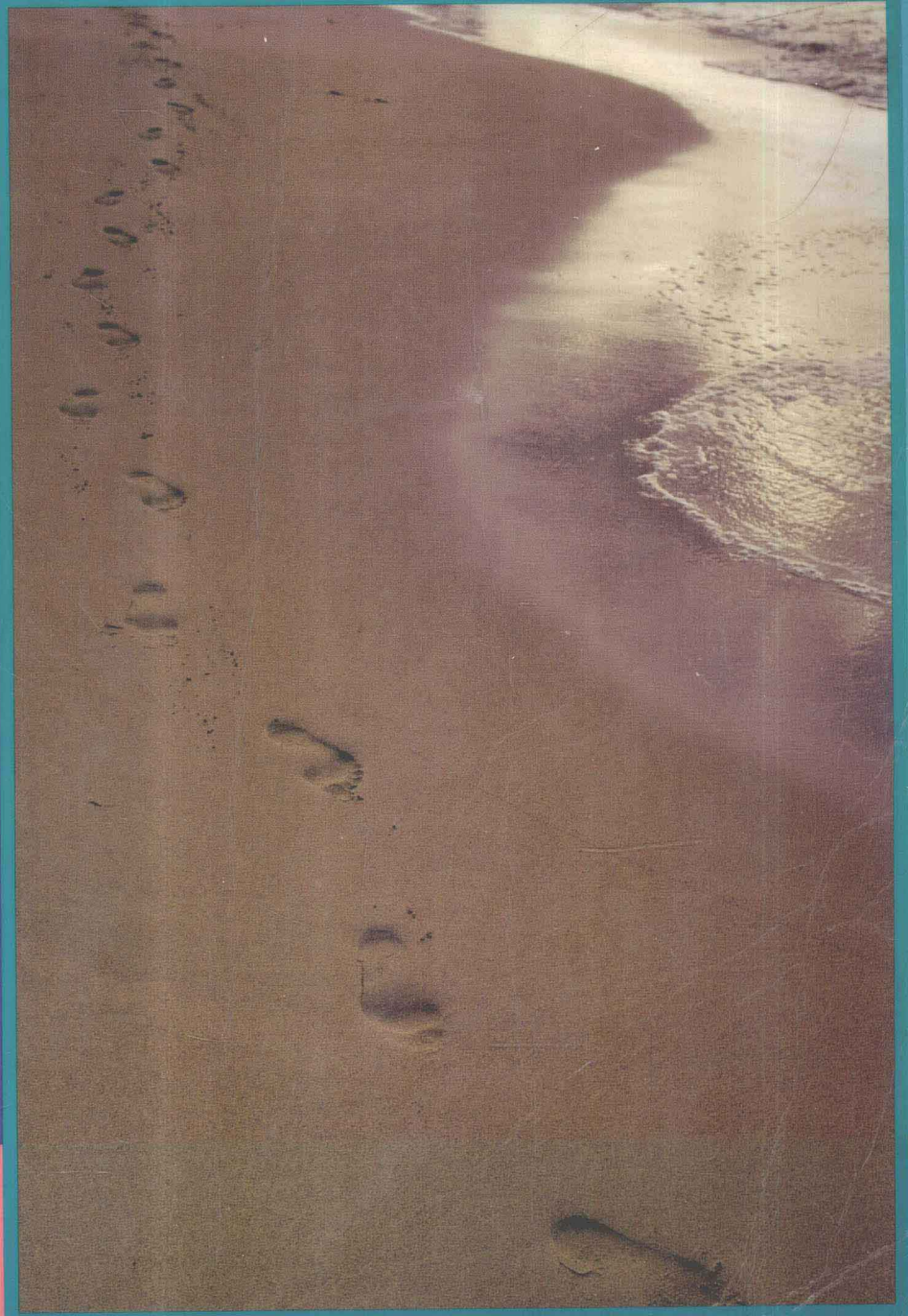


# HUMAN BIOLOGY



SANDRA S. GOTTFRIED

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*with 452 illustrations*



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# Preface

Are you 18 or 80? . . . or somewhere in between? Are you an English major or an art major? Or are you studying to be an elementary school teacher? Perhaps you are a returning student, tackling college courses after being out of school for many years. You may not have studied science or biology for a long time; perhaps you're even "science shy" and are reluctant or afraid to take a science course. Hopefully, your fears will melt away as you begin to study the human body and find that you can understand, appreciate, and even enjoy a scientific approach to the study of "you" while you explore topics that are vital to your health and well-being.

Students take a course in human biology for a variety of reasons. Your classroom holds a group of students with a wide range of backgrounds, skills, motivations, and goals. I wrote *Human Biology* for you, the introductory student who is most likely majoring in a field other than biology. Having worked with a variety of students for over 20 years in biology education, I feel I am well aware of my audience—students like you—and their needs. My training in scientific research, biology, and education and my experience as a science writer and teacher enabled me to write this book so that it is understandable even though you may have no prior knowledge of biology. I have worked to make my writing style easy to read, and to develop scientific concepts by providing understandable descriptions that will be a solid basis for your learning and comprehension. In addition, I have used everyday situations or concerns you may have encountered in the media as examples whenever possible. I have also provided information about your own physiology to help you make informed decisions about life-style choices that will affect your body, such as choosing what foods to eat or whether or not to smoke.

*Human Biology* also contains eight case studies that raise bioethical questions, one at the beginning of each part of the book. These case studies are related to the scientific content of *Human Biology*. They offer situations that reflect the often-conflicting values of various groups and individuals as well as the ethical dilemmas raised by the application of current biological knowledge to medical treatment, reproductive choices, or consumer choices that may affect the environment. These dilemmas are as real as a government's decision to fund family planning clinics or a family's struggle to decide what medical care an elderly parent should receive. The decisionmaking framework that concludes each part of the book will help you focus on the bioethical questions each case addresses and devise a strategy for recognizing and analyzing similar bioethical dilemmas in your own life.

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## Organization

The 26 chapters of *Human Biology* are thematically grouped into eight parts. No parts are longer than five chapters, providing a manageable framework. However, the chapters are also designed to stand alone so that professors can use the text in the order in which it was written or in an alternative order. The chapter opening pedagogy provides "Highlights" for each chapter, which is a menu of the chapter's content. These Highlights will help professors determine the chapter order that best suits the organization of their courses. Page references to concepts previously defined and explained are noted throughout the chapters.

In general, the book is organized in a traditional fashion. Basic biological concepts are presented in the introduction, with chemistry, cell anatomy and physiology, and tissues comprising Part One. Parts Two to Four describe the systems of the human body. Parts Five and Six describe reproduction on the cellular and organismal levels, including a discussion of DNA, the hereditary material, and gene expression. The last part discusses human evolution and ecology.

## Introduction

This short, introductory part consists of Chapter 1 (Biology: A Human Focus), which discusses scientific process as the unifying theme among all sciences. It gives an overview of research in human biology and describes how scientists build theories. The themes of biology are also discussed as a context in which to embed a study of human biology. The chapter closes with a discussion of principles of scientific classification.

## Part One Molecules, Cells, and Tissues

Part Two contains information about basic chemistry (Chapter 2, The Chemistry of Life) and cell structure (Chapter 3, Cell Structure and Function). Cell physiology is presented in Chapters 4 and 5 (The Flow of Energy Within Organisms and Cellular Respiration). The concluding chapter of this part describes the tissue level of organization of the human body in detail and gives an overview of organs and organ systems (Chapter 6, Levels of Organization in the Human Body).

## Part Two Maintenance Systems

The four chapters in this part include the systems of the body involved with: digesting food and absorbing nutrients (Chapter 7, Digestion), delivering oxygen to the lungs and eliminating the carbon dioxide from the body (Chapter 8, Respiration), transporting nutrients, oxygen, and other needed substances to cells and transporting wastes away from cells (Chapter 9, Circulation), and filtering the blood to maintain homeostasis, a “steady state” of the body (Chapter 10, Excretion).

## Part Three Communication and Regulatory Systems

The next four chapters describe both the “fast” communication system of the body, the nervous system, and the “slow” communication system, the endocrine system. Chapter 11 (Nerve Cells and How They Transmit Information) describes the structure of nerve cells and how impulses are conducted along their membranes and from nerve cell to nerve cell. This latter discussion provides the background and context for an explanation of how drugs cause their effects on the human brain. The next two chapters (Chapter 12, The Nervous System and Chapter 13, The Senses) look at the organ level of nervous system communication, describing the structure and function of the central and peripheral nervous systems as well as the sense organs. Chapter 14 (Hormones) describes the chemical messengers produced by cells and how they regulate other cells of the body, as well as describing the variety of endocrine glands and their specific roles.

## Part Four Protection, Defense, and Support

This part is made up of two chapters: Chapter 15, Protection, Support, and Movement and Chapter 16, Defense Against Disease. Chapter 15 discusses the integumentary, skeletal, and muscular systems and describes how the skin, bones, and muscles work together. Chapter 16 describes the nonspecific and specific defenses the body uses to combat foreign substances (including agents of infection, cancer cells, and foreign tissues) that enter the body.

## Part Five How Cells Pass on Biological Information

This unit discusses genetics, beginning with its molecular and cellular aspects in Chapter 17 (DNA, Gene Expression, and Cell Reproduction). Chapter 18 (Abnormal Cell Reproduction: Cancer) defines the term *cancer*, describes the molecular biology of this group of diseases, and discusses

factors that increase or decrease the risk of cancer. Chapter 19 (Patterns of Inheritance) covers classical Mendelian genetics. The part closes with a look at human inheritance patterns, including genetic disorders, in Chapter 20 (Human Genetics).

## Part Six How Humans Reproduce

Part 6 is made up of three chapters: Chapter 21, Sex and Reproduction; Chapter 22, Development Before Birth; and Chapter 23, Sexually Transmitted Diseases. Chapter 21 describes the anatomy and physiology of the male and female reproductive systems and also discusses various methods of birth control and how they work. Chapter 22 describes prenatal development. Chapter 23 gives an overview of viruses and bacteria before describing the sexually transmitted diseases they cause. Sexually transmitted diseases caused by other organisms, although not as prevalent, are included.

## Part Seven Human Evolution and Ecology

Three chapters comprise this part. Chapter 24 (Human Evolution) provides a summary of the evolution of all life as a prelude to the focus of this chapter: the evolution of humans. Chapter 25 (Human Population Concerns) describes how populations grow and explains the factors that influence the size of a population. The human population explosion is the focus of the last part of the chapter, which provides a natural transition to Chapter 26 (The Human Impact on the Environment). This last chapter explores current environmental issues affecting the land, water, and atmosphere, including topics such as species extinction, acid rain, air pollution, and the depletion of the ozone layer.

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## Features

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Several pedagogical features make *Human Biology* easy to use. Students should find these features a great help when reading their assignments for class and reviewing for exams and quizzes.

Each chapter opens with a short “vignette” that is designed to spark student interest. Sometimes these vignettes explain something that may already be familiar to the student in a context that relates to the chapter material. For example, Chapter 14 (Hormones) opens with a vignette about the dangers of anabolic steroids. The vignette in Chapter 23 (Sexually Transmitted Diseases) discusses the debate on condom handouts in the New York City school district, the first school district in the country to distribute condoms to its students.

In addition to the vignettes, the chapter openers contain a list of chapter “Highlights”, as mentioned previously,

that describe key concepts of the chapter. These highlights provide students with a content overview before they read the chapter. An "Outline" of the chapter accompanies the highlights, providing a topical summary of the chapter to help students organize chapter concepts.

Within each chapter are "Concept Summaries" that provide synopses at key points in the chapter. They help students identify the key ideas in the narrative and are valuable study aids.

"Boxed Essays," listed in boldface in the table of contents, are found in most chapters. Some link topics in human biology to students' everyday lives, highlighting the personal relevance of many biological concepts. Others highlight the links among human biology, technology, and societal issues. And lastly, some boxed essays describe the work of scientists in detail, often answering the question, "How do we know that?"

Each chapter closes with a "Summary" that lists all the key concepts in the chapter, a selection of "Review Questions" that test students' comprehension of the chapter content, and a few "Discussion Questions" designed to initiate class discussion and debate. Each chapter also has a short list of "Further Readings," chosen with the introductory student in mind. The articles are taken from periodicals such as *Scientific American*, *Science*, *Smithsonian*, and *National Geographic*.

At the back of the book, a glossary provides the pronunciation, definition, and derivation for each key term in the book and also gives the page reference for each term. An appendix provides answers to the review questions.

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## The art program

*Human Biology* uses its art program to help students visualize and understand concepts and processes. It accomplishes this task by following these principles:

- Illustrations and photographs should be used to make abstract concepts more concrete and to enhance student understanding.
- The content of the narrative and the art should match—concepts, processes, or structures should not be presented in the art that are not discussed in the narrative. Additionally, the narrative and the art should be integrated in a meaningful way.
- Illustrations that depict processes should use a clear, simple layout. For complex processes, numbered steps should be used.
- Legends should be a helpful guide to the illustration and should not introduce material that is not in the text.
- Art should be visually appealing so that students are prompted to "take a look."

We have followed these principles in *Human Biology*, with the result that the art program represents another important focus in the pedagogical program and is an element in itself.

---

## Ancillaries

Carefully designed and executed, the ancillaries to *Human Biology* supplement, support, and enhance its student-oriented approach.

## Instructor's Resource Guide

For the instructor, the *Instructor's Resource Guide* is a valuable teaching resource. Written by Elmer Kellman, a veteran teacher of biological sciences, each chapter contains a complete synopsis, suggested topics for class discussion, lecture outlines, and teaching ideas. In addition, the *Instructor's Resource Guide* provides complete instructor support for the bioethical essays and decisionmaking framework materials found as part openers and part closers in the textbook. The decisionmaking framework for each essay is discussed in detail. In addition, teaching strategies for using bioethical decisionmaking in the classroom are explained completely, providing an array of options for the instructor. This resource guide is also available on disk for IBM and Macintosh users.

A test bank of approximately 1000 questions, written by Margaret Foy Kelly, is also included in the manual, as are transparency masters of key illustrations in *Human Biology*.

## Computerized Test Bank

The test bank questions are also available on Computest, a computerized test generation system for IBM users. It has many features that make it easy for the instructor to design tests and quizzes. The instructor can browse and select questions for inclusion on an examination using several different criteria, including question type and level of difficulty. A similar test-generating system is available for Macintosh and Apple users.

## Transparency Acetates

Also available for the instructor is a set of full-color transparency acetates that reproduce the important illustrations in *Human Biology*. Labeling is clear, bold, and large enough for even students seated in the back of a large room to see.

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## Acknowledgments

Producing a textbook such as *Human Biology*, with a full-color art program, professional layout and design, and ancillaries cannot be accomplished by an author alone. A variety of highly-skilled professionals at Mosby have turned my manuscript for *Human Biology* into an attractive text-

book program that will be a motivating learning tool for students and a useful teaching resource for instructors. Catherine Schwent, production editor, and Betty Schulz, book designer, worked long and carefully to make *Human Biology* an accurate, attractive teaching tool. *Human Biology* could not have been completed without the hard work of Jean Babrick, developmental editor. Jean has my deepest gratitude for her skillful editing and coordination of this project. In addition, Jean researched and acquired many of the outstanding photographs used in this book—a task that at times we thought was going to be impossible. Thank you, Jean, for your diligence, patience, talent, and caring in all aspects of your work. My thanks also go to Bob Callanan, acquisitions editor, for continuing to encourage innovation and excellence. His support of the bioethical decisionmaking feature in this textbook is only one example of his commitment to the production of books that are pedagogically sound and that incorporate features reflecting current goals in science education.

The Hastings Center of Briarcliff Manor, New York, and Bruce Jennings, an ethicist at that institute, played an important role in the development of the bioethical decisionmaking framework of *Human Biology*. Many of the bioethical essays used in *Human Biology* are adaptations of essays published in *The Hastings Center Newsletter*. In addition,

the decisionmaking framework is adapted from a similar framework outlined in *New Choices, New Responsibilities*, a publication of the Center. Many thanks go to Bruce Jennings for acting as a consultant to this project.

I also want to thank some other important people who contributed their time and talents to the development of this book: Lucy Bradley-Springer, Harvey Friedman, Cris Hochwender, Peggy Foy Kelly, Eilene Lyons, Cynthia J. Moore, Wendy Schiff, Kathleen Scogna, and Carl Thurman.

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Some of the bioethical decisionmaking case studies, and the decision making framework in *Human Biology*, have been adapted from Bruce Jennings, Kathleen Nolan, Courtney S. Campbell, and Strachan Donnelley, *New Choices, New Responsibilities: Ethical Issues in the Life Sciences*. Nutley, NJ: Hoffman-LaRoche, Inc., 1990. This teaching resource was developed by The Hastings Center with support from Hoffman-LaRoche, Inc.

# An Introduction to Bioethical Decisionmaking

Scientific and technological advances have expanded our knowledge and given us new powers such as the ability to manipulate human genes, transplant organs, and keep profoundly sick or injured infants, children, and adults alive with specialized equipment and therapies. At the same time, science has been challenged to develop effective treatments for devastating diseases such as acquired immune deficiency syndrome (AIDS). Our new powers are awesome, and the need to confront these new medical challenges is urgent. Furthermore, both the powers and the challenges carry ethical responsibilities.

Many people use the terms ethics and morals interchangeably, but they have different meanings. *Morals* are the beliefs and standards of good and bad, right and wrong, upheld by a society. *Ethics* is the study of moral practices; it describes the theory or philosophy that underlies moral beliefs and behavior. The case studies presented at the beginning of each part of this text will challenge you to use one type of ethics: normative ethics. This field of ethics develops the ethical principles that spell out moral standards. *Normative ethics* offers answers to the questions, "What should I do?" and "How should I live?". It also offers reasons why a person should accept these answers. Normative ethics applied to decisionmaking and public policy in the areas of biology, medicine, and health care is *bioethics*. Bioethics is concerned with basic scientific research and with the social applications of biological knowledge and biomedical technology. This textbook offers a planned approach to bioethical decisionmaking that you can use by yourself to

develop your critical thinking skills and decisionmaking strategies. As a part of classroom activities, the decisionmaking process will explore new dimensions of human biology as you, your classmates, and instructor discuss and debate bioethical issues.

The eight bioethical case studies that make up the part openers of this text are pertinent to a human biology course. A case is discussed at the beginning of each part of this book; it links in some way with the content of the chapters in that part. These cases require in-depth consideration of the often-conflicting values and the ethical dilemmas raised by the application of current biological knowledge. Each part ends with a bioethical decisionmaking framework. This framework consists of six basic questions that are repeated with each case along with in-depth questions that elaborate on these six questions. These questions will help you structure your thinking, focus it on the bioethical questions the case addresses, and devise a strategy for recognizing and analyzing similar bioethical dilemmas in your own life, be it reproductive choices, medical care for a family member, or choices as a consumer and citizen that affect your environment.

These case studies and the decisionmaking frameworks that accompany them will *not* offer clear-cut answers to the bioethical issues they raise. Ethical issues are rarely either neat or simple. Each of these cases contains questions of choice—understanding one's options—and questions of responsibility—what values are at stake in your choices and what moral principles should guide your decisions.



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# *to Human Biology*

differently on persons with different stages of the disease, and that their tolerance of the drug's side effects would differ. The researchers also acknowledged that the patients' age and manner of infection may affect how the disease progresses. Also, patients may have other diseases, such as hemophilia, to be considered in the research design. With these issues in mind, the researchers chose a methodology called a double-blind crossover study.

In such a study, half of the participants (all volunteers at a similar stage of AIDS) are randomly chosen to receive the new drug. This is the experimental group. The other half of the participants receive a placebo, a pill that resembles the drug but that contains no medication. This is the control group. The course of the disease in these groups is compared. Halfway through the study, the experimental group receiving the new drug "crosses over" to the placebo, and the control group crosses over to the actual drug. (Nobody involved in the study, including the researchers, knows which pill contains the drug and which contains the placebo; the pills are stamped with code letters by the drug company, and the code is revealed only after the study ends.) The researchers believe this "blinding" is necessary to remove any possible bias as they evaluate the drug's effects. (Placebos and a control group are necessary parts of the research design in a blinded study.)

The researchers believe that this cross-over design is the most ethical approach because they will be asking the study participants to stop taking all

other medications. This is necessary if they are to determine the effects of the new drug alone and to avoid any drug interactions. By crossing over midway in the study, control group participants who might be doing badly would have a change in therapy and perhaps improve. However, the researchers also realize that the new drug's positive effects might not be revealed for a long time and that the crossing-over patients might not benefit if this is the case. The participants in the study, all volunteers, are fully informed about the use of placebos and have consented.

Based on the recommendations of both the initial review group and the advisory council, who found the proposal scientifically sound and ethically acceptable, the agency approved the research. After approval was announced, however, activists who publicize perceived or real injustices against people with AIDS began to picket the agency. The group claimed that withholding the new drug from some of the participants in the study, even for scientific research, is unethical because AIDS is a fatal disease. Using placebos for part of the experiment might worsen the disease or even lead to death, because the participants would be receiving no medication at all. The protestors charged that informed consent was irrelevant in this case. They demanded that the study design be changed and that the new drug be tested without the use of placebos.

If you were director of the agency, would you stand by the decision reached by the review process to approve this study?