components
- the location, size, and shape of the main muscle groups, their action, origin, insertion, and innervation (You needn't memorize all—there are about 700 of them!)
- the structure and action of a voluntary muscle: the tendon, epimysium, bundle of muscle fibers, nucleus, single muscle fiber, and myofibril (light band, dark band, sarcomere unit containing contractile proteins); flexor versus extensor muscles
- the structure and action of an involuntary muscle; location is in the skin, around hair follicles, and in the internal organs (digestive tract, respiratory tract, urogenital tract, and circulatory system); the way an involuntary muscle is supplied by the autonomic nervous system; its composition of fusiform or spindle-shaped cells without striations

- the structure and function of the cardiac muscle: for example, Purkinje fibers; intercalated discs; pacemaker channels; action of the vagus nerve to produce bradycardia; action of cholinergic stimulation to increase blood pressure and heart rate
- the structures of the heart; how the cardiac muscle works; how blood circulates; and names of major blood vessels and lymphatic vessels
- the makeup of blood: (1) plasma—90% water; also contains fibrinogen (plasma protein to help clotting), inorganic ions, dissolved gases (for example, oxygen and carbon dioxide), organic nutrients (amino acids and fats), hormones, antibodies, enzymes, and waste materials (for example, uric acid and urea); (2) erythrocytes (red blood cells); (3) leukocytes and phagocytes (white blood cells); and (4) platelets. You should become familiar with what each type of blood cell does.
- the makeup of lymph (called tissue fluid in the intercellular spaces): alkaline, colorless (or yellowish or milky), and consisting mostly of water; also contains (1) proteins (serum albumin, serum globulin, serum fibrinogen); (2) salts; and (3) organic substances (urea, creatinine, neutral fats, glucose). You should become familiar with what each component contributes.
- general facts about blood groups, blood banks, tissue and organ transplants
- general facts about blood types/antigens (for example, ABO, Rh factor) and blood transfusion; why blood typing is important
- some common blood disorders: for example, various kinds of anemia, hemophilia, leukemia, polycythemia, or thrombosis
- basics of homeostasis: acids, bases, normal blood pH, fluid and electrolyte balance
- the basic characteristics of the immune system
- characteristics and importance of B cells and T cells (the two main classes of lymphocytes) and their antigen receptors; the central role of T cells—cytotoxic or killer T cells and helper T cells
- the molecular basis of antigen-antibody specificity
- the nature of antibodies (a class of proteins called immunoglobulins or Igs—includes IgM, IgG, IgA, IgD, and IgE) and how they work in the human body
- the cellular basis for specificity and diversity
- the humoral response and activation of B cells; T-dependent and T-independent antigens
- the main immune disorders—autoimmune diseases, immunodeficiency, especially AIDS (acquired immunodeficiency syndrome) and HIV—and their treatment
- the following terms and concepts related to the immune system (among others): humoral immunity, cell-mediated immunity, effector cells, plasma cells, clonal selection, primary and secondary immune responses, memory cells, self-tolerance, cytokines (for example, interleukin-1 and -2), interferon
- the organs of respiration (especially the lungs) and their specific structures and functions
- how breathing is controlled (nerves in the breathing center)
- gas exchange in humans
- the following terms and concepts related to the respiratory system (among others): oxygen transport and carbon dioxide transport, negative pressure breathing, tidal volume, volume capacity, residual volume
- major structures of the digestive system and the function of each: oral cavity, esophagus, diaphragm, liver, gallbladder, stomach, pancreas, spleen, large intestine (colon), small intestine, cecum, sigmoid colon, appendix, rectum, anus. The alimentary canal and accessory organs—the salivary glands (saliva, salivary amylase), pancreas, liver, and gallbladder—and their functions
- the various sphincters and the mechanism of peristalsis
- the function and composition of gastric juices (for example, pepsin/pepsinogen, hydrochloric acid), zymogens, gastrin, acid chyme
- hormones and enzymes involved in the digestive process

- how digestive secretions are regulated
- absorption and distribution of nutrients—the villi, microvilli, lacteal, chylomicrons, lipoproteins, capillaries, and hepatic portal vein leading to the liver
- the process of elimination of waste
- the structure and function of the renal system, especially the kidneys (collecting duct, cortex, medulla, glomeruli, Bowman's capsule, loop of Henle, and others) and the renin-angiotensin-aldosterone axis
- renal fluid composition
- concepts of pressure gradients, diffusion, osmosis, active transport, filtration, concentration, diuresis
- the nervous system and functions of its main parts—for example, the spinal cord and its regions (cervical, thoracic, lumbar, sacral); and nerves (ulnar, median, radial, cauda equina, sciatic, femoral, saphenous, vagus)
- the brain and functions of main parts—frontal lobe, temporal lobe, parietal lobe, occipital lobe, cerebellum, brain stem
- the various areas of control in the brain—for example, the voluntary motor area, frontal lobe, speech center, olfactory area, somatic sensory area, visual area, cerebellum, auditory area
- the cells of the nervous system, i.e., the neurons and supporting cells
- neurons—cell body, dendrites, axons, Schwann's cells, myelin sheath (covers the axons of nerve cells, composed of lipids and proteins), synaptic terminals, synapses. The three kinds of neurons: sensory neurons, motor neurons, and interneurons
- supporting cells (glial cells—meaning "glue cells")—for example, in the central nervous system, astrocytes (which contribute to the blood-brain barrier) and oligodendrocytes; in the peripheral nervous system, Schwann cells
- how electrical signals are transmitted along a neuron
- the origin of electrical membrane potential
- the endocrine glands: hypophysis/pituitary, parathyroid, thyroid, suprarenal/adrenal glands, islet of Langerhans in the pancreas, and gonads (ovaries/testes)
- the hormones (chemical signals transmitted throughout the body via the circulatory system; act upon body structures more or less distant) and their target cells
- the three general classes of hormones based on chemical structure: (1) steroid hormones, including sex hormones; (2) amino acid derivatives, generally from tyrosine, which include epinephrine/adrenaline, the "fight or flight" hormone; and (3) peptides, the most diverse class, which includes insulin
- the hormone receptors
- the male and female reproductive structures and functions
- the hormonal control of human reproduction: (1) in males, androgens, especially testosterone; (2) in females, the menstrual cycle, consisting of menstrual flow phase, proliferative phase, secretory phase; and the ovarian cycle, consisting of the follicular phase/ovulation and the luteal phase, hormones, in particular, estrogen, progesterone, and oxytocin
- spermatogenesis and oogenesis
- the main aspects of fertilization, embryo formation, and development from zygote to fetus
- the three trimesters of pregnancy

Questions

21. Which of the following is one of the functions of Meissner's corpuscles?

a. to detect light touch
b. to detect pain
c. to detect heat
d. to detect cold

22. Which of the following structures is part of the axial skeleton?
a. the bones of the limbs
b. the pectoral girdle
c. the pelvic girdle
d. the skull

23. Repetitive muscle contraction depends upon a phosphate group being added to ADP by
a. phosphagens.
b. phosphorylases.
c. phospholipids.
d. phosphokinase.

24. The inner layer of squamous cells that lines the blood vessels is called the
a. endoderm.
b. endothelium.
c. endometrium.
d. endomembrane.

25. Which of the following aspects of the immune system is responsible for the rejection of organ transplants?
a. phagocytosis
b. the formation of antibodies
c. the major histocompatibility complex
d. the activation of B cells

26. The enzyme that hydrolyzes protein in the digestive system is called
a. erepsin.
b. steapsin.
c. ptyalin.
d. pepsin.

27. The process of inhaling air begins with stimulation of the diaphragm by the
a. phrenic nerve.
b. trigeminal nerve.
c. pressor nerve.
d. splanchnic nerve.

28. Which of the following is a disorder of body fluids common in renal disease?
a. acidocytosis
b. phagocytosis
c. acidosis
d. polyposis

29. Much of typically human emotion is thought to rely on interactions between the cerebral cortex and the
a. hindbrain.
b. R-complex.
c. corpus callosum.
d. limbic system.

30. The area of the brain that integrates endocrine and neural functions is the
a. hippocampus.
b. gyrus.
c. hypothalamus.
d. pons.

31. LH and FSH are both
a. pituitary gonadotropins.
b. placental hormones.
c. steroids.
d. androgens.

32. Which of the following structures is partially responsible for the fact that a mother does not reject the embryo as a foreign body, as she would a tissue or organ graft?
a. the endometrium
b. the erythroblast
c. the placenta
d. the trophoblast

Answers

21. a. Meissner's corpuscles, which lie relatively close to the surface of the skin, detect light touch.

22. d. The vertebrate frame has two parts, the axial skeleton and the appendicular skeleton. The skull, vertebral column, and rib cage make up the axial skeleton. The other answer choices make up the appendicular skeleton.

23. a. Phosphagens are high-energy phosphate compounds, found in animal tissues, that supply a phosphate group to ADP to make ATP.

24. b. Endothelium is the correct answer. The other choices relate to systems other than the human circulatory system.

25. c. The major histocompatibility complex is part of the cell-mediated response system. Choice **a**, phagocytosis, is involved in the inflammatory response; choices **b** and **d** are part of the humoral immune response system.

26. d. Pepsin is the chief enzyme found in gastric juice and is responsible for hydrolyzing protein. Choices **a**, **b**, and **c** are enzymes present in intestinal juice, pancreatic juice, and saliva, respectively.

27. a. The phrenic nerve arises in the cervical plexus, enters the thorax, and passes into the diaphragm. Choices **b**, **c**, and **d** are involved in processes of nonrespiratory organs.

28. c. Acidosis is the excess acidity of body fluids found in renal disease and diabetes.

29. d. The limbic system is that area of the human brain midway between the R-complex and the neocortex in both locale and evolutionary age. It is thought to play a major role in the generation of strong, vivid emotions. Some scientists believe that the beginnings of altruistic behavior are to be found in the limbic system.

30. c. The hypothalamus initiates endocrine signals after receiving information about the environment from the peripheral nerves and other parts of the brain.

31. a. LH (luteinizing hormone) and FSH (follicle-stimulating hormone) are pituitary gonadotropins, hormones whose levels affects oogenesis and spermatogenesis.

32. d. The trophoblast is a barrier that prevents the embryo from coming into contact with maternal tissue.

D. Bacteria and Viruses

1. Definitions

a. Viruses

Viruses: the simplest of all genetic systems, infectious particles the largest of which can barely be seen with a light microscope

Viruses hover between life and nonlife, being either very complex molecules or very simple life forms. They lack the structure and most of the equipment of cells, including ribosomes, and they lack enzymes for metabolism; they are merely aggregates of nucleic acids and proteins—cores of nucleic acid packaged in protein coats called *capsids*. Some also bear an outer envelope of proteins and lipids. Viruses are parasites of animals, plants, and some bacteria, and can only metabolize and reproduce within a living host cell. The discovery of viruses began with the German scientist Adolf Mayer in 1883; however, most of the research done with viruses has been done in the last twenty years.

Structure: nucleic acid coated with a shell of protein called a capsid, and sometimes a membranous envelope (shell of protein and lipids) coating the capsid. The envelope may help the virus enter the host cell. Whereas other genes are made of double-stranded DNA, genomes of the virus may consist of double-stranded DNA, single-stranded DNA, double-stranded RNA, or single-stranded RNA.

Kinds of virus: DNA virus and RNA virus

b. Bacteria

Bacteria: unicellular organisms—prokaryotes—with no true nucleus

Bacteria are classified into two groups, gram-positive and gram-negative, based on differences in cell wall composition detected by Gram's staining. Gram-negative bacteria are more dangerous to other life forms than gram-positive bacteria. Bacteria are extremely adaptable with regard to their physiological adjustment to changes in the environment. They are the principal decomposers of most ecosystems. Bacteria were discovered by the Dutch maker of microscopes, Antoni van Leeuwenhoek (1632–1723).

2. Structure, Shapes, Metabolism, and Life Cycle of Bacteria

a. Structure

The bacterial genome is mainly a single double-stranded DNA molecule. Prokaryotes lack membrane-enclosed organelles. (See Section A for more detail.)

b. Shapes and Metabolic Requirements

Bacteria are initially grouped according to:

- **Shape.** Bacteria can be placed in three groups: cocci, with a spherical shape; bacilli, with a rod-like shape; and spirilla, with a spiral shape.
- **Metabolic requirements.** Bacteria are further classified as to, for example, whether they require oxygen. (For more on groupings of bacteria, see Classification of Bacteria.)

Bacteria have greater metabolic diversity than all eukaryotes combined. With regard to procurement of energy and carbon, they fall into four categories:

- **Photoautotrophs** harness light energy for synthesis of organic compounds from carbon dioxide—for example, cyanobacteria (formerly called blue-green algae).
- **Photoheterotrophs** use light to generate ATP but can get carbon only in organic form.
- **Chemoautotrophs** obtain energy by oxidizing inorganic substances, although they need only CO_2 as source of carbon—for example, Sulfobolus, which oxidizes sulfur.
- **Chemoheterotrophs** use organic molecules for both energy and carbon—the majority of bacteria are in this category.

Bacteria also vary in the effect oxygen has on metabolism (obligate aerobes, facultative anaerobes, obligate anaerobes), and in nitrogen metabolism.

c. Life Cycle

In their life cycle, bacteria do not undergo mitosis or meiosis, although they may undergo genetic recombination by three mechanisms: transformation, conjugation, and transduction. Instead, they reproduce by binary fission, each daughter cell receiving a copy of the single parental chromosome. Bacteria are exceptionally resistant to environmental destruction; some cannot even be killed by boiling water, and endospores may remain dormant for centuries. Unchecked by unfavorable environmental conditions, their growth is geometric. Generation times are usually one to three hours, but some species may double every 20 minutes.

3. Classification of Bacteria

Bacteria used to be classified as plants; however, prokaryotes and plants have a completely different molecular composition. Instead of cellulose, bacterial walls are composed of peptidoglycan, which consists of polymers of modified sugars cross linked by short polypeptides that vary according to species. Classification of bacteria is still in flux. They are usually classified in the Kingdom Monera and are generally divided into two subkingdoms.

a. Archaebacteria

Archaebacteria may be descendants of the earliest forms of life. They include methanogens, extreme halophiles, and thermoacidophiles.

b. Eubacteria

Eubacteria (or "true" bacteria) are sometimes said to belong to the order Schizomycetes, although, as noted above, classification of bacteria is in flux. Eubacteria include, among others, actinomycetes (e.g., *Mycobacterium*), chemoautotrophic bacteria (e.g., *Nitrobacter*), cyanobacteria (e.g., *Chroococcus*), endospore-forming bacteria (e.g., *Bacillus*), enteric bacteria (e.g., *Escherichia*), mycoplasmas (e.g., *Mycoplasma*), myxobacteria (e.g., *Myxococcus*), nitrogen-fixing aerobic bacteria (e.g., *Azotobacter*), pseudomonads (e.g., *Pseudomonas*), rickettsias and chlamydias (e.g., *Rickettsia* and *Chlamydia*), and spirochetes (e.g., *Borrelia*).

4. Diseases

a. Viral Diseases

Not all viruses are disease-causing; many viruses do no apparent harm. Diseases caused by viruses include the common cold, influenza, AIDS, herpes, viral pneumonia, meningitis, hepatitis, polio, and rabies in animals, and tobacco mosaic disease in plants. Types of viruses include adenovirus, arbovirus, herpesvirus, human immunodeficiency virus (HIV, the retrovirus that causes AIDS), myxovirus, papillomavirus, picornavirus, poxvirus, retrovirus, and (in plants) the tobacco mosaic virus.

Bacterial viruses are called *bacteriophages* or simply phages and include, among many others, seven that infect *Escherichia coli*.

b. Bacterial Diseases

Approximately half of all human diseases are caused by bacteria; they may be intruders from outside or opportunistic, that is, they live inside the body of a healthy host, becoming destructive only when the host's defenses are weakened. Pathogenic bacteria can disrupt the physiology of the host by growing inside and invading the tissues. Others exude poisons that are one of two types: exotoxins or endotoxins. (See Mechanism of Infection/Bacteria.)

Examples of diseases caused by bacteria include pneumonia, caused by the bacterium *Streptococcus pneumoniae*; tuberculosis, caused by the bacterium *Mycobacterium tuberculosis*, which destroys parts of the lung tissue and is spread through inhalation and exhalation; syphilis, caused by the bacterium *Treponema pallidum*; and many others.

5. Mechanisms of Infection

a. Viruses

Lock-and-key fit is the method by which viruses identify their host. Some viruses can infect several species, for instance, the swine flu virus and the rabies virus; some can infect only a single species, for example, the human cold virus and HIV. Some viruses depend on coinfection by other viruses. The host range is the range of host cells a particular type of virus can infect.

- **Lytic cycle:** the reproductive cycle of virulent viruses that ends in the death of the host
- **Lysogenic cycle:** the reproductive cycle of temperate viruses, which coexist with the host rather than killing it
- **Vaccines:** variants or derivatives of pathogenic microbes that help the cell defend against infection (e.g., polio, rubella, measles, and mumps). There is little that can be done to cure a viral infection once it begins, as antibiotics are powerless; however, many new antiviral agents have been developed in recent years.

b. Bacteria

One mechanism of infection is growing and invading tissues. Bacteria that use this mechanism include rickettsias that cause Rocky Mountain spotted fever and typhus, and actinomycetes that cause tuberculosis and leprosy. Others produce toxins of two types:

- **Exotoxins:** proteins secreted by the bacterial cell; examples are *Clostridium botulinum*, which causes the often fatal disease botulism, and *Vibrio cholerae*, which causes cholera
- **Endotoxins:** not secreted by the bacterium, but are merely components of its outer membrane; examples are the various species of *Salmonella*, which cause food poisoning, and *Salmonella typhi*, which causes typhoid fever

Many bacteria are harmless or even beneficial; certainly they have had wide-ranging benefits to humankind. From bacteria, we have learned much about metabolism and molecular biology. Methanogens are used for sewage treatment by aerating sewage. Some soil species of pseudomonads are used to decompose pesticides and certain harmful synthetic substances. Bacteria are used to make vitamins, antibiotics, and certain foods—e.g., to convert milk to yogurt and some types of cheese.

Whether destructive or beneficial, bacteria do not act alone but form relationships with other bacterial species and organisms from other kingdoms through symbiosis, which means "living together"—if one symbiont is larger than another, it is known as the host. There are three categories of symbiotic relationships:

- **Mutualism:** both symbionts benefit
- **Commensalism:** one symbiont receives benefits while neither harming nor helping the other
- **Parasitism:** one symbiont benefits but harms the host

You Should Review

- the structure and evolutionary origin of viruses
- reproduction mechanism of viruses
- plant viruses and viroids (even simpler pathogens than viruses)
- characteristics of the two kinds of virus, DNA and RNA
- Gram's staining
- metabolic processes of prokaryotes
- nutritional needs of prokaryotes: Some are very specific in their needs (for example, *Lactobacillus* needs all 20 amino acids, several vitamins, and various organic compounds); some are not specific (for example *E. coli* can grow on a medium containing glucose or a substitute for glucose as the only organic component).
- process of nitrogen fixation
- kinds of chemoheterotrophic bacteria—for example, saprophytes (decomposers) and parasites; there are no known present-day phagotrophic bacteria
- life cycle of bacteria
- reproductive process of binary fission
- the various diseases caused by viruses and bacteria
- Koch's postulates
- the reproductive cycle of the HIV virus
- the lytic cycle and defense mechanisms of certain bacteria against certain phages (e.g., restriction enzymes)
- the many variations of viral infection among animal viruses, especially viruses with envelopes and viruses with RNA genomes, and the reproductive cycle of each
- retroviruses; reverse transcriptase
- viruses and cancer; tumor viruses: HIV (the AIDS-causing virus)
- the main groups of bacteria and kinds of bacteria in these groups
- sizes of various bacteria, along with motility; capsules; spores; reproduction; colony formation; food, oxygen, and temperature requirements; and activities (enzyme production, toxin production, etc.)

Questions

33. Which of the following is NOT a reason gram-negative bacteria are more threatening to other life forms than gram-positive bacteria?
- **a.** The lipopolysaccharides on the walls of gram-negative bacteria are often toxic.
- **b.** The outer membrane provides protection for gram-negative bacteria against the defenses of their hosts.
- **c.** Gram-negative bacteria are more resistant to antibiotics than are gram-positive bacteria.
- **d.** Gram-negative bacteria cause hemolysis of blood, whereas gram-positive bacteria do not.

34. Which of the following is NOT a factor differentiating bacteria and viruses?
- **a.** Bacteria are susceptible to antibiotics, whereas viruses are not.
- **b.** The mechanism of replication is different in bacteria than in viruses.
- **c.** Unlike viruses, bacteria are true cells.
- **d.** Bacteria are often parasitic, whereas viruses cannot be.

35. The resistant cells some bacteria form to resist environmental destruction are called
- **a.** endospores.
- **b.** coenocytes.
- **c.** coenobia.
- **d.** endosomes.

36. If one member of an isolated bacterial colony is found to be genetically different from the rest, which of the following is the most likely explanation?
- **a.** Mitosis has taken place.
- **b.** Mutation has taken place.
- **c.** Sexual reproduction has taken place.
- **d.** Cloning has taken place.

37. Which of the following groups of microorganisms is an example of an obligate anaerobe?
- **a.** methanogens
- **b.** cyanobacteria
- **c.** chemoautotrophs
- **d.** chemoheterotrophs

38. The ability, possessed by certain bacteria, to assimilate atmospheric nitrogen into nitrogenous compounds that can be used by plants is called nitrogen
- **a.** production.
- **b.** fixation.
- **c.** cycling.
- **d.** equilibrium.

39. Which of the following microorganisms encodes the enzyme reverse transcriptase?
- **a.** the ECHO virus
- **b.** the masked virus
- **c.** the HIV virus
- **d.** the attenuated virus

40. Which of the following is a kind of movement of which certain bacteria are capable?
- **a.** chemotaxis
- **b.** chemosmosis
- **c.** chemosynthesis
- **d.** chemylosis

41. Destruction of bacteria by a lytic agent is called
- **a.** bacteriogenesis.
- **b.** bacteriophagia.
- **c.** bacteremia.
- **d.** bacteriostasis.

42. The discovery of the virus began with German scientist Adolf Mayer, while he was seeking the cause of
- **a.** Rocky Mountain spotted fever.
- **b.** rabies.
- **c.** tobacco mosaic disease.
- **d.** fungal blight.

Answers

33. d. Some gram-positive bacteria do cause hemolysis—for example, the very common *Streptococcus*.

34. d. Viruses are parasites, often even of bacteria.

35. a. The resistant cells, called endospores, can survive almost anything, including boiling water, lack of nutrients or water, and most poisons.

36. b. Since bacteria reproduce asexually by binary fission, generally in an isolated colony all will be genetically identical. Differences in offspring in an isolated colony can, however, be caused by mutation. Neither mitosis nor sexual reproduction (choices **a** and **c**) take place in bacteria; cloning (choice **d**) produces genetically identical individuals.

37. a. Methanogens produce methane and are obligate or strict anaerobes, found in oxygen-deficient environments such as marshes, swamps, sludge, and the digestive systems of ruminants (such as cows).

38. b. Nitrogen fixation is important to the nutrition of plants and can only be performed by certain bacteria. In terms of nutrition, this ability makes cyanobacteria the most self-sufficient organisms on Earth.

39. c. The retrovirus HIV encodes the enzyme reverse transcriptase, which uses RNA as a template for DNA synthesis.

40. a. The word *chemotaxis* is derived from the Greek *chemeia* (chemistry) + *taxis* (arrangement). Positive chemotaxis is the moving toward a chemical; negative chemotaxis is the moving away from a chemical.

41. b. Bacteriophages are viruses that are parasitic to bacteria. The lytic cycle of a bacteriophage culminates in the death of the host.

42. c. Mayer noted that tobacco mosaic disease was contagious, but he could find no microbe in the infectious sap. He concluded that the causal agent was a bacterium too small to be seen with a microscope. Only later were scientists able to discern the characteristics that set viruses apart from bacteria.

E. Plants

1. Distinction between Plants and Animals

Plants are multicellular eukaryotes, nearly all terrestrial in origin, though some have evolved so that they can live in water. They differ from animals in structure, life cycle, and modes of nutrition, and are the mainstay of most ecosystems on Earth. They draw their energy directly from light—mainly sunlight—and directly or indirectly feed the rest of the creatures on Earth, including animals; without them most ecosystems would simply die. They are autotrophic in nutrition, making their food by photosynthesis, or the conversion of light energy into chemical energy, a property they share with algae and certain prokaryotes.

2. Photosynthesis

a. Definition

Photosynthesis: the process by which light energy, captured by the chloroplasts of plants, is converted to chemical energy

b. Process

Plants are equipped with the light-absorbing molecules chlorophyll a and chlorophyll b and certain carotenoid pigments that are accessory in photosynthesis.

3. Cellular Anatomy

The cell walls of plants consist mostly of cellulose, and they store food in the form of starch. See Section A of this chapter for more on the structure of plant cells.

4. Nutritional Requirements

In order to live, plants require both macronutrients, including carbon, oxygen, hydrogen, nitrogen, sulfur, phosphorus, calcium, potassium, and magnesium; and micronutrients, including iron, chlorine, copper, manganese, zinc, molybdenum, boron, and nickel.

5. Structure and Function

Plants are classified as either nonvascular or vascular.

a. Nonvascular Plants

Nonvascular plants have simpler tissues than vascular plants. They are covered by a waxy cuticle to prevent dehydration, require water to reproduce, and lack woody tissue and so do not grow tall but rather grow in mats low to the ground. The nonvascular plants include mosses, liverworts, and hornworts.

b. Vascular Plants

Vascular plants have much more elaborate tissues, including vascular tissue; cells are joined into tubes for transport of nutrients and water throughout. There are two types of vascular tissue: phloem, which transports sugars from leaves to other parts of the plant; and xylem, which transports water and dissolved mineral nutrients from roots to other parts of the plant. Vascular plants are of two types: seedless, including horsetails and ferns, and seed plants. Seed plants in turn fall into two categories:

- **Gymnosperms:** seeds are uncovered; plants achieve fertilization mainly through windborne pollen. This category includes conifers and cyads, pines, firs, and spruce.
- **Angiosperms:** flowering plants such as garden and wild flowers and hardwood trees; the dominant plant form today (about 235,000 species). Angiosperms have the most advanced structural form; seeds are enclosed in carpels; animals and insects are employed for transfer of pollen in order to achieve fertilization. Important structures of flowering plants include its flower, which is the reproductive structure (includes the stamen, with filament and anthers, petals, pistil with its stigma, style, ovary, and sepal); and the fruit, which is the structure formed from the ovary of a flower, usually after ovules have been fertilized, and which protects dormant seeds and aids dispersal.

6. Reproduction and Development

Some plants reproduce sexually; seeded plants hold an egg, which, after the plant matures, is fertilized by pollen from itself or another plant. Others reproduce asexually by cloning; bulbs, feelers, and rhizomes require only one plant; there is no change in the chromosome number; and the offspring is exactly the same genetically as the parent. Fixed nitrogen is important to all aspects of a plant's life cycle.

You Should Review

- the process of photosynthesis
- plant cellular anatomy
- main characteristics of nonvascular and vascular plants
- plant morphology and anatomy, especially of flowering plants
- the processes of sexual and asexual reproduction in plants
- division of plants into monoecious plants (have both male and female reproductive organs in the same flower) and dioecious plants (have either male or female reproductive organs in separate flowers)
- symbiotic relationships that exist between certain plants and animals

- the various types of plants cells—for example, parenchyma cells, collenchyma cells, sclerenchyma cells, water-conducting cells, food-conducting cells
- the transport systems of plants
- plant hormones
- the following concepts and terms (among others): autotrophic nutrition; photoautotrophy; light reactions; the Calvin cycle; nitrogen fixation; dermal, vascular, and ground tissue systems; sporophyte and gametophyte

Questions

43. The sticky tip of the carpel of a flower, which receives the pollen, is called the
a. stigma.
b. filament.
c. anther.
d. style.

44. The Calvin cycle is one of the two stages of plant
a. germination.
b. photoperiodism.
c. photosynthesis.
d. flowering.

45. A representation of the most recent evolutionary stage of plants is
a. the cypress tree.
b. the orchid.
c. the ostrich fern.
d. the liverwort.

46. The European butterwort, sundew, and pitcher plant are examples of plants that are
a. medicinal.
b. poisonous.
c. parasitic.
d. carnivorous.

47. The term *morphogenesis*, an area particularly important in plant development, refers to the development of an organism's
a. external form.
b. reproductive organs.
c. cytoskeleton.
d. nutritional uptake system.

48. The orientation of a plant toward or away from light is called
a. photogenesis.
b. phototropism.
c. photosynthesis.
d. photoautotrophism.

49. Which of the following could be called a plant "antiaging hormone"?
a. cytokinin
b. gibberellin
c. auxin
d. florigen

50. The major sites of photosynthesis in most plants are the
a. stems.
b. seeds.
c. leaves.
d. taproots.

51. The least specialized of all plant cells are the
a. sclerenchyma cells.
b. water-conducting cells.
c. food-conducting cells.
d. parenchyma cells.

52. Angiosperms respond physiologically to day length by flowering. This response is called
a. the circadian rhythm.
b. day-neutrality.
c. photoperiodism.
d. vernalization.

Answers

43. a. The stigma, located at the carpel, one of the reproductive organs of a flower, receives pollen.

44. c. Photosynthesis consists of two stages: light reactions and the Calvin cycle.

45. b. The orchid is an angiosperm, a type of flowering plant. Flowering plants came into existence about 140 to 125 million years ago. The other choices are considerably older.

46. d. All these plants are carnivorous, supplementing their nutrition (usually in nutrient-poor habitats such as acid bogs) by feeding on insects.

47. a. The term morphogenesis is related to the term morphology, which is the study of the external structure of an organism.

48. b. Phototropism (*photo* means light and *tropos* means turning) is the correct answer. Positive phototropism is the turning of a plant shoot toward light, negative phototropism the turning away from light.

49. a. Cytokinins inhibit protein breakdown, stimulate RNA and protein synthesis, and mobilize nutrients. These attributes are thought to be involved in the retardation of aging in some plant organs.

50. c. Although green stems do perform photosynthesis, the leaves are the most important photosynthetic organs in most plants.

51. d. Parenchyma cells, relatively unspecialized and usually lacking secondary walls, carry on most of the plant's metabolic functions.

52. c. Photoperiodism is the physiological response of any organism to day length.

III. Other Concepts You Should Be Familiar With

The following are not formal divisions of your health occupations entrance exam; however, concepts within them overlap with the subjects mentioned above and may find their way into some of the questions.

A. The Scientific Method

1. General

The scientific method is employed by all sciences to study the natural world, regardless of the particular subject matter. Science studies only those aspects of nature that can be apprehended by the senses.

2. Steps

Ideally, the scientific method involves the following steps, though the process is never as smooth as that outlined here, and steps may be taken out of order:

- Formulate the problem, the solution to which explains an order or process in nature.
- Collect data via observations, measurements, and review of the past—look for regularity and relationships between the data.
- Form a hypothesis, an educated guess as to what is going on, using inductive logic (specific to general) to infer a general or universal premise. The hypothesis must be logical and testable. Then formulate the hypothesis using deductive logic (general to specific—If . . . , then . . .).
- Test the hypothesis by experimentation and gathering of new data. A hypothesis can be disproved, but never absolutely proved—it may change with tomorrow's evidence. Experiments must be free of bias and sampling error, with control and experimental groups. An adequate amount of data and/or adequate

numbers of individuals must be tested, and experiments must be reproducible by other scientists.
- Decide whether the hypothesis is to be accepted, modified, or denied.

3. The Science of Biology

Biology applies the scientific method to living organisms in order to attempt to arrive at an understanding of them. It looks at life using chemical and physical approaches, mainly those processes that involve transformation of matter and energy. There are vast numbers of kinds of living entities and therefore many branches of biology.

B. The Origin of Life

1. The Mechanistic View

Held by most scientists, the mechanistic view of the origin of life holds that the Earth is billions of years old and that life occurred at a point in time along a continuum of increasingly complex matter. Biologists postulate a natural origin for life, but they do not deny the existence of other phenomena that arise in human beings, which cannot be measured exactly—love, faith, morality, etc.

2. Distinction between Living and Nonliving Entities

Many biologists regard the distinction between living and nonliving entities as arbitrary, believing instead that there is a continuum, generally involving complexity.

Overall, however, there is a difference, in that living entities ordinarily are capable of self-regulation, metabolism, movement; irritability (response to stimuli in its internal and external environments); growth (increase in mass through use of materials from the environment); adaptation (a tendency to change, resulting in improved capacity to survive); and reproduction (production of new individuals like themselves).

C. Classification of Living Entities

1. Systems of Classification

The classification of living entities is an artificial construct. There are various systems, ranging from 2- to 13-kingdom classifications. Following are three examples:

- 5-kingdom classification: Monera, Protista, Fungi, Plantae, Animalia
- 6-kingdom classification: Prokaryotae, Archaebacteria, Protista, Fungi, Plantae, Animalia
- Ecological classification: Autotrophs, including green plants and some bacteria; heterotrophs, including herbivores, carnivores, omnivores, scavengers, decomposers, and parasites

2. Linnaean System

The hierarchical system most widely used is the Linnaean system, devised by Swedish botonist Carolus Linnaeus (Carl Linné, 1707–1778). This system consists of Kingdom, Phylum, Class, Order, Family, Genus, and Species.

3. Binomial Nomenclature

A system also devised by Linnaeus, binomial nomenclature is still used for naming genus and species of an organism. The first part is the generic name, the second the specific—the creature's genus (capitalized) and species (lowercase) are reflected in the name. For example, the common house cat is called *Felis silvestris;* a bacterium that causes one type of streptococcal pneumonia is called *Streptococcus pneumoniae.*

D. Social Behavior of Animals

1. Humans

A heated debate continues to rage over the distinction termed "nature versus nurture." Some scientists, particularly sociobiologists, believe that aspects of human behavior shared across cultures, such as avoidance of incest, can be viewed as innate, somehow evolutionarily programmed. Others insist that such cultural features as taboos would be unnecessary if behavior were truly innate; therefore, they say, much of what we view as particularly human behavior is learned. Those on the "nurture" side of the debate often point to altruistic behavior, which exists to a much greater extent in humans than in any other species. Those on the "nature" side of the debate insist that most altruistic behavior, if carefully looked at, does in some way enhance the individual, even when it causes that individual's death.

2. Other Species

Although much of the social behavior between members of a species involves cooperation, it is still the case that individuals act in their own best interest, and that a good deal of competitive behavior arises in all animal populations. Important aspects of social interaction include:

- agnostic behavior/competitive behavior—for example, for food or a mate—involving a contest in which individuals threaten one another until one backs down. Often such behavior is ritualistic, as natural selection would favor individuals able to settle a contest without injury.
- dominance hierarchies
- territoriality
- courtship rituals
- communication among individuals
- altruistic behavior, though to a lesser extent than in humans

Questions

53. In science, which of the following is most nearly synonymous with the word "theory"?
a. a proven fact
b. a hypothesis that has withstood repeated testing
c. an untested supposition
d. a body of published data

54. A distinguishing feature of the Kingdom Monera is that the cells of the organisms in that kingdom
a. contain many specialized parts.
b. contain mitochondria.
c. obtain food through photosynthesis.
d. lack nuclei.

55. The majority of primary producers in an ecosystem are
a. autotrophs.
b. carnivores.
c. detrivores.
d. herbivores.

56. When rattlesnakes engage in "combat" in which one tries to pin the other to the ground, but neither uses its deadly fangs, such behavior is called
a. survival of the fittest.
b. territoriality.
c. ritualistic agonistic behavior.
d. a mating dance.

57. An alternative view of the mechanistic origin of life holds that at least some organic compounds, including amino acids, originated in the hundreds of thousands of meteorites and comets that hit the earth during its early formation—that is, that life had extraterrestrial origins. This idea is called
a. abiotic synthesis.
b. panspermia.
c. protobiotic aggregation.
d. the Oparin hypothesis.

58. From the point of view of the scientific method, the most important requirement for a sound hypothesis is that it be
a. able to be confirmed.
b. intuitively possible.
c. useful in a practical sense.
d. testable through experimentation.

59. The category of classification of organisms that contains one or several similar or closely related families is the
a. phylum.
b. class.
c. order.
d. genus.

60. The primary feature that distinguishes life from nonlife is that living organisms are capable of
a. reproduction.
b. entropy.
c. chemical evolution.
d. atomic bonding.

Answers

53. b. A theory has undergone testing. The word is often mistakenly used to mean "just a guess." This misuse is seen in such a statement as, "Evolution is just a theory." In fact, evolution is regarded in the scientific community as a hypothesis that is so well-supported by data as to be fact.

54. d. The Kingdom Monera consists of simple, single-celled prokaryotic organisms, whose cells lack nuclei and certain other specialized parts.

55. a. The primary producers of an ecosystem are autotrophs, most of them photosynthetic organisms that synthesize organic compounds directly from light energy. All the other choices are consumers, directly or indirectly dependent on photosynthetic products for nutrition.

56. c. This kind of ritualistic or symbolic combat has an advantage, in that even the loser lives to reproduce.

57. b. The theory of panspermia gained strength in 1986 when spacecraft flying near Halley's Comet showed that the comet contained far more organic material than had previously been thought.

58. d. A hypothesis that is not testable is useless from a scientific point of view. Hypotheses can never be absolutely confirmed (choice **a**). Hypotheses frequently fly in the face of intuition (choice **b**); for instance, a flat Earth probably seems more intuitively right than a spherical one. Many scientific hypotheses have no immediately recognizable practical applications (choice **c**); an example might be David Reznik's hypotheses concerning guppy populations in Trinidad.

59. c. Order is the category that holds one or several similar or closely related families of organisms. Order names typically end in *-ales* for botany, *-a* for zoology (for example, Rosales and Carnivora).

60. a. All the other choices are properties of both living and nonliving entities.

IV. Suggested Sources for Further Study

All of the following are available in bookstores, as well as through the Internet from Amazon Books (www.amazon.com).

Textbooks

Campbell, Neil L. *Biology, 7th edition*. (Redwood City, CA: Benjamin/Cumming, 2004). This is an excellent, 1,200-page, basic college textbook: authoritative, thorough, clear, and readable (even enjoyable). It will be an excellent main source for

you to study. The 6th edition (2001) is still a good reference and less expensive.

Gould, James L. and Keeton, William T. with Carol Grant Gould. *Biological Science, 6th edition*. (New York: Norton, 1996). This is a very fine textbook, well organized, thorough, and authoritative.

Reference Works

Barnes-Svarney, Patricia, ed. *The New York Public Library Science Desk Reference*. (New York: Macmillan, 1995). The sections on "Biology" and "The Human Body and Biomedical Science" will make good supplements to more detailed works and will help you create an organized outline of subject areas.

Martin, Elizabeth, ed. *A Dictionary of Biology, 4th edition*. Oxford Paperback Reference Series. (Oxford: Oxford University Press, 2000). This is an up-to-date and well-respected dictionary of biology—though by no means the only one—which contains the majority of the terms you will need to be familiar with on your health occupations entrance exam.

Stedman, Thomas. *Stedman's Concise Medical Dictionary for the Health Professions, 4th edition*. (Baltimore: Williams and Wilkins, 2001). Stedman's is an excellent, user-friendly medical dictionary, illustrated and with a CD-ROM.

Study Guides

Fried, George. *Schaum's Outline of Biology, 2nd edition*. Schaum's Outline Series. (New York: McGraw-Hill, 1999). As part of a popular college course series, this book contains a detailed overview of the subject of biology. It is well organized and readable.

Kaplan MCAT All-in-One: Test Prep Plus Medical School Admissions. (New York: Bantam Doubleday Dell, 2005). This study guide for the Medical College Admission Test includes much of the information you will need for the biology section of your health occupations entrance exam. It is well organized and user-friendly and includes a book and CD-ROM with sample tests.

Silver, Theodore and James L. Flowers. *The Princeton Review: Flowers Annotated MCATs with Sample Tests on Computer Disks 1997*. (Princeton, NJ: Princeton Review, 1996). This is a clear, well-organized study guide that includes sample tests on disk and boasts online and telephone support. Although it is technically a preparation guide for the Medical College Admission Test, it contains much of the information you will need for the biology section of your health occupations entrance exam.

Supplemental Works

Gould, Stephen Jay. *Dinosaur in a Haystack: Reflections in Natural History*. (New York: Crown, 1996).

Gould, Stephen Jay. *The Panda's Thumb: More Reflections in Natural History*. (New York: Norton, 1992). Stephen Jay Gould is known for his provocative and authoritative essays on biology and natural history. Both this collection and the previous one will make good supplements to the more detailed textbooks mentioned.

Sagan, Carl. *Broca's Brain: Reflections on the Romance of Science*. (New York: Ballantine, 1993). Both works by Sagan contain knowledgeable, readable essays that make biology and natural history topics accessible to the layperson but never talk down. Like Stephen Jay Gould's books, these collections will be good additions to the other more complete, technical works in this list.

CHAPTER

8 Chemistry Review

CHAPTER SUMMARY

This chapter is a general outline and review of the important chemistry concepts that are tested by many health occupations entrance exams. It begins with a topic outline of the chemistry subjects covered, complete with page numbers for each reference. The chapter then reviews these important chemistry concepts, in the same outline format.

▶ Chemistry Review: Important Concepts

I. General Introduction

A. Description of How Health Occupations Entrance Exams Test Chemistry

This chapter reviews essential concepts in chemistry that are covered in many health occupations entrance exams. Some tests contain specific chemistry or science sections; others ask you to be able to recognize important ideas and terms.

Some of these key concepts are atomic structure, periodic table, chemical bonds, chemical equations, stoichiometry, energy and states of matter, reaction rates, equilibrium, acids, bases, oxidation-reduction, nuclear chemistry, and organic compounds.

B. How to Use This Chapter

This chapter is presented in outline form as a systematic presentation of important chemistry topics to help you review for your exam. This chapter does not constitute a comprehensive chemistry review—use it as an aid to help you recall concepts you have studied and to identify areas in which you need more study. At the end of this chapter, you will find a list of references and resources for a more complete review.

Read each topic in this chapter and answer the questions that follow. After answering the sample test questions, you can pinpoint where you want to concentrate your efforts. If a question poses particular difficulty for you, study more problems of this type. The more you hone your problem-solving skills, understand basic principles, and recognize core terms, the more relaxed and confident you will feel on test day.

Study Tips for Chemistry

- Review the topics covered in this chapter carefully. Keep a copy of one or more of the suggested resource books handy for more extensive review.
- Don't try to review all topics in one or two study sessions. Tackle a couple of topics at a time. Focus more in-depth study on the items within a topic that you feel least confident about first.
- Complete each group of practice questions after you study each topic, and check your answers. If you experience particular difficulty with one type of question, choose similar questions from the other resources listed to practice some more.
- Review all the answer choices carefully before making your selection. The wrong answers often give you hints at the correct one, and also help you confirm that you really do know the correct answer. Remember that recognition is not necessarily understanding.
- When checking your answers to practice questions with the answer key, be sure you understand why the identified choice is the correct one. Practice writing out your reasoning for choosing a particular answer and checking it against the reasoning given in the answer key.
- Practice pronouncing chemical terminology aloud. If you can pronounce a term with ease, you are more likely to remember the term and its meaning when reading it.
- Review carefully the visual aspects of chemistry, such as the use of symbols, arrows, and sub- and superscripts. If you know the circumstances under which particular symbols are used, you will have immediate clues to right and wrong answers.
- Focus on developing problem-solving skills. Almost all chemical problems require the analysis, sorting, and understanding of details.

II. Main Topics

A. Atoms

1. Atomic Structure

An **atom** is the basic unit of an element that retains all the element's chemical properties. An atom is composed of a nucleus (which contains one or more protons and neutrons) and one or more electrons in motion around it.

An **electron** is of negligible mass compared to the mass of the nucleus and has a negative charge of –1.

A **proton** has a mass of 1 amu (atomic mass unit) and a positive charge +1.

A **neutron** has a mass of 1 amu also but no charge.

Atoms are electrically neutral because they are made of equal numbers of protons and electrons.

2. Dalton's Atomic Theory

In 1808, John Dalton proposed his hypotheses about the nature of matter that became the basis of Dalton's atomic theory:

- All elements are made of tiny, indivisible particles called atoms (from the Greek *atomos*, meaning indivisible).
- Atoms of one element are identical in size, mass, and chemical properties.
- Atoms of different elements have different masses and chemical properties.
- Compounds are made up of atoms of different elements in a ratio that is an integer (a whole number) or a simple fraction.
- Atoms cannot be created or destroyed. They can be combined or rearranged in a **chemical reaction**.

Later experiments completed the understanding of atoms:

- **J. J. Thomson** discovered the electron.
- **E. Rutherford** established that the atom is composed of negatively charged electrons moving in the empty space surrounding a dense, positively charged nucleus.
- **A. Becquerel** and **Marie Curie** discovered that the decay of radioactive (unstable) nuclei resulted in the release of particles and energy.

3. Mass Number

Mass number is the sum of protons and neutrons in the nucleus of the atom. It varies with the isotopes of each element. The mass number is indicated by the number to the upper right of the element symbol: Na^{23}.

4. Atomic Number

Atomic number is the number of protons in the atom, specific for each element. The atomic number is indicated by the number in the lower left of the element symbol: $_{11}Na$.

5. Isotopes

Isotopes are atoms of the same element that have the same number of protons (same atomic number) but different number of neutrons (different mass number). Isotopes have identical chemical properties (same reactivity) but different physical properties (for example, some decay while others are stable).

ISOTOPES OF HYDROGEN	
^{1}H	protium (simply proton)
^{2}H (or D)	deuterium
^{3}H (or T)	tritium

The **atomic weight** (or mass) of an element is given by the weighted average of the isotopes' masses.

6. Classification of Matter

a. Elements

Elements are substances that are composed of only one type of atom. Elements have chemical symbols (letters of their names) that are used for their representation in the periodic table. The latest element is Darmstadtium, or Ds.

The element hydrogen, or H, is made of two hydrogen atoms (H or H_2 in its simplest, *elemental* form). The element sodium is made of one sodium atom, Na.

b. Compounds

A **compound** is a combination of two or more atoms of different elements in a precise proportion by mass. In a compound, atoms are held together by attractive forces called *chemical bonds*.

c. Mixtures

A **mixture** is a combination of two or more compounds (or substances) interacting but not bonded chemically with one another. Substances that make up a mixture can be separated.

You Should Review

- law of conservation of mass
- law of constant proportion
- law of multiple proportions
- chemical symbols

Questions

1. Which of the following statements about atoms is true?
- **a.** They have more protons than electrons.
- **b.** They have more electrons than protons.
- **c.** They are electrically neutral.
- **d.** They have as many neutrons as they have electrons.

2. What is the mass number of an atom with 60 protons, 60 electrons, and 75 neutrons?
- **a.** 120
- **b.** 135
- **c.** 75
- **d.** 195

3. What is the atomic number of an atom with 17 protons, 17 electrons, and 20 neutrons?
- **a.** 37
- **b.** 34
- **c.** 54
- **d.** 17

4. Two atoms, L and M, are isotopes. Which of the following properties would they NOT have in common?
- **a.** atomic number
- **b.** atomic weight
- **c.** chemical reactivity
- **d.** the number of protons in the nucleus

5. An atom with an atomic number of 58 and an atomic mass of 118 has
- **a.** 58 neutrons.
- **b.** 176 neutrons.
- **c.** 60 neutrons.
- **d.** 116 neutrons.

6. According to Dalton's theory, the only way a compound can consist of its elements in a definite ratio by mass is that it is made from the elements in
- **a.** a definite ratio by volume.
- **b.** a definite ratio by number of atoms.
- **c.** multiple whole-number ratios by mass.
- **d.** multiple whole-number ratios by volume.