THE WILEY BICENTENNIAL-KNOWLEDGE FOR GENERATIONS

Elach generation has its unique needs and aspirations. When Charles Wiley first opened his small printing shop in lower Manhattan in 1807, it was a generation of boundless potential searching for an identity. And we were there, helping to define a new American literary tradition. Over half a century later, in the midst of the Second Industrial Revolution, it was a generation focused on building the future. Once again, we were there, supplying the critical scientific, technical, and engineering knowledge that helped frame the world. Throughout the 20th Century, and into the new millennium, rations began to reach out beyond their own borders and a new international community was born. Wiley was there, expanding its operations around the world to enable a global exchange of ideas, opinions, and know-how.

For 200 years, Wiley has been an integral part of each generation’s journey, enabling the flow of information and understanding necessary to meet their needs and fulfill their aspirations. Today, bold new technologies are changing the way we live and learn. Wiley will be there, providing you the must-have knowledge you need to imagine new worlds, new possibilities, and new opportunities.

Generations come and go, but you can always count on Wiley to provide you the knowledge you need, when and where you need it!

William J. Pesce
President and Chief Executive Officer

Peter Booth Wiley
Chairman of the Board
Visualizing

HUMAN BIOLOGY

Kathleen Anne Ireland
David J. Tenenbaum

In collaboration with
THE NATIONAL GEOGRAPHIC SOCIETY
Visualizing Human Biology is designed to help your students learn effectively. Created in collaboration with the National Geographic Society and our Wiley Visualizing Consulting Editor, Professor Jan Plan of New York University, Visualizing Human Biology integrates rich visuals and media with text to direct students’ attention to important information. This approach represents complex processes, organizes related pieces of information, and integrates information into clear representations. Beautifully illustrated, Visualizing Human Biology shows your students what the discipline is all about, its main concepts and applications, while also instilling an appreciation and excitement about studying the human body.

Visuals, as used throughout this text, are instructional components that display facts, concepts, processes, or principles. They create the foundation for the text and do more than simply support the written or spoken word. The visuals include diagrams, graphs, photographs, illustrations, schematics, animations, and videos.

Why should a textbook based on visuals be effective? Research shows that we learn better from integrated text and visuals than from either medium separately. Beginners in a subject benefit most from reading about the topic, attending class, and studying well-designed and integrated visuals. A visual, with good accompanying discussion, really can be worth a thousand words!

Well-designed visuals can also improve the efficiency with which information is processed by a learner. The more effectively we process information, the more
prediction can also be based on visuals. Visuals can be very useful for drawing inferences, for predicting, and for problem solving.

5. Use visuals to situate learning in authentic contexts. Learning is made more meaningful when a learner can apply facts, concepts, and principles to realistic situations or examples. Visuals can provide that realistic context.

6. Use visuals to encourage collaboration. Collaborative groups often are required to practice interactive processes such as giving explanations, asking questions, clarifying ideas, and argumentation. These interactive, face-to-face processes provide the information needed to build a verbal mental model. Learners also benefit from collaboration in many instances such as decision making or problem solving.

Visualizing Human Biology not only aids student learning with extraordinary use of visuals, but it also offers a rich selection of visuals in the supplementary materials that accompany the book. To complete this robust package the following materials are available: Test Bank with visuals used in assessment, PowerPoints, Image Gallery to provide you with the same visuals used in the text, interactive animations on the Web, and videos from National Geographic.
This text begins the study of life by focusing on the definitive characteristics of life. A general understanding of chemistry, cell biology, and tissues rounds out Unit 1: Introduction to the Study of Life. Unit 2: Movement through the Environment discusses the human systems involved in movement: the skeletal, muscular, and nervous systems. Unit 3: Protection from the Environment describes how the integumentary and lymphatic systems protect the body against injury and invasion by pathogens. Unit 4: Thriving within the Environment describes how the cardiovascular and respiratory systems transport nutrients and oxygen to the tissues, and how food is digested and wastes are eliminated. Unit 5: Populating the Environment covers the action of the endocrine system, which brings us to sexual maturity and the reproductive system. Fertilization and development complete this unit. Finally, Unit 6: Adapting to and Affecting the Environment relates this information to inheritance and DNA, human evolution, and the ecological balance of the biosphere, which serve to tie the entire book together.
CHAPTER OUTLINES use visual illustrations from the chapter to visually anticipate the content.

ETHICS AND ISSUES BOXES in each chapter highlight controversial topics in human biology to encourage critical thinking about such current issues as stem cell research, use of prescription drugs to treat youth behavioral problems, the human role in global warming, the use of antibiotics in livestock, eating disorders, and the hazard of bird flu.

HEALTH, WELLNESS, AND DISEASE BOXES provide information and insight on personal and community health. Topics include cancer, HIV/AIDS, fad diets, STDs, fetal alcohol syndrome, genetic engineering, and the human impact on the globe.
Why is the atomic mass of carbon different from its atomic number?

How many protons? How many neutrons?

Why are molecules that contain polar covalent bonds, such as water, wettable by water? Which molecules are not wettable by water? Why?

How do covalent bonds differ from ionic bonds?

What are van der Waals forces, and how strong are they in comparison to a covalent bond?

What is the difference between a covalent bond and a bond? How do they differ in strength?

What are the three types of chemical bonds and give an example of each?
TEST BANK (AVAILABLE IN WILEYPLUS AND ELECTRONIC FORMAT)
The visuals from the textbook are also carried through in the Test Bank, which was prepared by Corey Paulin of Allegany College of Maryland.

The test generation program has approximately 50 test items per chapter, with at least 20 percent incorporating visuals from the book. The test items include multiple choice, true/false, and short-answer questions.

INSTRUCTOR’S RESOURCES
The Instructor’s Resources begins with a special introduction on Using Visuals in the Classroom, prepared by Matthew Leavitt of Arizona State University, which provides guidelines and suggestions on using visuals to teach the course. Kathleen Ireland has carefully prepared Instructor’s Resources that will further help instructors use visuals and prepare interesting lectures. For each chapter, she has prepared:

• Guide to Using Video Lecture Launchers
• Chapter Objectives
• Teaching Tips
• Additional Activities
• Answers to Critical Thinking Questions

ANIMATIONS
A robust suite of multimedia learning resources have been designed for Visualizing Human Biology. Red Web icons throughout the text direct students to animations or additional Web content. Animations visually support the learning of a difficult concept or process, many of them built around a specific feature such as a Process Diagram, or key visual in the chapter. The animations go beyond the content and visual presented in the book, providing students with the opportunity to interact with the animation by completing activities.
ACKNOWLEDGMENTS

This book would not have come about without the tremendous work, creative energy, and tireless support of the Wiley team. Kathleen especially thanks Executive Editor Bonnie Roesch, who took a chance on a new author, giving her the opportunity to share her enthusiasm for the subject and her unconventional teaching style by putting it in paper. Kathleen and David sincerely appreciate Bonnie’s heavy and strong support of this project from start to finish. Special thanks to Kaye Pace, Executive Publisher, who oversaw the project and thanks to Barbara Heaney, Director of Development for all her guidance. Jeffrey Rocker, Marketing Manager for the Visualizing Series, and Ashaki Charles, Marketing Manager for Biology, also helped make this book a success. Thanks to Mary O’Sullivan, Development Editor, who helped us start this project. Perhaps most responsible for shaping this book and handling the recurrent crises with calm professionalism and a touch of humor was Project Editor Lorena Raccuia. Production Manager Kelly Tavares, Christine Cervoni of Camelot Editorial Services, and Development Editor Karen Trott all spent countless hours on the project, ensuring that the tone and attitude of the text mirrored our original idea. The amazing images and illustrations reflect the patient efforts of photo editors Mary Ann Price and Tara Sanford, as well as Sandra Rigby, Illustration Coordinator. We love the book of the—thank you, Hope Miller, for designing such a delightful cover. The interior is equally engaging, due to the design of Harry Nolan, Creative Director. We appreciate the talents of our page layout artist, Karim Kanchelor, who laid out the pages to be visually attractive and pedagogically effective, creating a student-friendly style. Media is a large part of this text, and Linda Mirabile, Senior Media Editor, did a fantastic job knitting it together. Mahalo ni ka Mā. Mai Ehu!

CLASS TESTING AND STUDENT FEEDBACK

In order to make certain that Visualizing Human Biology met the needs of current students, we asked several instructors to test text a chapter. The feedback that we received from students and instructors confirmed our belief that the visualizing approach taken in this book is highly effective in helping students to learn. We wish to thank the following instructors and their students who provided us with helpful feedback and suggestions:

Christine Barron, Prince George’s Community College
Robert Cheevers, William Paterson University
William Gashua, Clark College
Gary Egert, Florida Gulf Coast University
Sheldon R. Gordon, Oakland University
Nancy Mann, Goshen College
Lisa Maranzo, Prince George’s Community College
Emi Murray, Georgia Perimeter College
Polly Phillips, Florida International University
Melody Ricci, Victor Valley College
Beverly A. Schiefer, Wright State University
Alcina Stinhardt, Hartnell Community College
For my heart and soul: “the G-bud” and “baby M,” Gregory and Marcus Tatum.

PROFESSIONAL FEEDBACK

Throughout the process of developing the concept of visual pedagogy for Wiley’s Visualizing textbook, including Visualizing Human Biology and others, we benefited from the comments and constructive criticism provided by the instructors and colleagues listed below. We offer our sincere appreciation to these individuals for their helpful reviews:

Loren Ammerman, Angelo State University
Carli Anderson, Idaho State University
Bert Atia, Union County College
Thomas Bahl, Aquinas College
Jamie M. Chapman, Central Community College
Elizabeth A. Cowles, Eastern Connecticut State University
Gerard Crouse, Oglethorpe Community College
Michael Dote, Central Connecticut State
Ellie Dau, Westfield State College
James Dunn, Laredo Community College
Linda Ellis, University of Toronto at Scarborough
Steve Fields, Winthrop University
Heidi L. Forman, Buffalo State College
Mary Louise Gresley, St. John’s University
Robert Greene, Niagara University
Greg Stoll, Alasmane Community College
Martin E. Hahn, William Paterson University
Richard R. Jarin, University of Northern Colorado
Martin A. Kappen, Central Connecticut State University
Jonathan Kepp, Butler University
Pushkar N. Kaul, Clark Atlanta University
Johanna Krockberg, Kirkwood Community College
M. Leal, Sacred Heart University
Marty Lowe, Bergen Community College
Carol Mack, Erie Community College
Nancy Jean Mann, Goshen College
James C. Macker, University of Wisconsin
Kelly Martin, University of Wisconsin
Corey Paulin, Allegany College of Maryland
Polly K. Phillips, Florida International University
Mary C. Reece, Mississippi State University
Melody L. Rici, Victor Valley College
Alessandra P. Robins, Ivy Tech Community College
April Rottman, Rock Valley College

For my heart and soul: “the G-bud” and “baby M.”

For Frances Tenenbaum: Always a writer, always an editor.

Kathleen Anne Ireland

For heart and soul: “the G-bud” and “baby M.”

Gary and Marcus Tatum.

David J. Tenenbaum
UNIT 1: INTRODUCTION TO THE STUDY OF THE LIFE

1 What is Life? 2
   Living organisms display nine specific characteristics 4
   ■ I WONDER: ARE VIRUSES CONSIDERED LIVING ORGANISMS? 5
   Living things must maintain homeostasis 6
   ■ HEALTH, WELLNESS, AND DISEASE: HOMEOSTASIS AND BLOOD
     CHEMISTRY 8
   Biological classification is based on structure 9
   Biological classification is logical 12
   Scientists approach questions using the scientific method 15
   ■ ETHICS AND ISSUES: GLOBAL WARMING—A HUMAN SOLUTION TO A
     HUMAN PROBLEM? 18
   Scientific findings often lead to ethical dilemmas 20

2 Everyday Chemistry of Life 26
   Life has a unique chemistry 28
   ■ I WONDER: DO I NEED TO TAKE DIETARY SUPPLEMENTS IN ORDER
     TO STAY HEALTHY? WILL THEY HELP ME LOSE WEIGHT? 29
   Atomic structure is the foundation of life 30
   ■ HEALTH, WELLNESS, AND DISEASE: RADIOTOPES IN SCIENCE AND
     MEDICINE 32
   Chemistry is a story of bonding 34
   Water is life’s essential chemical 37
   Hydrogen ion concentration affects chemical properties 39
   There are four main categories of organic chemicals 41
   ■ ETHICS AND ISSUES: AGING: MAKING THE MOST OF A NATURAL
     BIOLOGICAL PROCESS 45

3 Cells, Organization, and Communication 60
   The cell is highly organized 60
   ■ I WONDER: HOW CAN YOU SEE CELLS? 64
   The cell membrane isolates the cell 65
   ■ HEALTH, WELLNESS, AND DISEASE: THE SCIENCE OF INTRAVENOUS
     FLUIDS 70
   The components of a cell are called organelles 72
   Cell communication and cell division are the keys to cellular success 83
   ■ ETHICS AND ISSUES: SHOULD WE TRY TO CURE DEADLY DISEASES
     WITH EMBRYONIC STEM CELLS? 85
UNIT 2: MOVEMENT THROUGH THE ENVIRONMENT 118

National Geographic videos:
Hugh Herr: A Man with Robotic Limbs
The Search for Adam

I WONDER: WHAT HAPPENS WHEN WE LEARN? 210
ETHICS AND ISSUES: ATTENTION DEFICIT HYPERACTIVITY DISORDER: DOES DRUG TREATMENT MAKE SENSE? 216

The peripheral nervous system operates beyond the central nervous system 218

6 The Muscular System 156

The muscular system has many functions 158
Skeletal muscles are contractile organs 159
Muscle contraction occurs as filaments slide past one another 167
Whole-muscle contractions emerge from tiny impulses 172
Muscles require energy to work smoothly and powerfully 175

HEALTH, WELLNESS, AND DISEASE: MUSCLE FATIGUE, MUSCLE WOES 178
I WONDER: WHAT ARE THE HOLISTIC BENEFITS OF PHYSICAL EXERCISE? 179
ETHICS AND ISSUES: THE DANGERS OF STEROID HORMONES 180

7 The Nervous System 186

The nervous system makes sense of everything 188
The nervous system is categorized by function and structure 190
Nerve tissue is made of neurons and glial cells 193
Neurons work through action potentials 194

HEALTH, WELLNESS, AND DISEASE: PSYCHOACTIVE DRUGS: GETTING A GOOD RECEPTION AT THE SYNAPSE 201

The brain and spinal cord are central to the nervous system 202
I WONDER: WHAT HAPPENS WHEN WE LEARN? 210
ETHICS AND ISSUES: HOW TO CONFRONT THE OSTEOPOROSIS CRISIS 137

The peripheral nervous system operates beyond the central nervous system 218

CONTENTS  xxiii
The digestive system processes food from start to finish. Digestion is both mechanical and chemical. Nutritional health and eating disorders: you truly are what you eat.

ETHICS AND ISSUES: WHAT IS AN IDEAL WEIGHT? HOW FAR SHOULD YOU GO TO LOOK SKINNY?

I WONDER: E. coli BACTERIA HAZARDOUS TO MY HEALTH?

HEALTH, WELLNESS, AND DISEASE: ARE CHRONIC BRONCHITIS AND EMPHYSEMA SO DEADLY?

ETHICS AND ISSUES: TOBACCO: THE UNIVERSAL POISON

HEALTH, WELLNESS, AND DISEASE: CHRONIC OBSTRUCTIVE PULMONARY DISEASE: WHY ARE CHRONIC BRONCHITIS AND EMPHYSEMA SO DEADLY?

ETHICS AND ISSUES: IS BEING SHORT A DISEASE? WHAT ARE THE ETHICS OF HUMAN GROWTH HORMONE?

HEALTH, WELLNESS, AND DISEASE: DIABETES: WHAT IS IT AND WHY IS IT SO COMMON?

I WONDER: CAN I FIGURE OUT MY OWN BASAL METABOLIC RATE? CAN I Figure Out My Own Basal Metabolic Rate? 498

Development takes us from infancy to adulthood. 500
17 Pregnancy: Development from embryo to newborn

Fertilization creates an entire diploid genome.

I WONDER: WHAT CAUSES TWINS, AND HOW DO THEY CONTRIBUTE TO THE STUDY OF GENETICS AND HUMAN DEVELOPMENT? 556

The fertilized egg becomes a blastocyst 558

The embryonic stage is marked by growth and differentiation 562

Fetal development occupies the second and third trimesters 570

I WONDER: CAN PMS REALLY CAUSE MOOD SWINGS AND EMOTIONAL OUTBURSTS? 534

The orgasm is a moment of emotional and physiological epiphany 537

Sexually transmitted diseases can be a side effect of sexual contact 538

HEALTH, WELLNESS, AND DISEASE: STDs: THE SCIENCE OF PREVENTION 539

There are many birth control choices, none of them perfect 540

ETHICS AND ISSUES: SHOULD WE CLONE HUMANS? 546
Answers to Self Tests 708
Appendix A: The Periodic Table of Elements 710
Appendix B: Measurements 711
Glossary 713
Index 000

The first person to invent a car that runs on water…

… may be sitting right in your classroom! Every one of your students has the potential to make a difference. And realizing that potential starts right here, in your course.

When students succeed in your course—when they stay on-task and make the breakthrough that turns confusion into confidence—they are empowered to realize the possibilities for greatness that lie within each of them. We know your goal is to create an environment where students reach their full potential and experience the exhilaration of academic success that will last them a lifetime. WileyPLUS can help you reach that goal.

WileyPLUS is an online suite of resources—including the complete text—that will help your students:

• come to class better prepared for your lectures
• get immediate feedback and context-sensitive help on assignments and quizzes
• track their progress throughout the course

“I just wanted to say how much this program helped me in studying… I was able to actually see my mistakes and correct them. … I really think that other students should have the chance to use WileyPLUS.”

Ashlee Krisko, Oakland University

www.wiley.com/college/wileyplus

80% of students surveyed said it improved their understanding of the material.”
FOR INSTRUCTORS

WileyPLUS is built around the activities you perform in your class each day. With WileyPLUS you can:

- Prepare & Present
  Create outstanding class presentations using a wealth of resources such as PowerPoint™ slides, image galleries, interactive simulations, videos, and more. You can even add materials you have created yourself.

- Create Assignments
  Automate the assigning and grading of homework or quizzes by using the provided question banks, or by writing your own.

- Track Student Progress
  Keep track of your students’ progress and analyze individual and overall class results.

Now Available with WebCT and Blackboard!

“IT has been a great help, and I believe it has helped me to achieve a better grade.”

Michael Morris, Columbia Basin College

FOR STUDENTS

You have the potential to make a difference!

WileyPLUS is a powerful online system packed with features to help you make the most of your potential and get the best grade you can!

With WileyPLUS you get:

- A complete online version of your text and other study resources.
- Problem-solving help, instant grading, and feedback on your homework and quizzes.
- The ability to track your progress and grades throughout the term.

For more information on what WileyPLUS can do to help you and your students reach their potential, please visit www.wiley.com/college/wileyplus.

76% of students surveyed said it made them better prepared for tests. *

*Based on a survey of 972 student users of WileyPLUS