

Judith GOODENOUGH

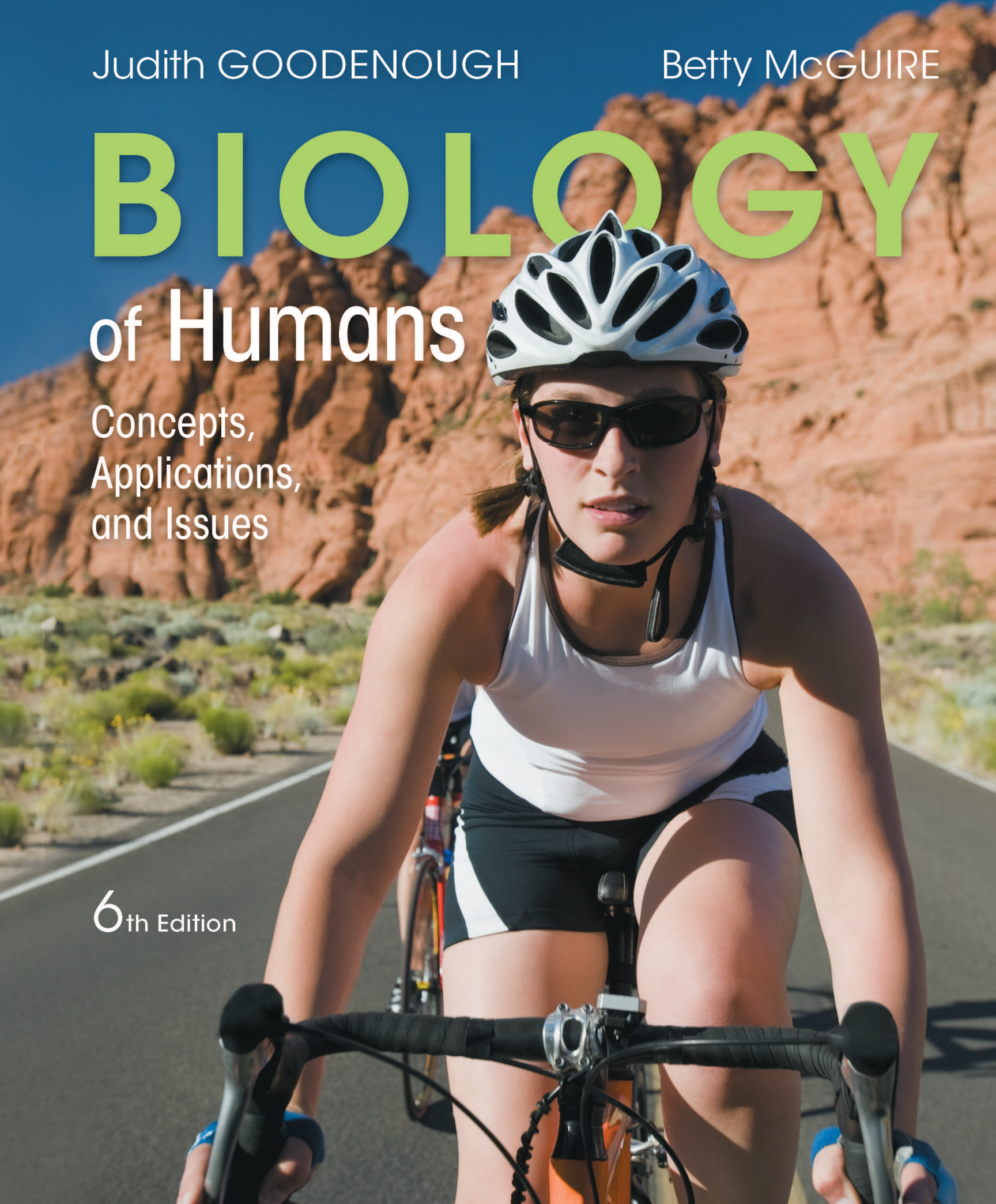
Betty McGUIRE

BIOLOGY

of Humans

Concepts,
Applications,
and Issues

6th Edition



Brief Contents

PART I

The Organization of the Body

- 
- 1 Humans in the World of Biology 1
 - 1a **SPECIAL TOPIC:** Becoming a Patient: A Major Decision 14
 - 2 Chemistry Comes to Life 21
 - 3 The Cell 43
 - 4 Body Organization and Homeostasis 65

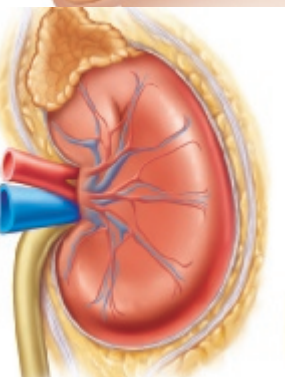
PART II

Control and Coordination of the Body

- 
- 5 The Skeletal System 86
 - 6 The Muscular System 101
 - 7 Neurons: The Matter of the Mind 115
 - 8 The Nervous System 127
 - 8a **SPECIAL TOPIC:** Drugs and the Mind 143
 - 9 Sensory Systems 151
 - 10 The Endocrine System 171
 - 10a **SPECIAL TOPIC:** Diabetes Mellitus 190

PART III

Maintenance of the Body

- 
- 11 Blood 198
 - 12 The Cardiovascular and Lymphatic Systems 213
 - 12a **SPECIAL TOPIC:** Cardiovascular Disease 232
 - 13 Body Defense Mechanisms 239
 - 13a **SPECIAL TOPIC:** Infectious Disease 259
 - 14 The Respiratory System 268
 - 15 The Digestive System and Nutrition 286
 - 15a **SPECIAL TOPIC:** The Obesity Epidemic 312
 - 16 The Urinary System 317


PART IV

Reproduction and Development

- 
- 17 Reproductive Systems 336
 - 17a **SPECIAL TOPIC:** Sexually Transmitted Diseases and AIDS 356
 - 18 Development throughout Life 366
 - 18a **SPECIAL TOPIC:** Autism Spectrum Disorder 387

PART V

Genes and DNA

- 
- 19 Chromosomes and Cell Division 394
 - 19a **SPECIAL TOPIC:** Stem Cells—A Repair Kit for the Body 412
 - 20 Genetics and Human Inheritance 419
 - 21 DNA and Biotechnology 436
 - 21a **SPECIAL TOPIC:** Cancer 458

PART VI

Evolution and Ecology

- 
- 22 Evolution and Our Heritage 470
 - 23 Ecology, the Environment, and Us 491
 - 24 Human Population, Limited Resources, and Pollution 508

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and Issues

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CONNECT WITH THE BIOLOGY OF HUMANS

SPECIAL TOPIC
Cancer **21a**

DID YOU KNOW?

- There are nearly 15 million cancer survivors in the United States, and that number is expected to reach 19 million by 2018.
- There are more than 200 types of cancer.

21a.1 Uncontrolled Cell Division
21a.2 Development of Cancer
21a.3 Multiple Mutations
21a.4 Cancer and Epigenetics
21a.5 Cancer Stem Cell Hypothesis
21a.6 Known Causes of Cancer
21a.7 Reducing the Risk of Cancer
21a.8 Diagnosing Cancer
21a.9 Treating Cancer

IN THE PREVIOUS FEW CHAPTERS, we learned about cell division, genes, and gene function. In this chapter, we consider how cancer cells escape the normal controls over cell division. We then learn about some causes of cancer and how we can reduce our risk of developing the disease. Finally, we identify some means of diagnosing and treating cancer.

Cancer, the “Big C,” is perhaps the disease that people in the industrialized world dread the most—and with good reason. Cancer touches the lives of nearly everyone. One of every three people in the United States will develop cancer at some point in life, and the other two are likely to have a friend or relative with cancer.

21a.1 Uncontrolled Cell Division

All forms of cancer share one characteristic—uncontrolled cell division. Cancer cells may behave like a virus taking over our bodies, but they are actually malicious cells from within our own bodies.

Benign or Malignant Tumors

An abnormal growth of cells can form a mass of tissue called a tumor or neoplasm (meaning “new growth”). However, not all tumors are cancerous; tumors can be either benign or malignant. A benign tumor is an abnormal mass of tissue that is surrounded by a capsule of connective tissue and that usually remains at the site where it forms. Its cells do not invade surrounding tissue or spread to distant locations, although the tumor can and does grow. In most cases, a benign tumor does not threaten life, because it can be removed completely by surgery.

Known for its unique “Special Topic” chapters and emphasis on everyday health concerns, the **Sixth Edition** helps learners apply course material to their everyday lives, making the science information more accessible as they build twenty-first century skills. The authors give students a practical and friendly introduction for understanding how their bodies work and for preparing them to navigate today's world of rapidly expanding—and shifting—health information.

ABUNDANT APPLICATIONS

EMPHASIS ON SKILL BUILDING

CONSIDER THIS CASE

You spend the day with your Aunt Sally on her 55th birthday. She has a salad for lunch and suffers no ill effects. When she indulges in fried chicken and fries for dinner, however, she is rushed to the emergency room a few hours later with severe pain on the right side of her abdomen. She reports that she has had bouts of pain over the past month or so.

- What do you think is wrong with Aunt Sally?
- Why isn't the pain continuous?

Finding and Evaluating Information

E-cigarettes are becoming increasingly popular in the United States, including among children and teens. We have seen that the cells of the linings of the air tubules are the first cells exposed to environmental substances. They protect us against harmful substances we may inhale. For this reason, researchers wanted to determine the effect of vapor from the liquid in e-cigarettes on cells of the air tubule lining of young people. Using tissue cultures from deceased children who had donated their bodies to research, they exposed epithelial cells from air tubules to vapors from e-cigarettes. After 10 minutes of exposure to the vapors, the cells were damaged and were more susceptible to rhinoviruses, which cause the common cold. The damage occurred whether or not the liquid contained nicotine.

The authors concluded:

“This is the first study to demonstrate the adverse effects of e-cigarettes on primary airway epithelial functions from young people. Our data suggest that even nicotine-free e-liquid promotes

pro-inflammatory response and HRV infection. Moreover, both e-liquid without nicotine and with nicotine inhibits lung innate immunity (e.g., SPLUNC1) that is involved in lung defense against HRV (human rhinovirus) infection.”

You can read the entire study at: Q. Wu et al., “Electronic cigarette liquid increases inflammation and virus infection in primary human airway epithelial cells,” *PLoS ONE* 9(9) [2014]: e108342. doi:10.1371/journal.pone.0108342

1. What problems might there be with applying data from cells in tissue cultures to living people?
2. How would you design the experiment to confirm these data on living people?
3. Use reliable sources to investigate the evidence for and against adverse health effects of e-cigarettes.

NEW CASE EXERCISES

APPLY AND USE SKILLS IN CONTEXT

CONSIDER THIS CASE

Elsa, a high school and college tennis champion, had begun to work her way up through the ranks in professional tennis. Her training regimen involved daily matches against the best players she could find. After one professional win, her opponent Maria confessed to news reporters, "It is a great challenge to return a serve from Elsa's powerful right arm."

Over the holidays Elsa returned home to Vermont for a family celebration. While she was there, she slipped on the ice and fell forward. She was able to keep her face from hitting the ground with her outstretched arms, but found that she had broken her left arm.

- Why would you expect that only her left arm broke when there was equal force on both arms?
- How would you test your hypothesis?

NEW! Consider This Case exercises close each chapter with a scenario relating to the chapter content, followed by critical thinking questions that ask students to apply what they've learned in the chapter.

NEW! Finding and Evaluating Information

activities present a brief excerpt from an intriguing article or blog post and ask students to evaluate the information and conclusions presented, as well as to explore other reliable sources of information on the topic.

Finding and Evaluating Information

An important function of skin is to be a protective barrier against infectious organisms. Cleanliness is important to the skin's ability to perform this function, and hand sanitizers are a popular way to achieve cleanliness. But are all sanitizers created equal? Below are excerpts from R. Babeluk et al., "Hand hygiene—evaluation of three disinfectant hand sanitizers in a community setting."¹ The entire article can be found at: www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0111969

This study involved "sixty undergraduate students . . . (who had) no prior training in hand hygiene and were therefore believed to be representative of the general (non-healthcare) population. . . . The 60 volunteers were briefed to attend the two testing sessions at the University, using public transport. They were also asked to contaminate their hands by touching typical everyday surfaces (i.e. hand rails, door handles, vending machines, money) with both hands prior to testing.

"On arrival at the University laboratory, a swab of each subject's left palm and finger tips was taken and cultured on agar plates to determine a maximum spectrum of microbes present. This provided the base line for the testing.

"The volunteers were randomized into three groups of 20, each group was allocated one of the three hand sanitizers."

¹R. Babeluk et al., "Hand hygiene—evaluation of three disinfectant hand sanitizers in a community setting," *PLoS One* 9 [2014]: e111969.

The participants then cleaned their hands with the assigned sanitizer. Their hands were swabbed and the swabs were plated as before.

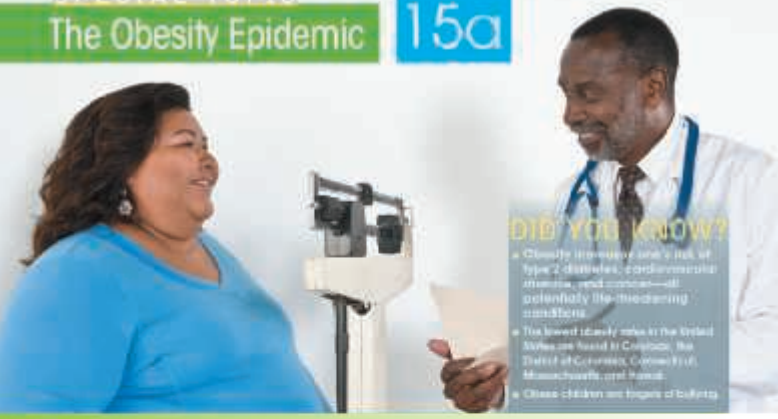
"Before disinfection . . . there was no significant difference between the groups in the bacterial load detected on hands." Following disinfection, "there was a significant overall reduction in bacteria following hand disinfection with all three products."

Two of the three sanitizers "led to a satisfactory bacterial reduction." The researchers conclude that there "are significant differences in efficacy between products that have been certified in accordance with the applicable European standards, compared to the non-certified product. The two certified products achieved superior outcomes compared to the non-certified product."

1. Is the conclusion in the paper valid based on the experimental design and results?
2. It is often difficult to determine the truth behind claims made in the media. For cleaning hands, is hand washing with soap superior to using hand sanitizers? Which hand sanitizers are most effective? Does use of these sanitizers lead to the development of antibiotic-resistant bacteria? Do these products contain toxic ingredients? Use reliable sources of information (books, newspapers, magazines, journals, or trustworthy websites) to find answers to these questions so you can make an informed decision on whether to use hand sanitizers. Create a list of guidelines for the use of hand sanitizers. Cite your sources.

APPLY YOUR LEARNING TO EVERYDAY LIFE

SPECIAL TOPIC
The Obesity Epidemic 15a



DID YOU KNOW?
A study from the Centers for Disease Control and Prevention (CDC) found that obesity is a leading cause of death in the United States. It is also a leading cause of disability. Obesity is a complex condition that is influenced by many factors, including genetics, environment, and lifestyle. Obesity is a leading cause of death in the United States. It is also a leading cause of disability. Obesity is a complex condition that is influenced by many factors, including genetics, environment, and lifestyle.

- The lowest obesity rates in the United States are found in Colorado, the District of Columbia, Connecticut, Massachusetts, and Hawaii.
- Obese children are targets of bullying.

15a.1 What is Obesity?

Although overweight and obese are both terms used to describe people who have excess body weight, they do not have exactly the same meaning. An obese person is overweight because of excess fat. An overweight person weighs more than the ideal on a height and weight chart. An athletic person whose muscles are well developed may weigh more than the weight listed as desirable on height–weight tables, but such a person is not obese. However, most people who are overweight have too much body fat. Overweight and obese generally refer to ranges of weight considered to be unhealthy.

Body Mass Index

The body mass index (BMI) is a number that provides a reliable indicator of body fat because it evaluates your weight in relation to your height (Figure 15a.1). A BMI greater than 30 is generally considered unhealthy and an indication of obesity. However, a very muscular person can have a BMI above 30 and not be considered obese. A person in the healthy weight range can have too much fat and still have a BMI below 30.

15a.2 Health Risks of Obesity

15a.3 Regulation of Food Intake

15a.4 Weight Management

IN THE PREVIOUS CHAPTER, we learned how food is broken down into its subunits, which are then absorbed and used to build new body molecules or are used to release energy for ATP production. Next we considered nutrients and how the body uses them. Finally, we explored ways to plan a healthy diet by selecting foods containing a balance of nutrients. In this chapter, we will consider obesity, which results when we choose an improper mix or amount of foods.

Ten **Special Topic** chapters explore high-interest health topics more thoroughly than can be accomplished in a brief essay.

NEW! Special Topic Chapter 15a

The Sixth Edition features a new **Special Topic** chapter, titled **The Obesity Epidemic**. Focusing on the problem of obesity, this chapter covers topics such as:

1. Health risks associated with obesity
2. Regulation of food intake
3. Weight management.

Expanded **Did You Know?** boxes now open every chapter, link directly to the chapter opening photo, and pique students' interest with fascinating and little-known facts about the topic that follows.

12a



DID YOU KNOW?

- In the United States, heart disease is the cause of one in every four deaths per year. A stress test reveals how your heart responds to exertion and can help you develop an appropriate exercise plan.
- A male's primary heart attack symptom is chest pain, but a woman's heart attack symptoms are nausea, indigestion, and shoulder aches.

CONSIDER THE ISSUES BEFORE FORMING AN OPINION

ENVIRONMENTAL ISSUE

Noise Pollution

If you suffer from excessive amounts of noise, you may have trouble hearing. Noise pollution threatens your hearing and your health. Exposure to excessive noise is to blame for the hearing loss of one-third of all hearing-impaired people. Loud noise damages the hairs on the hair cells of the inner ear. When the hairs are exposed to too much noise, they wear down, lose their flexibility, and can fuse together (Figure 9.8). Unfortunately, there is no way to undo the damage; you cannot give your ears a rest.

The loudness of noise is measured in decibels (dB). The decibel scale is logarithmic. An increase of 10 dB generally makes a given sound twice as loud. The decibel ratings and effects of some familiar sounds are shown in Table 9.6. Most people judge sounds over 60 dB to be intrusive, over 80 dB to be annoying, and over 100 dB to be extremely bothersome. The Federal Occupational Safety and Health Administration (OSHA) has set 85 dB as the safety limit for 8 hours of exposure. The threshold for physical pain is 140 dB.

A surprising number of young people also have impaired hearing, the culprit is most likely noise—probably in the form of music. How can you protect yourself? Don't listen to loud music. Keep it turned low enough that you can still hear or hear sounds if you are listening with ear buds, no one else should be able to hear the




Figure 9.8 The hair cells of the inner ear can be permanently damaged by loud noise.

Three categories of **Special Interest Essays** use the basic scientific content of the chapters to explore issues having broader impact on individual health, society, and the environment.

HEALTH ISSUE

Breast Cancer

Breast cancer usually begins with abnormal growth of the cells lining the milk ducts of the breast, but it sometimes begins in the milk glands themselves. Some types of breast cancer aggressively invade surrounding tissues. Typically, cancerous cells begin to spread when the tumor is about 20 mm (about 3/4 in.) in diameter. At this point, they break through the membranes of the ducts or glands where they initially formed and move into the connective tissue of the breast. They may then move into the lymphatic vessels or blood vessels permeating the breast or into both; the vessels may transport the cells throughout the body.

Detecting Breast Cancer

Early detection is a woman's best defense against breast cancer. A monthly breast self-exam (BSE) is helpful in detecting a lump early (Figure 17.4). If a woman begins doing regular breast self-exams in early adulthood, she becomes familiar with the consistency of her breast tissue. With this experience, it is easier to notice changes that might be signs of breast cancer. Mammograms, which are x-ray exams of breast tissue, can also help detect early breast cancer because they can reveal a tumor too small to be felt as a lump. A tumor large enough to be felt contains a billion or more cells—a few of which may already have spread from the tumor to other tissues of the body. After cancer cells spread, the woman's chance of survival decreases dramati-

ETHICAL ISSUE

Gene Testing

Genetic screening is the practice of testing people who have no symptoms to determine whether they carry genes that will influence their chances of developing certain genetic diseases. Genetic screening technologies are advancing rapidly, and their use is gaining popularity. However, genetic screening raises many ethical questions.

Among the advantages of genetic testing is that it enables people who discover they are at risk for a treatable or preventable condition to take steps to reduce their risk. By informing people that they carry a recessive allele they were unaware of or a dominant allele that is not expressed until late in life, genetic screening can also help reduce the incidence of serious genetic diseases in future generations. Consider Tay-Sachs disease, an autosomal recessive disorder that causes the death of children, usually by the age of 5. Tay-Sachs disease is especially prevalent in descendants of Jewish people from eastern Europe. As a result of voluntary screening programs, the number of children born with Tay-Sachs disease has decreased markedly in many communities.

Genetic testing also has a dark side. The psychological consequences of test results can be devastating. More genetic diseases cannot be prevented or treated. How does a person who may have one of these disorders prepare for the consequences of knowing now what will result in his or her death? Huntington's disease, for example, is caused by a dominant allele that provides no hints of its existence until relatively late in life, usually past child-bearing years. About 60% of people with Huntington's disease are diagnosed between the ages of 35 and 50. The gene causes degeneration of the brain, leading to muscle spasms, personality disorders, and death, usually within 10 to 15 years. Because Huntington's disease is caused by a dominant allele, a person has a 50% chance of passing it to his or her children. Thus, a person whose parent died of Huntington's disease might well be tested and receive the good news that the test did not detect the allele. But it is equally likely that the allele will show up in the test. Many people at risk for Huntington's disease prefer to live without knowing their possible fate.

There is also concern that the results of genetic tests will remain private information but instead be used by employers as well as life and health insurers, if you were an employer who had genetic information about prospective employees, would you choose to invest time and money in training a person who carried an allele that increased the risk of cancer, heart disease, Alzheimer's disease, or osteoarthritis? As an insurer, would you knowingly cover such a carrier?

The results of genetic testing can have both positive and negative consequences for individuals being tested and for their families. Who, then, should decide whether screening should be done, for which genes, on whom, and in which communities? At first blush, one might be tempted to say, "There ought to be a law!" Should we leave ethical issues to judges and legislators? Should moral matters be decided by society or clergy? Or should they be personal decisions? There are not easy questions to answer or even to think about—yet we do not take care in the debate, we will be leaving others to decide these crucial issues for us.

Questions to Consider

- If genetic testing is done, should the person being tested be told the results no matter what? If the affected person is an infant, should the parents always be told the results, even if the condition is poorly understood? How do we balance helping such children with the possibility of stigmatizing them?
- We live in a world of limited resources. In addition to deciding who should be tested, we must decide who should pay the bill. Both testing and treatment are expensive. Should testing be done only when treatment or preventive measures are available? How much say should the agent that pays for the procedure have in deciding who is tested and who receives medical treatment?

QUESTIONS TO CONSIDER

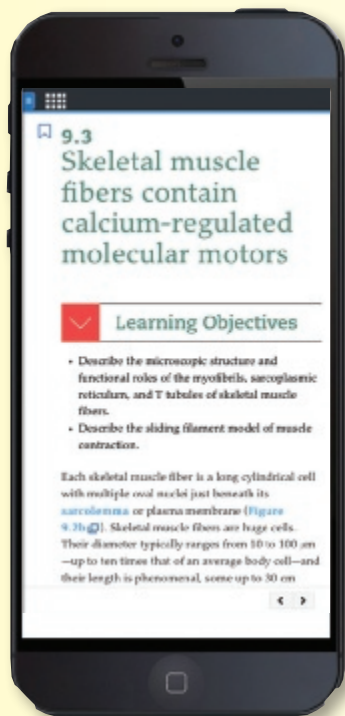
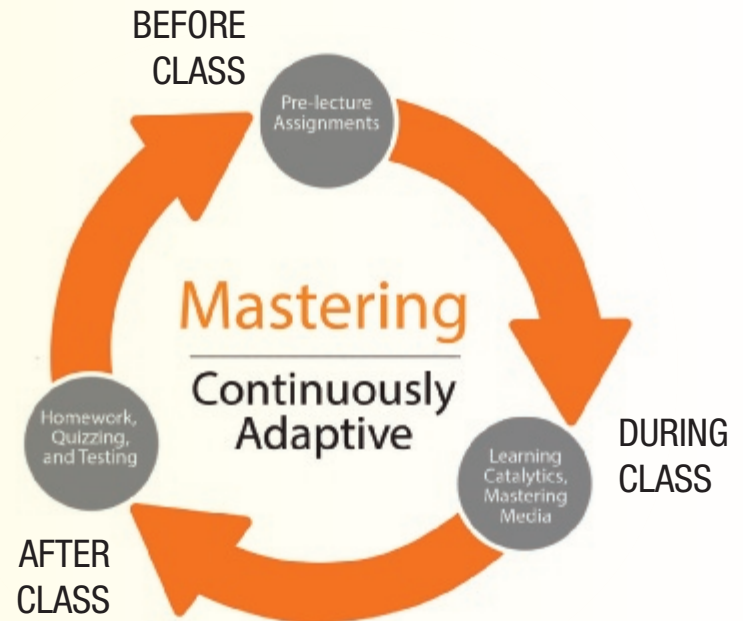
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Questions to Consider conclude each box and ask students to think about the ethical implications of certain behaviors (such as taking anabolic steroids) or medical procedures (such as generating extra embryos as part of infertility treatments).

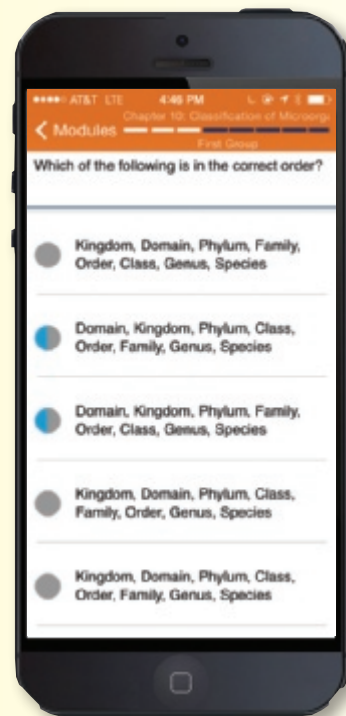
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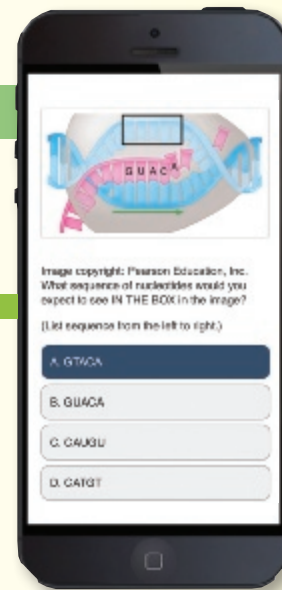
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NEW! **Everyday Biology Videos** briefly explore interesting and relevant biology topics that relate to concepts in the course. These videos, produced by the BBC, can be shown in class or assigned as homework in MasteringBiology.

AFTER CLASS

A wide range of question types and activities are available for homework assignments, including the following **NEW** assignment options for the Sixth Edition:

- **Interactive Physiology 2.0** help students advance beyond memorization to a genuine understanding of complex physiological processes. Full-color animations and videos demonstrate difficult
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Brief Contents

PART I

The Organization of the Body

- 
- 1 Humans in the World of Biology 1
 - 1a **SPECIAL TOPIC:** Becoming a Patient: A Major Decision 14
 - 2 Chemistry Comes to Life 21
 - 3 The Cell 43
 - 4 Body Organization and Homeostasis 65

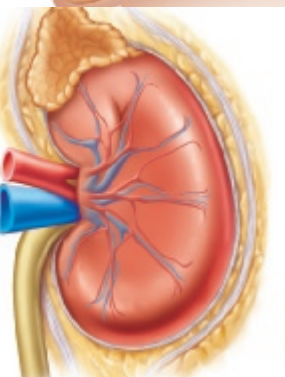
PART II

Control and Coordination of the Body

- 
- 5 The Skeletal System 86
 - 6 The Muscular System 101
 - 7 Neurons: The Matter of the Mind 115
 - 8 The Nervous System 127
 - 8a **SPECIAL TOPIC:** Drugs and the Mind 143
 - 9 Sensory Systems 151
 - 10 The Endocrine System 171
 - 10a **SPECIAL TOPIC:** Diabetes Mellitus 190

PART III

Maintenance of the Body

- 
- 11 Blood 198
 - 12 The Cardiovascular and Lymphatic Systems 213
 - 12a **SPECIAL TOPIC:** Cardiovascular Disease 232
 - 13 Body Defense Mechanisms 239
 - 13a **SPECIAL TOPIC:** Infectious Disease 259
 - 14 The Respiratory System 268
 - 15 The Digestive System and Nutrition 286
 - 15a **SPECIAL TOPIC:** The Obesity Epidemic 312
 - 16 The Urinary System 317

PART IV

Reproduction and Development

- 
- 17 Reproductive Systems 336
 - 17a **SPECIAL TOPIC:** Sexually Transmitted Diseases and AIDS 356
 - 18 Development throughout Life 366
 - 18a **SPECIAL TOPIC:** Autism Spectrum Disorder 387

PART V

Genes and DNA

- 
- 19 Chromosomes and Cell Division 394
 - 19a **SPECIAL TOPIC:** Stem Cells—A Repair Kit for the Body 412
 - 20 Genetics and Human Inheritance 419
 - 21 DNA and Biotechnology 436
 - 21a **SPECIAL TOPIC:** Cancer 458

PART VI

Evolution and Ecology

- 
- 22 Evolution and Our Heritage 470
 - 23 Ecology, the Environment, and Us 491
 - 24 Human Population, Limited Resources, and Pollution 508

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Detailed Contents

About the Authors xxiii

Preface xviii

PART I

The Organization of The Body

1 Humans in the World of Biology 1

1.1 Basic Characteristics of All Living Things 1

ENVIRONMENTAL ISSUE

Medicinal Plants and the Shrinking Rain Forest 2

1.2 Evolution: A Unifying Theme in Biology 4

1.3 Levels of Biological Organization 5

1.4 Scientific Method 6

Inductive and Deductive Reasoning 8

Clinical Trials 8

Epidemiological Studies 9

1.5 Critical Thinking to Evaluate Scientific Claims 10

1a SPECIAL TOPIC: Becoming a Patient: A Major Decision 14

1a.1 Young Adults and Health Care 14

1a.2 Selecting a Primary Care Physician 15

Responsibilities of Primary Care Physicians 15

Primary Care Physician Settings 15

Evaluating Primary Care Physicians 15

1a.3 Getting the Most Out of an Appointment with Your Doctor 16

Preparing for an Appointment 16

What to Expect during an Appointment 16

Understanding Medications 17

1a.4 Finding a Specialist and Getting a Second Opinion 17

1a.5 Appointing a Health Care Agent 18

1a.6 Selecting a Hospital and Staying Safe 18

Accreditation Status 19

Extent of Experience and Treatment Success 19

Preventing Medical Errors 19

1a.7 Researching Health Conditions on Your Own 20

2 Chemistry Comes to Life 21

2.1 The Nature of Atoms 21

Elements 22

Isotopes and Radioisotopes 22

2.2 Chemical Bonds and Compounds 24

Covalent Bonds 24

Ionic Bonds 25

2.3 The Role of Water in Life 26

Polarity and Hydrogen Bonds 27

ENVIRONMENTAL ISSUE

Radon Gas: A Killer That Can Be Stopped 28

Properties of Water 28

Acids and Bases 29

The pH Scale 29

Buffers 30

2.4 Major Molecules of Life 31

Carbohydrates 31

Lipids 33

Proteins 35

ENVIRONMENTAL ISSUE

Toilet to Tap 36

Nucleic Acids and Nucleotides 38

3 The Cell 43

3.1 Eukaryotic Cells Compared with Prokaryotic Cells 43

3.2 Cell Size and Microscopy 45

3.3 Cell Structure and Function 46

3.4 Plasma Membrane 46

Plasma Membrane Structure 46

Plasma Membrane Functions 47

Movement across the Plasma Membrane 48

3.5 Organelles 51

Nucleus 51

Endoplasmic Reticulum 52

Golgi Complex 52

Lysosomes 54

Mitochondria 55

ENVIRONMENTAL ISSUE

The Deadly Interaction between Asbestos and Lysosomes 56

3.6 Cytoskeleton 56

3.7 Cellular Respiration and Fermentation in the Generation of ATP 57

Cellular Respiration 58

Fermentation 60

HEALTH ISSUE

Mitochondrial Diseases 62

4 Body Organization and Homeostasis 65

4.1 From Cells to Organ Systems 65

Tissues 65

Cell Junctions 71



Organs and Organ Systems 71
 Body Cavities Lined with Membranes 71

4.2 Skin: An Organ System 73

Skin Functions 73
 Skin Layers 73
 Skin Color 77
 Hair, Nails, and Glands 77

HEALTH ISSUE

Fun in the Sun? 78

HEALTH ISSUE

Acne: The Miseries and Myths 79

4.3 Homeostasis 79

Negative Feedback Mechanisms 80
 Hypothalamus and Body Temperature 81

PART II.

Control and Coordination of the Body

5 The Skeletal System 86

- 5.1 Bone Functions 86
- 5.2 Bone Structure 87
- 5.3 Bone as a Living Tissue 88
 - Cartilage Model 88
 - Hormones and Bone Growth 88
- 5.4 The Role of Fibroblasts and Osteoblasts in Repairing Bone Fractures 89
- 5.5 Bone Remodeling 90
- 5.6 Axial Skeleton 91

HEALTH ISSUE

- Osteoporosis: Fragility and Aging 92
 - Skull 92
 - Vertebral Column 94
 - Rib Cage 94
- 5.7 Appendicular Skeleton 94
 - Pectoral Girdle 94
 - Pelvic Girdle 95
- 5.8 Joints 95
 - Synovial Joints 96
 - Damage to Joints 97
 - Arthritis 98

6 The Muscular System 101

- 6.1 Function and Characteristics of Muscles 101
- 6.2 Skeletal Muscles Working in Pairs 102
- 6.3 Contraction of Muscles 102
 - Sliding Filament Model 104
 - Calcium Ions and Regulatory Proteins 105
 - Role of Nerves 105
 - Muscular Dystrophy 107
- 6.4 Voluntary Movement 107
 - Motor Units and Recruitment 107
 - Muscle Twitches, Summation, and Tetanus 108
- 6.5 Energy for Muscle Contraction 108
- 6.6 Slow-Twitch and Fast-Twitch Muscle Cells 109
- 6.7 Building Muscle 110

ETHICAL ISSUE

Anabolic Steroid Abuse 111



7 Neurons: The Matter of the Mind 115

- 7.1 Cells of the Nervous System 115
 - Neuroglial Cells 115
 - Neurons 116
- 7.2 Structure of Neurons 116
 - Axons and Dendrites 116
 - Myelin Sheath 116
- 7.3 Nerve Impulses 118
 - Plasma Membrane of a Neuron 118
 - Resting Potential 118
 - Action Potential 118
- 7.4 Synaptic Transmission 120
 - Release of the Neurotransmitter and the Opening of Ion Channels 120
 - Summation of Input from Excitatory and Inhibitory Synapses 121
 - Removal of Neurotransmitter 121
 - Roles of Different Neurotransmitters 122

HEALTH ISSUE

Neurotransmitters and Disease 123

8 The Nervous System 127

- 8.1 Organization of the Nervous System 127
- 8.2 The Central Nervous System 128
 - Protection of the Central Nervous System 128
 - Brain: Command Center 129
 - Spinal Cord: Message Transmission and Reflex Center 135

HEALTH ISSUE

Brain Injury: A Silent Epidemic 136

- 8.3 The Peripheral Nervous System 137
 - Somatic Nervous System 137
 - Autonomic Nervous System 137
- 8.4 Disorders of the Nervous System 139
 - Headaches 139
 - Strokes 139
 - Coma 139
 - Spinal Cord Injury 139

8a SPECIAL TOPIC: Drugs and the Mind 143

- 8a.1 Psychoactive Drugs and Communication between Neurons 143
- 8a.2 Drug Dependence 144
- 8a.3 Alcohol 144
 - Absorption and Distribution 145
 - Rate of Elimination 145
 - Health-Related Effects 146
- 8a.4 Marijuana 147
 - THC Receptors in the Brain 147
 - Health-Related Effects of Long-Term Use 147
 - Legalized Marijuana 148

- 8a.5 **Stimulants** 148
 - Cocaine 148
 - Amphetamines 149
 - Nicotine 149
- 8a.6 **Hallucinogens** 149
- 8a.7 **Opiates** 150
 - Prescription Painkillers 150
 - Heroin 150

9 Sensory Systems 151

- 9.1 **Sensory Receptors** 151
- 9.2 **Classes of Receptors** 152
- 9.3 **The General Senses** 152
 - Touch, Pressure, and Vibration 153
 - Temperature Change 153
 - Body and Limb Position 153
 - Pain 153
- 9.4 **Vision** 154
 - Wall of the Eyeball 154
 - Fluid-Filled Chambers 156
 - Focusing and Sharp Vision 156
 - Light and Pigment Molecules 157
 - Rods: Vision in Dim Light 158
 - Cones: Color Vision 158
- 9.5 **Hearing** 159
 - Form and Function of the Ear 160
 - Loudness and Pitch of Sound 163
 - Hearing Loss 163
 - Ear Infections 164
- 9.6 **Balance and the Vestibular Apparatus of the Inner Ear** 164

ENVIRONMENTAL ISSUE

Noise Pollution 166

- 9.7 **Smell and Taste** 166

10 The Endocrine System 171

- 10.1 **Functions and Mechanisms of Hormones** 171
 - Hormones as Chemical Messengers 172
 - Feedback Mechanisms and Secretion of Hormones 174
 - Interactions between Hormones 175
- 10.2 **Hypothalamus and Pituitary Gland** 175
 - Anterior Lobe 177
 - Posterior Lobe 178
- 10.3 **Thyroid Gland** 179

ETHICAL ISSUE

Hormone Therapy 180

- 10.4 **Parathyroid Glands** 182
- 10.5 **Adrenal Glands** 183
 - Adrenal Cortex 183
 - Adrenal Medulla 184
- 10.6 **Pancreas** 185
- 10.7 **Thymus Gland** 185
- 10.8 **Pineal Gland** 185
- 10.9 **Locally Acting Chemical Messengers** 186

10a SPECIAL TOPIC: Diabetes Mellitus 190

- 10a.1 **General Characterization and Overall Prevalence** 190
- 10a.2 **Type 1 and Type 2 Diabetes** 191
 - Characterization and Risk Factors 191

- Symptoms and Complications 192
- Diagnosis 193
- Treatments 194
- Lifestyle Changes and Key Recommendations after Diagnosis 195
- Prognoses 195

10a.3 Gestational Diabetes 196



PART III

Maintenance of the Body

11 Blood 198

- 11.1 **Functions of Blood** 198
- 11.2 **Composition of Blood** 199
 - Plasma 199
 - Formed Elements 199
- 11.3 **Blood Cell Disorders** 204
 - Disorders of Red Blood Cells 204
 - Disorders of White Blood Cells 204

HEALTH ISSUE

Blood Tests: Important Clues in Diagnosis 205

- 11.4 **Blood Types** 206
 - ABO Blood Types 206
 - Rh Factor 207
 - Blood Donation 208
- 11.5 **Blood Clotting** 208

12 The Cardiovascular and Lymphatic Systems 213

- 12.1 **Cardiovascular System** 213
- 12.2 **Blood Vessels** 213
 - Arteries 215
 - Capillaries 216
 - Veins 218
- 12.3 **Heart** 219
 - Two Circuits of Blood Flow 219
 - Cardiac Cycle 222
 - Internal Conduction System 223
 - Electrocardiogram 224

12.4 **Blood Pressure** 224

12.5 **Lymphatic System** 225

HEALTH ISSUE

Benefits of Cardiovascular Exercise 226

12a SPECIAL TOPIC: Cardiovascular Disease 232

- 12a.1 **The Prevalence of Cardiovascular Disease** 232
- 12a.2 **Blood Clots** 232

- 12a.3 Problems with Blood Vessels 233
 - High Blood Pressure 233
 - Aneurysm 233
 - Atherosclerosis 233
- 12a.4 Heart Attack and Heart Failure 236
- 12a.5 Cardiovascular Disease and Cigarette Smoking 237
- 12a.6 Preventing Cardiovascular Disease 238

13 Body Defense Mechanisms 239

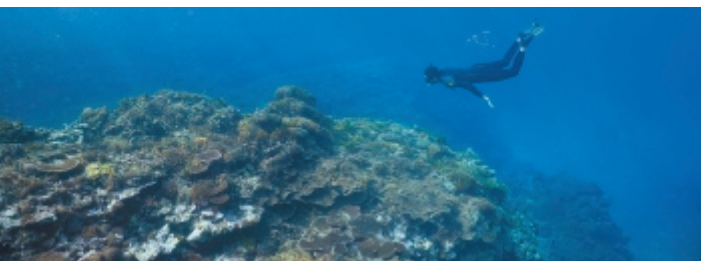
- 13.1 The Body's Defense System 239
- 13.2 Three Lines of Defense 240
 - First Line of Innate Defense: Physical and Chemical Barriers 240
 - Second Line of Innate Defense: Defensive Cells and Proteins, Inflammation, and Fever 240
 - Third Line of Defense: Adaptive Immune Response 244
- 13.3 Distinguishing Self from Nonself 245
- 13.4 Antibody-Mediated Responses and Cell-Mediated Responses 245
- 13.5 Steps of the Adaptive Immune Response 246
- 13.6 Active and Passive Immunity 251
- 13.7 Monoclonal Antibodies 252
- 13.8 Problems of the Immune System 252
 - Autoimmune Disorders 252

HEALTH ISSUE

- Rejection of Organ Transplants 253
- Allergies 254

13a SPECIAL TOPIC: Infectious Disease 259

- 13a.1 Pathogens 259
 - Bacteria 259
 - Viruses 261
 - Protozoans 263
 - Fungi 264
 - Parasitic Worms 264
 - Prions 264
- 13a.2 Spread of a Disease 264
- 13a.3 Infectious Diseases as a Continued Threat 266
 - Emerging Diseases and Reemerging Diseases 266
 - Global Trends in Emerging Infectious Diseases 267
 - Epidemiology 267



14 The Respiratory System 268

- 14.1 Structures of the Respiratory System 268
 - Nose 269
 - Sinuses 270
 - Pharynx 271
 - Larynx 271
 - Trachea 273
 - Bronchial Tree 273
 - Alveoli 273
 - Lungs 274

14.2 Mechanism of Breathing 274

- Inhalation 274
- Exhalation 275
- The Volume of Air Moved into or out of the Lungs during Breathing 275

14.3 Transport of Gases between the Lungs and the Cells 276

- Oxygen Transport and Hemoglobin 276
- Carbon Dioxide Transport and Bicarbonate Ions 277

14.4 Respiratory Centers in the Brain 278

- Basic Breathing Pattern 278
- Chemoreceptors 279

14.5 Respiratory Disorders 279

- Common Cold 279

HEALTH ISSUE

- Surviving a Common Cold 280
 - Flu 280
 - Pneumonia 280
 - Strep Throat 281
 - Tuberculosis 281
 - Cystic Fibrosis 281
 - Chronic Obstructive Pulmonary Disease (COPD) 281
 - Lung Cancer 282

HEALTH ISSUE

- Smoking and Lung Disease 283

15 The Digestive System and Nutrition 286

15.1 The Gastrointestinal Tract 286

15.2 Specialized Compartments for Food Processing 287

- Mouth 287
- Pharynx 290
- Esophagus 290
- Stomach 290
- Small Intestine 292
- Accessory Organs: Pancreas, Liver, and Gallbladder 294
- Large Intestine 296

HEALTH ISSUE

- Peptic Ulcers 297

15.3 Nerves and Hormones in Digestion 298

15.4 Planning a Healthy Diet 299

15.5 Nutrients 300

- Lipids 301
- Carbohydrates 302
- Proteins 303
- Vitamins 304
- Minerals 304
- Water 304

15.6 Food Labels 306

15.7 Energy Balance 307

15.8 Eating Disorders 307

15a SPECIAL TOPIC: The Obesity Epidemic 312

- 15a.1 What Is Obesity? 312
 - Body Mass Index 312

- 15a.2 Health Risks of Obesity 313

15a.3 Regulation of Food Intake 314

15a.4 Weight Management 315

16 The Urinary System 317

16.1 Eliminating Waste 317

16.2 Components of the Urinary System 318

16.3 Kidneys and Homeostasis 318

Structure of the Kidneys 318

Nephrons 319

Acid-Base Balance 324

Water Conservation 324

Hormones and Kidney Function 324

HEALTH ISSUE

Urinalysis 326

Red Blood Cells and Vitamin D 328

16.4 Dialysis and Transplant Surgery 328

Dialysis 329

Kidney Transplant Surgery 329

16.5 Urination 330

16.6 Urinary Tract Infections 332

ETHICAL ISSUE

Kidney Donation and Trafficking 333

PART IV

Reproduction and Development

17 Reproductive Systems 336

17.1 Gonads 336

17.2 Male and Female Reproductive Roles 336

17.3 Form and Function of the Male Reproductive System 337

Testes 337

Duct System 337

Accessory Glands 337

Penis 339

Sperm Development 340

Hormones 341

17.4 Form and Function of the Female Reproductive System 342

Ovaries 342

Oviducts 342

Uterus 343

External Genitalia 343

Breasts 343

Ovarian Cycle 343

Coordination of the Ovarian and Uterine

Cycles 345

Menopause 347

17.5 Disorders of the Female Reproductive System 347

HEALTH ISSUE

Breast Cancer 348

17.6 Stages of the Human Sexual Response 349

17.7 Birth Control 350

Abstinence 350

Sterilization 350

Hormonal Contraception 350

Intrauterine Devices 351

Barrier Methods 351

Spermicidal Preparations 352

Fertility Awareness 352

Emergency Contraception 352

17a SPECIAL TOPIC: Sexually Transmitted Diseases and AIDS 356

17a.1 Long-Lasting Effects of STDs and STIs 356

17a.2 STDs Caused by Bacteria 357

Chlamydia and Gonorrhea 357

Syphilis 358

17a.3 STDs Caused by Viruses 359

Genital Herpes 359

HPV and Genital Warts 360

17a.4 HIV/AIDS 361

Global Pandemic 361

Form of HIV 361

Replication of HIV and Implications for

Treatment 362

Transmission of HIV 362

Sites of HIV Infection 363

Stages of HIV Infection 363

Treatments 364

18 Development throughout Life 366

18.1 Periods of Development in Human Life 366

18.2 Prenatal Period 366

Pre-embryonic Period 367

ETHICAL ISSUE

Making Babies 371

Embryonic Period 372

Fetal Period 376

18.3 Birth 376

18.4 Birth Defects 378

18.5 Milk Production by Mammary Glands 380

18.6 Postnatal Period 380

Possible Causes of Aging 381

HEALTH ISSUE

Disparities in Health and Health Care at All Life Stages 382

High-Quality Old Age 383



18a SPECIAL TOPIC: Autism Spectrum Disorder 387

18a.1 Characterization and Prevalence 387

18a.2 Diagnosis 389

18a.3 Possible Causes 390

18a.4 Treatment and Therapy 391

18a.5 Fear That Vaccines Cause Autism Spectrum Disorder 392



PART V

Genes and DNA

19 Chromosomes and Cell Division 394

- 19.1 Two Types of Cell Division 394
- 19.2 Form of Chromosomes 395
- 19.3 The Cell Cycle 395
 - Interphase 396
 - Division of the Nucleus and the Cytoplasm 396
- 19.4 Mitosis: Creation of Genetically Identical Diploid Body Cells 396
- 19.5 Cytokinesis 398
- 19.6 Karyotypes 400
- 19.7 Meiosis: Creation of Haploid Gametes 400
 - Functions of Meiosis 400
 - Two Meiotic Cell Divisions: Preparation for Sexual Reproduction 400
 - Genetic Variability: Crossing Over and Independent Assortment 404
 - Extra or Missing Chromosomes 406

ETHICAL ISSUE

Trisomy 21 408

19a SPECIAL TOPIC: Stem Cells—A Repair Kit for the Body 412

- 19a.1 Stem Cells: Unspecialized Cells 412
- 19a.2 Sources of Human Stem Cells 413
 - Adult Stem Cells: Unipotent and Multipotent 413
 - Umbilical Cord and Placental Stem Cells: Multipotent 413
 - Embryonic Stem Cells: Pluripotent 414
 - Induced Pluripotent Stem Cells 416
- 19a.3 Potential Uses for Stem Cells 416
 - Replacement for Damaged Cells 416
 - Growing New Organs 416
 - Testing New Drugs 418

20 Genetics and Human Inheritance 419

- 20.1 Principles of Inheritance 419
 - Gamete Formation 420
 - Mendelian Genetics 420
 - Pedigrees 423
 - Dominant and Recessive Alleles 425
 - Codominant Alleles 426
 - Incomplete Dominance 426
 - Pleiotropy 427
 - Multiple Alleles 427
 - Polygenic Inheritance 428
 - Genes on the Same Chromosome 429

- Sex-Linked Genes 429
- Sex-Influenced Genes 429

20.2 Breaks in Chromosomes 430

20.3 Detecting Genetic Disorders 431

- Prenatal Genetic Testing 431
- Newborn Genetic Testing 431
- Adult Genetic Testing 431

ETHICAL ISSUE

Gene Testing 432

21 DNA and Biotechnology 436

- 21.1 Form of DNA 436
- 21.2 Replication of DNA 437
- 21.3 Gene Expression 438
 - RNA Synthesis 438
 - Protein Synthesis 439
- 21.4 Mutations 443
- 21.5 Epigenetics: Regulating Gene Activity 444
 - Gene Activity at the Chromosome Level 444
 - Regulating the Transcription of Genes 444
- 21.6 Genetic Engineering 444
 - Recombinant DNA 444
 - Applications of Genetic Engineering 447
 - Gene Therapy 448
- 21.7 Genomics 449
 - Human Genome Project 449

HEALTH ISSUE

Genetically Modified Food 450

ENVIRONMENTAL ISSUE

- Environment and Epigenetics 452
 - The Epigenome 452
 - Microarray Analysis 452
- Comparison of Genomes of Different Species 453

ETHICAL ISSUE

Forensic Science, DNA, and Personal Privacy 454

21a SPECIAL TOPIC: Cancer 458

- 21a.1 Uncontrolled Cell Division 458
 - Benign or Malignant Tumors 458
 - Stages of Cancer Development 459
- 21a.2 Development of Cancer 460
 - Lack of Restraint on Cell Division 460
 - DNA Damage and Cell Destruction 461
 - Unlimited Cell Division 461
 - Blood Supply to Cancer Cells 462
 - Adherence to Neighboring Cells 462
 - Body Defense Cells 462
- 21a.3 Multiple Mutations 462
- 21a.4 Cancer and Epigenomics 463
- 21a.5 Cancer Stem Cell Hypothesis 464
- 21a.6 Known Causes of Cancer 464
 - Viruses 464
 - Chemicals 465
 - Radiation 465
- 21a.7 Reducing the Risk of Cancer 465
- 21a.8 Diagnosing Cancer 466
- 21a.9 Treating Cancer 468
 - Surgery 468
 - Radiation 468

Chemotherapy 468
 Targeted Cancer Treatment 468
 Immunotherapy 469
 Inhibition of Blood Vessel Formation 469
 Gene Therapy 469

PART VI

Evolution and Ecology

22 Evolution and Our Heritage 470

22.1 Evolution of Life on Earth 470

Small Organic Molecules 471
 Macromolecules 471
 Early Cells 472

22.2 Scale of Evolutionary Change 472

Microevolution 472
 Macroevolution 474

22.3 Evidence of Evolution 476

Fossil Record 476
 Geographic Distributions 478
 Comparative Molecular Biology 479

ETHICAL ISSUE

Conducting Research on Nonhuman Primates 479
 Comparative Anatomy and Embryology 480

22.4 Human Evolution 481

Primate Characteristics 481
 Misconceptions 483
 Trends in Hominin Evolution 483

23 Ecology, the Environment, and Us 491

23.1 Earth as an Ecosystem 491

23.2 Biosphere 492

23.3 Ecological Succession 492

23.4 Energy Flow 494

Food Chains and Food Webs 494
 Energy Transfer through Trophic Levels 496
 Ecological Pyramids 496
 Health and Environmental Consequences of Ecological Pyramids 496

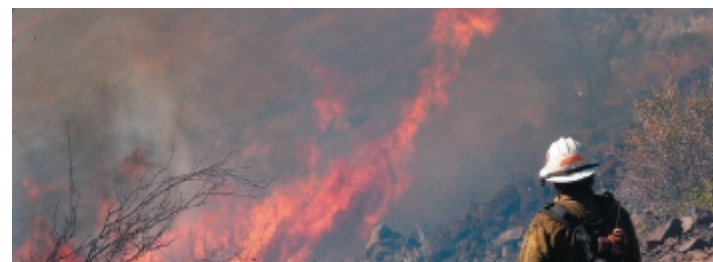
23.5 Chemical Cycles 498

The Water Cycle 498
 The Carbon Cycle 499
 The Nitrogen Cycle 501
 The Phosphorus Cycle 502

23.6 Biodiversity 502

ETHICAL ISSUE

Maintaining Our Remaining Biodiversity 504
 Causes for Loss of Biodiversity 504
 The Importance of Biodiversity 505



24 Human Population, Limited Resources, and Pollution 508

24.1 Population Changes 508

Population Growth Rate 508
 Age Structure 510
 Immigration and Emigration 510

24.2 Patterns of Population Growth 510

24.3 Environmental Factors and Population Size 511

24.4 Earth's Carrying Capacity 512

24.5 Human Impacts on Earth's Carrying Capacity 512

Agricultural Advances 512
 Depletion of Resources 512
 Pollution 515

24.6 Global Climate Change 516

Global Warming and Greenhouse Gases 516
 Carbon Footprint 517

ENVIRONMENTAL ISSUE

Air Pollution and Human Health 518

24.7. Looking to the Future 519

Appendix 1

Answers to Reviewing the Concepts Questions A-2

Appendix 2

Hints for Applying the Concepts Questions A-4

Appendix 3

Answers to Figure Questions A-6

Glossary G-1

Credits C-1

Index I-1

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Special Interest Essays

ENVIRONMENTAL ISSUES



Medicinal Plants and the Shrinking Rain Forest 2

Radon Gas: A Killer That Can Be Stopped 28

Toilet to Tap 36

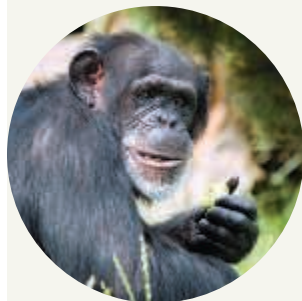
The Deadly Interaction between Asbestos and Lysosomes 56

Noise Pollution 166

Environment and Epigenetics 452

Air Pollution and Human Health 518

ETHICAL ISSUES



Anabolic Steroid Abuse 111

Hormone Therapy 180

Kidney Donation and Trafficking 333

Making Babies 371

Trisomy 21 408

Gene Testing 432

Forensic Science, DNA, and Personal Privacy 454

Conducting Research on Nonhuman Primates 479

Maintaining Our Remaining Biodiversity 504

HEALTH ISSUES



Mitochondrial Diseases 62

Fun in the Sun? 78

Acne: The Miseries and Myths 79

Osteoporosis: Fragility and Aging 92

Neurotransmitters and Disease 123

Brain Injury: A Silent Epidemic 136

Blood Tests: Important Clues in Diagnosis 205

Benefits of Cardiovascular Exercise 226

Rejection of Organ Transplants 253

Surviving a Common Cold 280

Smoking and Lung Disease 283

Peptic Ulcers 297

Urinalysis 326

Breast Cancer 348

Disparities in Health and Health Care at All Life Stages 382

Genetically Modified Food 450

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Judith Goodenough

Judith received her B.S. in biology from Wagner College (Staten Island, NY) and her doctorate in biology from New York University. She has more than 35 years of teaching experience at the University of Massachusetts, Amherst, until recently specializing in introductory-level courses. In 2009, she was selected as a College of Natural Sciences Fellow for Blended Learning and developed a hybrid course in introductory physiology. She has experience teaching in the classroom, hybrid courses, and online courses. Her insights into student concerns and problems—gained from more than 30 years of teaching human biology and 20 years of team-teaching the biology of social issues—have helped shape this book. In 1986, Judith was honored with a Distinguished Teaching Award from the University of Massachusetts. In addition to teaching, she has written articles in peer-reviewed journals, contributed chapters to several introductory biology texts, and authored numerous laboratory manuals. With the team of McGuire and Jakob, she is also the coauthor of *Perspectives on Animal Behavior*, Third Edition.



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Betty McGuire

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DEDICATION

*To Stephen, my husband,
best friend, personal hero,
and the funniest person I know.
To Aimee and Heather, my daughters,
who fill me with love, wonder, and amazement.
To Betty Levrat, my mother,
an excellent role model
and endless source of support and encouragement.
To "The Group," friends for more than 40 years,
who help me hold it all together.*

—J. G.

*In loving memory of James Patrick McGuire.
To Willy, Kate, and Owen Bemis,
and to Dora, Kevin, and Cathy McGuire.*

—B. M.

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Preface

HUMANS ARE CURIOUS BY NATURE. This book was written to stimulate that curiosity, inspiring appreciation for the intricacy of human biology and the place of humans in the biosphere. To satisfy that curiosity with solid and current information, we provide students with a conceptual framework for understanding how their bodies work and for dealing with issues relevant to human health in the modern world. We sustain the student's interest by continually illustrating the connections between biological concepts and issues of current social, ethical, and environmental concern. Our central belief is that the application of biological concepts to familiar experiences is the key to helping students see the excitement of science and understand its importance in their lives.

This edition builds on the Fifth Edition's strengths of clarity, liveliness, consistency, currency, and relevance. The writing is engaging, the explanations straightforward, and the pedagogical framework meticulously constructed. All features are designed to help students identify important facts and ideas, understand them, and appreciate why they matter.

Application of the material to students' interests brings concepts to life and illustrates the ethical and social relevance of human biology. This strategy is especially apparent in the "Special Topic" chapters and the dozens of Special Interest Essays distributed throughout the other chapters.

Practical Goals and Special Features

The principal goals of this textbook are (1) to give a *clear presentation of the fundamental concepts* of human anatomy, physiology, development, genetics, evolution, and ecology; (2) to *apply these concepts* in ways that will both interest and benefit students; (3) to help students *develop reasoning skills* so they can make use of their newly acquired knowledge in the situations they face in daily life; (4) to help students *evaluate the many sources of information* available to them and to select those that are reliable and accurate; and (5) to give students an understanding of how the choices they make can *affect society and the planet, as well as their own quality of life*.

Much of the material covered in human biology has a bearing on ethical, social, and environmental issues that are important to us all. Connections between human biology topics and ethical, social, and environmental issues help students develop a global perspective on their impact on the biosphere and will prepare them to be responsible citizens of their country and the world. Society is currently immersed in many pressing biological debates, and students need the tools to understand these issues and make informed decisions.

New to This Edition

The Sixth Edition includes new features and information that increase application of the material to students' everyday lives and make it more accessible as well as help them build twenty-first century skills.

- A new **Consider This Case** feature at the end of every chapter presents a scenario relating to the chapter content, followed by critical thinking questions that ask students to apply what they've learned in the chapter.
- A new **Finding and Evaluating Information** feature at the end of each main chapter presents new research highlighted in current media, and asks students to evaluate the information and conclusions presented, as well as to find other reliable sources of information on the topic.
- A new **Special Topic** chapter, titled The Obesity Epidemic, has been added. Focusing on the problem of obesity, this chapter covers topics such as (1) health risks associated with obesity; (2) regulation of food intake; and (3) weight management.
- Expanded **Did You Know?** boxes now open every chapter, link directly to the chapter opening photo, and pique students' interest with fascinating and little-known facts about the topic that follows.
- A new, inviting design makes the Sixth Edition more student-friendly, easier to read, and reflective of the course level. The new design also helps facilitate an integrated reading experience by using step numbers in complex process figures to connect the text and art.
- The MasteringBiology online homework, tutorial, and assessment system replaces the Human Biology Place companion website of previous editions. Each end-of-chapter review includes a reminder that directs students to MasteringBiology to access related quizzes, activities, and more.
- New to this edition are online Dynamic Study Modules, which help students study effectively on their own by continuously assessing their activity and performance in real time.

Special Topic Chapters

The text contains 10 **Special Topic** chapters: Chapter 1a, Becoming a Patient: A Major Decision; Chapter 8a, Drugs and the Mind; Chapter 10a, Diabetes Mellitus; Chapter 12a, Cardiovascular Disease; Chapter 13a, Infectious Disease; Chapter 15a, The Obesity Epidemic; Chapter 17a, Sexually Transmitted Diseases and AIDS; Chapter 18a, Autism Spectrum Disorder; Chapter 19a, Stem Cells—A Repair Kit for the Body; and Chapter 21a, Cancer. Created to further motivate students to learn, each of these short chapters builds on the "pure biology" presented in

the immediately preceding chapter to cover issues likely to be of personal interest. The discussions these chapters contain are more thoroughly developed than would be possible in a boxed essay. Even if instructors do not include these special topics in their reading assignments, we believe the issues are so pertinent to students that they will read the Special Topic chapters of their own volition, or at least refer to them occasionally as guides to a healthier lifestyle.

Much of the information offered in the text is practical: What can be done to prevent the spread of sexually transmitted diseases? How can one take steps to prevent or treat obesity? The body each of us is born with is a most intricate machine, but it does not come equipped with an owner's manual. In a sense, this book can be the students' owner's manual. Studying and applying the lessons to their individual lifestyles and health issues can help students live longer, happier, and more productive lives.

Special Interest Essays

Three categories of **Special Interest Essays** use the basic scientific content of the chapters to explore issues having broader impact on individual health, society, and the environment.

Environmental Issue essays deal with ways in which human activities alter the environment or, conversely (sometimes simultaneously), ways in which the environment influences human health. Among the topics discussed in **Environmental Issue** essays are asbestos, genetically modified foods, and noise pollution.

Ethical Issue essays explore ethical and social issues related to the topics in a chapter. They explore questions concerning such subjects as anabolic steroid use, gene testing, and the use of nonhuman primates in research.

Finally, **Health Issue** essays deal primarily with personal health topics. They provide current information on certain health problems that students, their families, or their friends might encounter. Topics discussed in **Health Issue** essays include acne, osteoporosis, treatments for the common cold, and disparities in health and health care.

All of these essays include **Questions to Consider**, which ask students to think about the ethical implications of certain behaviors (such as taking anabolic steroids) or medical procedures (such as generating extra embryos as part of infertility treatments).

Stop and Think Questions

The **Stop and Think** questions scattered throughout each chapter are intended to promote active learning. They invite students to pause in their reading to think about the information that was just presented and apply it to a new and interesting situation. These periodic checks allow students to determine whether they have followed and understood the basic chapter content. In the Sixth Edition we have increased the number of **Stop and Think** questions in each of the main chapters and added these questions to the Special Topic chapters.

What Would You Do? Questions

The **What Would You Do?** questions, which are also placed throughout each chapter, challenge the student to form an opinion or to take a stand on a particular issue that society faces today, as well as to identify the criteria used in reaching that opinion or decision. These questions help students see the relevance of biology to real-life problems and foster the practice of thinking through such complicated issues as the use of sperm-sorting technology by parents to select the gender of their offspring and strategies for slowing the growth of human populations. When the subject of one of these questions is controversial, the text presents examples of arguments from both sides, as well as evidence in support of competing arguments.

Enticing Illustration and Design Program

Users of previous editions—instructors and students alike—were unreservedly enthusiastic in praising the illustrations for their appeal and helpfulness. The visual program consists of simple but elegantly rendered illustrations that have been carefully designed for effective pedagogy. Their very beauty stimulates learning. This is particularly true of the many vibrant, three-dimensional anatomical figures, whose realistic style and appropriate depth and detail make them easy for students to interpret and use for review. Micrographs often appear side by side with illustrations to aid interpretation and understanding and to give the actual view of a structure or process being studied.

Within each category of illustrations—from molecular models to depictions of human tissues and organs—the figures are consistent in plan and style throughout the text. Numerous key figures pull concepts together to present the “big picture.” Reference figures help students locate particular structures within the body. Flowcharts walk students through a process one step at a time so they can visually follow the progress of a discussion after they have read an explanation in the body of the text. Similarly, step-by-step figures break complex concepts down into simpler components. Finally, color is used in the visual program as an effective means of organizing information and maintaining consistency throughout the text.

Figure Questions

A question accompanies at least one figure in each chapter. This feature asks a question prompting students to pause and critically examine the information in the figure. Answers are provided in Appendix 3.

Engaging Design

This Sixth Edition of *Biology of Humans* presents an engaging design that was created to complement the vibrancy of the illustrations, clarify the organizational structure of the chapters, and increase overall readability.

Organization and Pedagogy

After an introductory chapter on the science of biology, the text presents a discussion of the chemistry of life; proceeds through cells, tissues, organs, and organ systems; and ends with discussions of genetics, evolution, and ecology. As teachers ourselves, we understand the difficulty of covering all the topics in a human biology text in one semester. Instructors are inevitably forced to make difficult decisions concerning what to include and what to leave out. We also know there are many equally valid ways of organizing the material. For this reason, the chapters in this text are written so as not to depend heavily on material covered in earlier chapters. The independence of each chapter allows the instructor to tailor the use of this text to his or her particular course. At the same time, we provide cross-references where they may be helpful to direct students to relevant discussions in other chapters.

The pedagogical features that provide a consistent framework for every chapter have been designed not only to help students understand the information presented in their human biology course but also to help them study more effectively. Some of the most important of these elements are described next.

Chapter Outlines and Introductions

Each chapter begins with a list of the chapter's main topics constructed from the major headings. Because it identifies the chapter's important concepts and the relationships between them, this feature provides a conceptual framework on which students can mentally organize new information as they read. Special Interest Essay boxes are also included in this outline.

Key Terms and Glossary

Because this text is intended for students who are not science majors, we have held the use of technical language to a minimum. Important terms are set in bold type where they are formally introduced, and they are listed as key terms at the end of each chapter. Other terms of lesser importance are set in italics. The **Recognizing Key Terms** list also provides chapter page numbers indicating where each term is defined. The **Glossary** at the end of the book contains definitions for all the key terms and many of the terms set in italics.

Looking Ahead (and Back)

It's widely known that students often compartmentalize chapters and have trouble seeing how one chapter relates to the next. To address this issue, we conclude each chapter with a **Looking Ahead** box to show students how the following chapter will build on the one they have just finished reading. In addition, we begin each chapter with an introductory paragraph that clearly explains how the material from the previous chapter relates to what they're about to read in the present chapter. This **Looking Ahead** (and back) approach draws explicit ties between chapters.

End-of-Chapter Questions

The questions provided at the end of each chapter are designed in several formats to encourage students to review and understand the relevant material instead of simply memorizing a few salient facts. Some, specifically **Reviewing the Concepts**, are intended simply as content review. Others—particularly those under the heading **Applying the Concepts**—require critical thinking and challenge students to apply what they have learned to new situations. Answers to all **Reviewing the Concepts** questions are provided in Appendix 1, and hints for answering the **Applying the Concepts** questions can be found in Appendix 2. These hints, which help students identify the information needed to answer each question, are intended to guide students in their thinking process instead of simply providing a quick answer.

Finding and Evaluating Information

A new **Finding and Evaluating Information** feature prompts students to explore and evaluate resources beyond the text and can be used as a starting point for developing research papers or reports. Students are presented with a synopsis of (and often an excerpt from) new research featured in current media and asked key questions to evaluate the information and conclusions and to find other reliable sources of information on the topic.

Chapter Updates

All of the material in the book has been carefully reviewed, revised, and updated. The latest statistical information and medical advances have been incorporated throughout. The following is a list of some of the more significant changes in each chapter.

Chapter 1 The discussion of the scientific method has been modified to improve clarity, following reviewer suggestions. Several figures have been modified. Two additional levels of biological organization—atom and organelle—have been added to Figure 1.3. The figure supporting the experiment described in the section on the scientific method has been altered to indicate the research begins with a question. A graph of increased use of cell phones has been added.

Chapter 1a A new section specific to young adults and health care has been added. Estimates of medical errors have been updated. A figure showing the new bedside handoff procedure used by nurses has been included. In response to reviewer comments, new secondary headings have been incorporated into several sections of text, and examples of reliable health care websites are now included.

Chapter 2 The figure of the periodic table has been replaced with a simpler version, and an expanded description is now included in the figure caption. There is a new **Stop and Think** on atomic number and atomic mass that requires students to use the periodic table. The **Environmental Issue** essays on radon exposure in homes and worldwide water shortages have been expanded and updated. There is a new figure showing levels of protein structure.

Chapter 3 The figure of the eukaryotic cell has been enlarged, as requested by reviewers. The **Environmental Issue** essay on asbestos has been updated to include global production and use of asbestos. The **Health Issue** essay on mitochondrial diseases contains new information on maternal age effects and mutations in mitochondrial DNA. Two new **Stop and Think** features have been added; one concerns water intoxication and the other, cellular respiration.

Chapter 4 The discussion of homeostasis has been trimmed to avoid overlap with Chapter 2. The drawing of skin is now three-dimensional and is combined with a micrograph of skin. The micrographs of cell junctions are new.

Chapter 5 The role of calcitonin in bone remodeling has been clarified. The discussion of suture joints and synovial joints has been enhanced.

Chapter 6 Following reviewer suggestions, several figures were modified to increase clarity. The discussion of anabolic steroids now includes reference to the alleged use of anabolic steroids among professional baseball players. There is a short discussion on the new phenomenon “text neck,” which is caused by the increased frequency of texting.

Chapter 7 The figure showing the ionic events during an action potential and the figure illustrating the changes in voltage during an action potential have been made clearer.

Chapter 8 Within the **Health Issue** essay on traumatic brain injury, the focus has shifted from IED injuries to injuries in the NFL. The discussion of the brainstem parts has been reorganized to enhance clarity. The figure showing the organization of the nervous system has been altered so students will understand the divisions more readily.

Chapter 8a The discussion of marijuana, including both medical and recreational use, has been updated and expanded. The connection between prescription pain medication and heroin use is explained.

Chapter 9 The section on noise pollution was trimmed to highlight the most important information. The **Environmental Issue** essay now includes information on hearing loss in young people that is probably caused by loud music. The photographs illustrating differences in normal vision, farsightedness, and nearsightedness have been improved to help the student understand these differences. A photograph of a cataract has been added.

Chapter 10 A new figure of an exocrine gland has been included to highlight the structural differences between exocrine and endocrine glands. Two new **Stop and Think** features have been added, one concerning types of hormonal interactions and the other, Addison’s disease. A new figure illustrates how the hypothalamus and hormones of the adrenal glands regulate stress responses.

Chapter 10a The figure showing insulin regulation of blood glucose levels has been modified to improve clarity and flow of information. All statistics regarding prevalence of diabetes and all blood glucose values for diagnosing different forms of diabetes have been updated. The section on ways to self-administer

insulin now includes a discussion of the insulin patch pump; this device is shown in a new photograph, which allows comparison with the traditional insulin pump, also depicted in a new photograph. Emerging treatments, such as the artificial pancreas for treating type 1 diabetes, are discussed. A new photograph shows the excessive growth characteristic of babies born to mothers with untreated gestational diabetes.

Chapter 11 The formed elements discussion is reorganized so that these elements are covered in the order of the student’s familiarity with each. A new **Health Issue** essay on medical blood tests has been included to help students understand this common medical procedure. The discussion of intercalated discs is expanded.

Chapter 12 The size of several figures has been changed to reflect their importance in understanding the concepts. Lymphoid tissue is discussed at greater length than in previous editions. Multiple-choice questions, two of which involve the lymphatic system, were added to the end-of-chapter material.

Chapter 12a The discussion of HDL- and LDL-cholesterol has been expanded, and a new table has been included. In addition, references to HDLs and LDLs in other chapters have been added.

Chapter 13 Slight modifications have been made to several figures to increase clarity. New photos are intended to stimulate interest in the discussion of passive immunity.

Chapter 13a The material on emerging and reemerging diseases was expanded and updated. A discussion of disease transmission via IV drug use was added, as was a discussion of the role played by failure to vaccinate in the reemergence of disease. Several figures were slightly modified to enhance understanding.

Chapter 14 A discussion of COPD was added. Several figures were modified to increase clarity.

Chapter 15 To enhance clarity, steps were added to the text to accompany those in art. A new discussion predicts the 2015 Dietary Guidelines for Americans based on the recommendations from the committee.

Chapter 15a This new Special Topic chapter, The Obesity Epidemic, discusses biological issues of obesity. It begins by defining the problem and then explains the interrelationships among the three major health risks associated with obesity: cardiovascular disease, type 2 diabetes, and cancer. It continues by explaining the neural, hormonal, and genetic regulation of food intake. The discussion of genetic regulation of food intake includes the recently recognized role of epigenetics, which involves changes in gene activity produced by chemicals in the environment, including the diet. The chapter ends with suggestions for weight management.

Chapter 16 Discussions of the ways kidneys help regulate blood pH and promote the body’s use of calcium and phosphorus have been expanded. Statistics on the need for kidney transplants have been updated. Several figures have been modified to address reviewer requests. Additional detail has been added to the figure showing the organ systems involved in eliminating wastes from the body. A new photograph of a patient undergoing dialysis with an artificial kidney machine replaces the line drawing in the previous edition. In the section on urinary tract