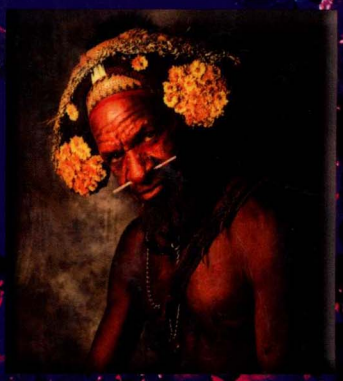
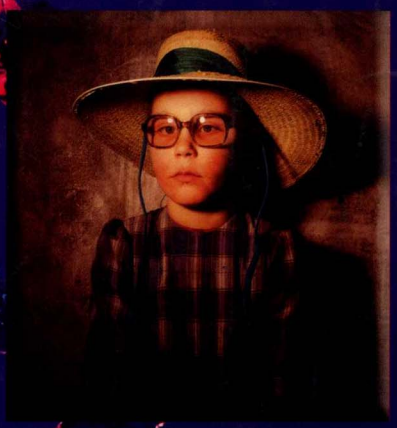
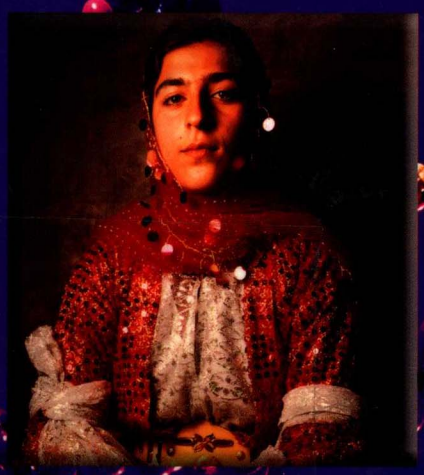
SEVENTH EDITION

THE Human Species

AN INTRODUCTION TO BIOLOGICAL ANTHROPOLOGY







JOHN H. RELETHFORD

SEVENTH EDITION

THE HUMAN SPECIES

An Introduction to Biological Anthropology

JOHN H. RELETHFORD
State University of New York College at Oneonta

McGraw-Hill Higher Education

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PREFACE

This text introduces the field of biological anthropology (also known as physical anthropology), the science concerned with human biological evolution and variation. The text addresses the major questions that concern biological anthropologists: What are humans? How are we similar to and different from other animals? Where are our origins? How did we evolve? Are we still evolving? How are we different from one another? and What does the future hold for the human species?

ORGANIZATION

This book is divided into four parts. Part I, "Evolutionary Background," provides the basic background in genetics and evolutionary theory used throughout the remainder of the text. Chapter 1 introduces the science of biological anthropology, the nature of science, and the history of evolutionary thought. Chapter 2 reviews molecular and Mendelian genetics as applied to humans, providing genetic background for later chapters and including a basic review of cell biology for those whose high school biology is a bit rusty. Chapter 3 focuses on evolutionary forces, the mechanisms that produce evolutionary change within and between populations. Chapter 4 looks at evolution over longer periods of time, focusing on the origin of new species, and includes discussion on how species are classified.

Part II, "Our Place in Nature," examines the biology and behavior of the primates, the group of mammals to which humans belong. The focus of this section is on two questions: What are humans? and How are we related to other living creatures? Chapter 5 looks at the basic biology and behavior of mammals in general and primates in particular. Chapter 6 examines the diversity of primate biology and behavior, with particular attention given to

our close relatives, the apes. Chapter 7 looks specifically at the human species and includes a comparison of human traits with those of apes.

Part III deals with questions of "Our Origins." Chapter 8 begins with discussion of the methods of paleoanthropology and concludes with a brief history of life on earth prior to the appearance of the first primates. Chapter 9 examines the fossil and genetic evidence for primate evolution from the appearance of the primate-like mammals through the split of ape and human lines by 6 million years ago. Chapter 10 deals with the beginning of human evolution, focusing on the fossil evidence for the first hominins and the evolution of bipedalism. Chapter 11 examines the origin and biological and cultural evolution of the genus *Homo*, including early *Homo*, *Homo erectus, Homo heidelbergensis*, and the Neandertals. Chapter 12 looks at the fossil, archaeological, and genetic evidence for the origin of modern humans and includes a discussion of current controversies.

Part IV, "Our Diversity," examines human biological variation in our species today from an evolutionary perspective. Chapter 13 focuses on the measurement and analysis of human variation, and contrasts evolutionary and racial approaches to human diversity. Chapter 14 provides several case studies of how information on genetic variation is used to address questions of population history and individual ancestry. Chapter 15 reviews a number of case studies of natural selection in human populations. Chapter 16 continues examining human variation from the broad perspective of human adaptation, both biological and cultural. Chapter 17 concludes the text by examining recent human evolution (over the past 12,000 years), focusing on the biological impact of culture change, with particular emphasis on changing patterns of disease, mortality, fertility, and population growth.

The organization of this text reflects my own teaching preference in terms of topics and sequence. Not all instructors will use the same sequence of chapters; some may prefer a different arrangement of topics. I have attempted to write chapters in such a way as to accommodate such changes whenever possible. For example, although I prefer to discuss human evolution before human variation, others prefer the reverse, and the chapters have been written and revised so that this alternative organizational structure can be used.

FEATURES

Throughout the text, I have attempted to provide new material relevant to the field and fresh treatments of traditional material. Key features include the following:

- All areas of contemporary biological anthropology are covered. In addition to traditional coverage of areas such as genetics, evolutionary theory, primate behavior, and the fossil record, the text includes material often neglected in introductory texts, including genetics and population history, human growth, epidemiology, and demography.

- The relationship between biology and culture is a major focus. The biocultural framework is introduced in the first chapter and integrated throughout the text.
- Behavior is discussed in an evolutionary context. The evolutionary nature of primate and human behavior is emphasized in a number of chapters, including those on primate biology and behavior (Chapters 5–7) and the fossil record of human evolution (Chapters 10–12).
- Emphasis is on the human species in its context within the primate order. Discussions of mammals and nonhuman primates continually refer to their potential relevance for understanding the human species. In fact, Chapter 7 is devoted *entirely* to treating our species from a comparative perspective.
- Hypothesis testing is emphasized. From the first chapter, in which students are introduced to the scientific method, I emphasize how various hypotheses are tested. Rather than provide a dogmatic approach with all the "right" answers, the text examines evidence in the context of hypothesis testing. With this emphasis, readers can see how new data can lead to changes in basic models and can better understand the "big picture" of biological anthropology.

NEW TO THIS EDITION

The text has been revised in light of new findings in the field and comments from users of the sixth edition and reviewers. Specific changes include the following:

- Several changes have been made in structure and chapter content. The chapters on human variation have been placed together and now appear after the chapters on human evolution, thus forming a more logical sequence of topics in human evolutionary history from past through the present. The discussion of species and classification methods has been moved to the chapter on macroevolution (4).
- The chapter on mammalian and primate biology and behavior (5) has been revised extensively to include material on life history theory, primate reproductive strategies, alloparenting, and dispersal and behavior.
- A new chapter (8) has been added on methods of paleoanthropological research, including dating methods, methods of ecological and behavioral analysis from fossils, and a brief history of evolution before the appearance of the first primates. This chapter also includes new material on how sex and age are determined from fossils, stable isotope analysis, experimental archaeology, and the use of nonhuman primate models for reconstructing behavior.
- The term *hominin* is now used throughout the text to refer to humans and their relatives since the time of divergence from the chimpanzee–bonobo line.

- The chapters on the fossil record of human evolution have been rewritten extensively to increase clarity and provide data on new discoveries and interpretations, including the virtual reconstruction of *Sahelanthropus,* foraging and the origin of bipedalism, debates over hunting versus scavenging in *Homo erectus,* the expensive tissue hypothesis, discovery of "the Hobbit" (*Homo floresiensis*), the increasing recognition of *Homo heidelbergensis* as a valid fossil species, and the extraction of nuclear DNA from a Neandertal fossil.
- Additional new topics have been added throughout the remainder of the text, including discussion of uniformitarianism and geologic time, recent developments in the "intelligent design" movement, new research on natural selection in the Duffy blood group and the *CCR5Δ32* allele, and new interpretations on nutrition in hunting-gathering societies, among others.
- There are four new "Special Topic" boxes, dealing with the issues of "Humans and Apes—What Genes Are Different?" (Chapter 7), "A Perspective on Geologic Time" (Chapter 8), "Our Common Ancestry" (Chapter 14), and "Are Humans Still Experiencing Natural Selection?" (Chapter 15).

STUDY AIDS

To make the text more accessible and interesting, I have included frequent examples and illustrations of basic ideas, as well as abundant maps, to help orient students. I have kept the technical jargon to a minimum, yet every introductory text contains a number of specialized terms that students must learn. At first mention in the text, these terms appear in boldface type, and accompanying short definitions appear in the text margins. A glossary is provided at the end of the book. Each chapter ends with a summary, a list of supplemental readings, and a list of Virtual Explorations, which provide hands-on exercises and activities for real-time applications of text material. Several appendices provide additional reference material, including a primer on mathematical population genetics and figures showing comparative primate anatomy. A list of references appears at the end of the book, providing the complete reference for studies cited in the text.

ANCILLARIES

Visit our Online Learning Center Web site at www.mhhe.com/relethford7 for robust student and instructor resources.

For Students
Student resources include self-quizzes (multiple-choice, true or false, essay), Internet links and exercises, flashcards, and chapter study aids.

For Instructors
The password-protected instructor portion of the Web site includes the instructor's manual, a comprehensive computerized test bank, PowerPoint lecture slides, and a variety of additional instructor resources.

ACKNOWLEDGMENTS

My thanks go to the dedicated and hardworking people at McGraw-Hill, both those whom I have dealt with personally and those behind the scenes. I give special thanks to my sponsoring editor, Monica Eckman for encouragement and support, and for listening to assorted complaints with great patience and understanding. My heartfelt thanks also go to Kate Scheinman, developmental editor, for her guidance in the revision process and patience in answering the same questions repeatedly. Special thanks also go to David Blatty, production editor, for excellence and professionalism. Thanks also Sheri Gilbert, permissions editor; Tom Briggs, manuscript editor; Cassandra Chu, design manager; Robin Mouat, art manager; Brian Pecko, photo researcher; and Rich DeVitto, production supervisor.

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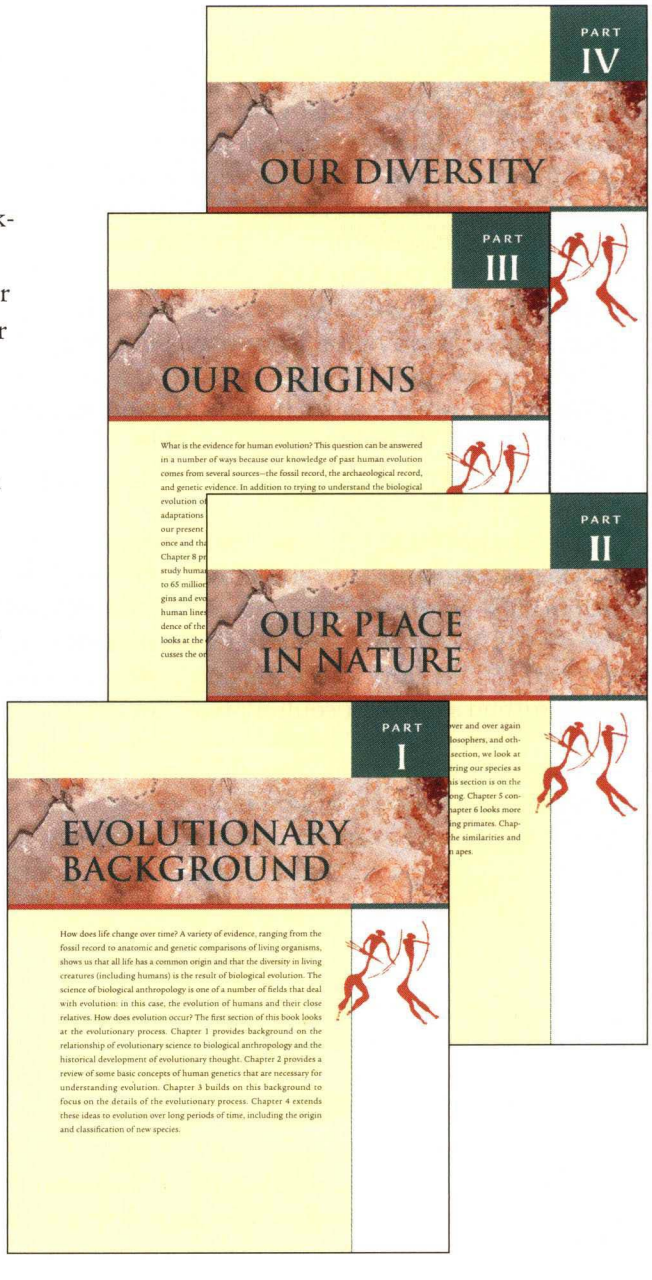
Last, but not least, I dedicate this as always to my family. To my wonderful sons, David, Benjamin, and Zane—thanks for all the smiles and hugs, which make it all worthwhile. Thanks also for all those questions that really make me think (the ones I couldn't answer as well as those I could). Finally, to my wife, Hollie, love of my life and my best friend—thanks for the love, friendship, and support. I couldn't have done this without you.

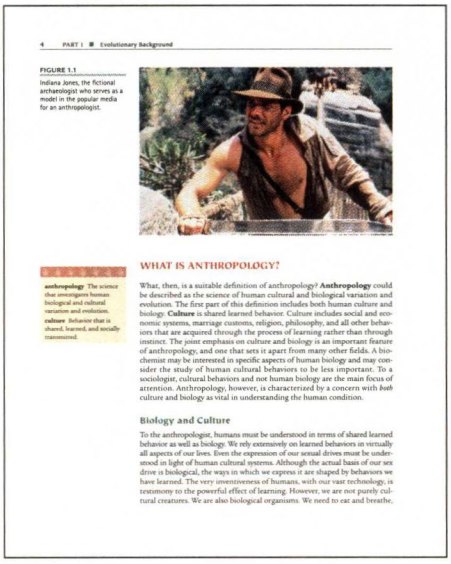
WALKTHROUGH

This book is divided into four major units: Part I, "Evolutionary Background," provides the basic background in genetics and evolutionary theory used throughout the remainder of the book. Part II, "Our Place in Nature," examines the biology and behavior of the primates, the group of mammals to which humans belong. The focus of this section are the questions "What are humans?" and "How are we related to other living creatures?" Part III deals with questions of "Our Origins." Part IV, "Our Diversity," examines human biological variation in our species today from an evolutionary perspective. The reorganization of the Seventh Edition provides a more logical sequence of topics in human evolutionary history from the past through the present.



THE BIOCULTURAL FRAMEWORK

The relationship between biology and culture is a major focus of this text. The biocultural framework is introduced in Chapter 1 and integrated throughout the text.



4 PART I ■ Evolutionary Background

FIGURE 1.1
Indiana Jones, the fictional archaeologist who serves as a model in the popular media for an anthropologist.

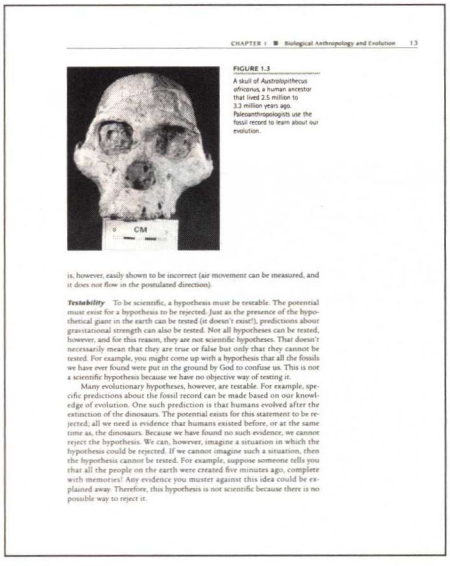
anthropology The science that investigates human biological and cultural variation and evolution.
culture Behavior that is shared, learned, and socially transmitted.

WHAT IS ANTHROPOLOGY?

What, then, is a suitable definition of anthropology? **Anthropology** could be described as the science of human cultural and biological variation and evolution. The first part of this definition includes both human culture and biology. **Culture** is shared learned behavior. Culture includes social and economic systems, marriage customs, religion, philosophy, and all other behaviors that are acquired through the process of learning rather than through instinct. The joint emphasis on culture and biology is an important feature of anthropology, and one that sets it apart from many other fields. A biochemist may be interested in specific aspects of human biology and may consider the study of human cultural behaviors to be less important. To a sociologist, cultural behaviors and not human biology are the main focus of attention. Anthropology, however, is characterized by a concern with *both* culture and biology as vital in understanding the human condition.

Biology and Culture

To the anthropologist, humans must be understood in terms of shared learned behavior as well as biology. We rely extensively on learned behaviors in virtually all aspects of our lives. Even the expression of our sexual drives must be understood in light of human cultural systems. Although the actual basis of our sex drive is biological, the ways in which we express it are shaped by behaviors we have learned. The very inventiveness of humans, with our vast technology, is testimony to the powerful effect of learning. However, we are not purely cultural creatures. We are also biological organisms. We need to eat and breathe,



CHAPTER 1 ■ Biological Anthropology and Evolution 13

FIGURE 1.3
A skull of *Australopithecus africanus*, a human ancestor that lived 2.5 million to 3.3 million years ago. Paleoanthropologists use the fossil record to learn about our evolution.

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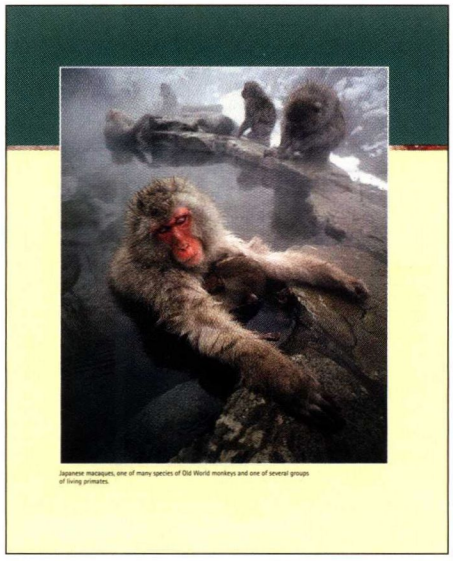
is, however, easily shown to be incorrect (air movement can be measured, and it does not flow in the postulated direction).

Testability To be scientific, a hypothesis must be testable. The potential must exist for a hypothesis to be rejected. Just as the presence of the hypothetical giant in the earth can be tested (it doesn't exist!), predictions about gravitational strength can also be tested. Not all hypotheses can be tested, however, and for this reason, they are not scientific hypotheses. That doesn't necessarily mean that they are true or false but only that they cannot be tested. For example, you might come up with a hypothesis that all the fossils we have ever found were put in the ground by God to confuse us. This is not a scientific hypothesis because we have no objective way of testing it.

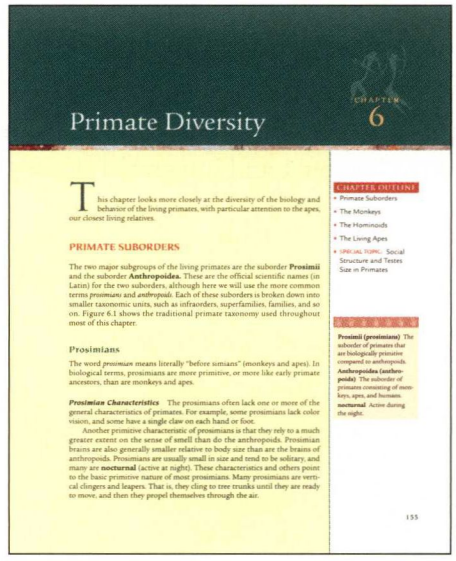
Many evolutionary hypotheses, however, are testable. For example, specific predictions about the fossil record can be made based on our knowledge of evolution. One such prediction is that humans evolved after the extinction of the dinosaurs. The potential exists for this statement to be rejected; all we need is evidence that humans existed before, or at the same time as, the dinosaurs. Because we have found no such evidence, we cannot reject the hypothesis. We can, however, imagine a situation in which the hypothesis could be rejected. If we cannot imagine such a situation, then the hypothesis cannot be tested. For example, suppose someone tells you that all the people on the earth were created five minutes ago, complete with memories! Any evidence you muster against this idea could be explained away. Therefore, this hypothesis is not scientific because there is no possible way to reject it.

HYPOTHESIS TESTING

Hypothesis testing is emphasized throughout the text, starting with Chapter 1, where students are introduced to the scientific method,. Rather than providing a dogmatic approach with all the "right" answers, the text examines evidence in the context of hypothesis testing. With this emphasis, readers can see how new data can lead to changes in basic models and can better understand the "big picture" of biological anthropology.



Japanese macaques, one of many species of Old World monkeys and one of several groups of living primates.



CHAPTER 6

Primate Diversity

This chapter looks more closely at the diversity of the biology and behavior of the living primates, with particular attention to the apes, our closest living relatives.

CHAPTER OUTLINE
- Primate Suborders
- The Monkeys
- The Hominoids
- The Living Apes
- SPECIAL TOPIC: Social Structure and Testes Size in Primates

PRIMATE SUBORDERS

The two major subgroups of the living primates are the suborder **Prosimii** and the suborder **Anthropoidea.** These are the official scientific names (in Latin) for the two suborders, although here we will use the more common terms *prosimians* and *anthropoids.* Each of these suborders is broken down into smaller taxonomic units, such as infraorders, superfamilies, families, and so on. Figure 6.1 shows the traditional primate taxonomy used throughout most of this chapter.

Prosimians

The word *prosimian* means literally "before simians" (monkeys and apes). In biological terms, prosimians are more primitive, or more like early primate ancestors, than are monkeys and apes.

Prosimian Characteristics The prosimians often lack one or more of the general characteristics of primates. For example, some prosimians lack color vision, and some have a single claw on each hand or foot.

Another primitive characteristic of prosimians is that they rely to a much greater extent on the sense of smell than do the anthropoids. Prosimian brains are also generally smaller relative to body size than are the brains of anthropoids. Prosimians are usually small in size and tend to be solitary, and many are **nocturnal** (active at night). These characteristics and others point to the basic primitive nature of most prosimians. Many prosimians are vertical clingers and leapers. That is, they cling to tree trunks until they are ready to move, and then they propel themselves through the air.

Prosimii (prosimians) The suborder of primates that are biologically primitive compared to anthropoids.
Anthropoidea (anthropoids) The suborder of primates consisting of monkeys, apes, and humans.
nocturnal Active during the night.

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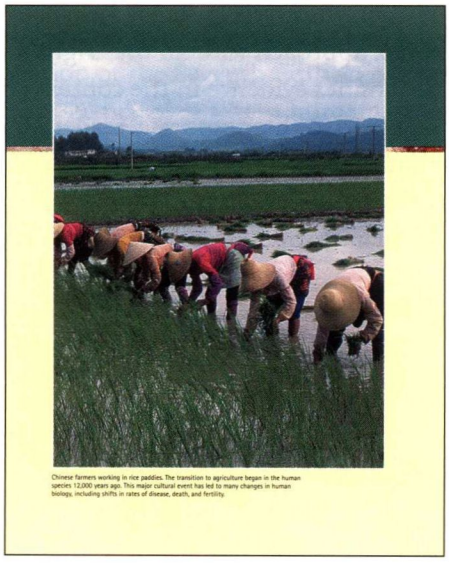
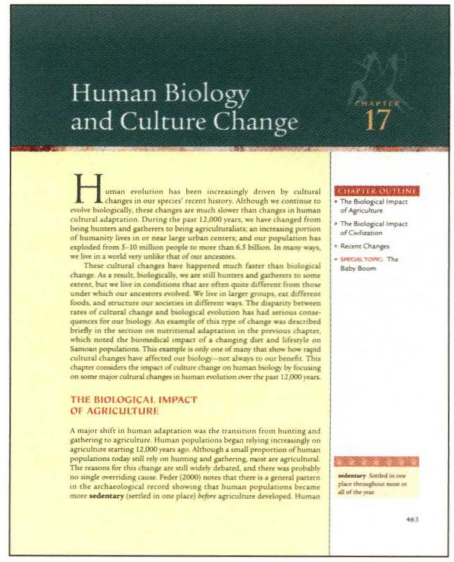
CHAPTER INTRODUCTIONS AND OUTLINES

Spectacular chapter openers provide a general overview of the upcoming content.



Chinese farmers working in rice paddies. The transition to agriculture began in the human species 12,000 years ago. This major cultural event has led to many changes in human biology, including shifts in rates of disease, death, and fertility.



CHAPTER 17

Human Biology and Culture Change

Human evolution has been increasingly driven by cultural changes in our species' recent history. Although we continue to evolve biologically, these changes are much slower than changes in human cultural adaptation. During the past 12,000 years, we have changed from being hunters and gatherers to being agriculturalists; an increasing portion of humanity lives in or near large urban centers; and our population has exploded from 5–10 million people to more than 6.5 billion. In many ways, we live in a world very unlike that of our ancestors.

These cultural changes have happened much faster than biological change. As a result, biologically, we are still hunters and gatherers to some extent, but we live in conditions that are often quite different from those under which our ancestors evolved. We live in larger groups, eat different foods, and structure our societies in different ways. The disparity between rates of cultural change and biological evolution has had serious consequences for our biology. An example of this type of change was described briefly in the section on nutritional adaptation in the previous chapter, which noted the biomedical impact of a changing diet and lifestyle on Samoan populations. This example is only one of many that show how rapid cultural changes have affected our biology—not always to our benefit. This chapter considers the impact of culture change on human biology by focusing on some major cultural changes in human evolution over the past 12,000 years.

CHAPTER OUTLINE
- The Biological Impact of Agriculture
- The Biological Impact of Civilization
- Recent Changes
- SPECIAL TOPIC: The Baby Boom

THE BIOLOGICAL IMPACT OF AGRICULTURE

A major shift in human adaptation was the transition from hunting and gathering to agriculture. Human populations began relying increasingly on agriculture starting 12,000 years ago. Although a small proportion of human populations today still rely on hunting and gathering, most are agricultural. The reasons for this change are still widely debated, and there was probably no single overriding cause. Fedje (2000) notes that there is a general pattern in the archaeological record showing that human populations became more **sedentary** (settled in one place) *before* agriculture developed. Human

sedentary Settled in one place throughout most or all of the year.

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RUNNING GLOSSARY

New terms are defined in the text margin when first introduced, and a comprehensive glossary is provided at the end of the book.

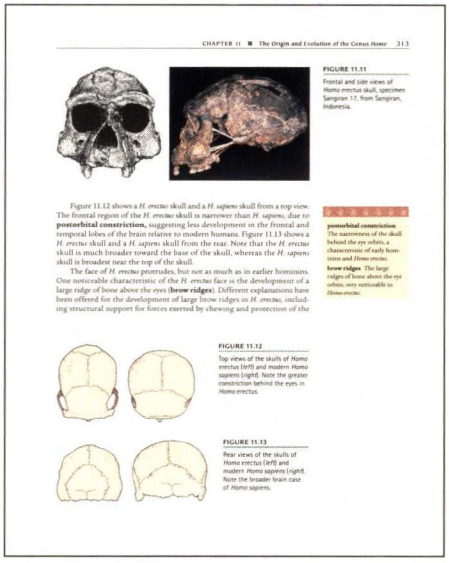
CHAPTER 11 ■ The Origin and Evolution of the Genus *Homo* 313

FIGURE 11.11
Frontal and side views of *Homo erectus* skull, specimen Sangiran 17, from Sangiran, Indonesia.

Figure 11.12 shows a *H. erectus* skull and a *H. sapiens* skull from a top view. The frontal region of the *H. erectus* skull is narrower than *H. sapiens*, due to **postorbital constriction,** suggesting less development in the frontal and temporal lobes of the brain relative to modern humans. Figure 11.13 shows a *H. erectus* skull and a *H. sapiens* skull from the rear. Note that the *H. erectus* skull is much broader toward the base of the skull, whereas the *H. sapiens* skull is broadest near the top of the skull.

The face of *H. erectus* protrudes, but not as much as in earlier hominins. One noticeable characteristic of the *H. erectus* face is the development of a large ridge of bone above the eyes (**brow ridges**). Different explanations have been offered for the development of large brow ridges in *H. erectus*, including structural support for forces exerted by chewing and protection of the

postorbital constriction The narrowness of the skull behind the eye orbits, a characteristic of early hominins and *Homo erectus*.

brow ridges The large ridges of bone above the eye orbits, very noticeable in *Homo erectus*.

FIGURE 11.12
Top views of the skulls of *Homo erectus* (left) and modern *Homo sapiens* (right). Note the greater constriction behind the eyes in *Homo erectus*.

FIGURE 11.13
Rear views of the skulls of *Homo erectus* (left) and modern *Homo sapiens* (right). Note the broader brain case of *Homo sapiens*.

SPECIAL TOPICS BOXES

High-interest, "hot topics" are featured in these boxes. Discussions include "Biological Anthropologists at Work" (Chapter 1), "Humans and Apes—What Genes Are Different?" (Chapter 7), "A Perspective on Geologic Time" (Chapter 8), "Our Common Ancestry" (Chapter 14), and "Are Humans Still Experiencing Natural Selection?" (Chapter 15).


SPECIAL TOPIC

Biological Anthropologists at Work

The research interests of biological anthropologists are quite varied. This photo essay provides some examples.

Dr. Barry Bogin is professor of anthropology in the Department of Behavioral Sciences at the University of Michigan at Dearborn and author of *Patterns of Human Growth* (1999) and *The Growth of Humanity* (2001). His area of specialization is human growth, with particular emphasis on biocultural interactions and the evolution of human physical growth. Much of his recent research has focused on the cultural correlates of differences in physical growth patterns of Ladinos and Mayans in Guatemala and the United States. He is shown here measuring the height of a Mayan woman who has immigrated to the United States.

Dr. Michael Crawford is a professor of anthropology at the University of Kansas. He specializes in anthropological genetics, the study of the forces affecting genetic variation between and within human populations. Dr. Crawford's research focuses on genetic markers from human populations across the globe. His research has taken him to Mexico, Belize, Ireland, Italy, Alaska, and Siberia. He is shown here with the Altai reindeer-herders of Siberia as he investigates their genetic relationship to the first inhabitants of the New World and their adaptation to extremely cold climates.

Dr. Dawnie Steadman, an associate professor at Binghamton University in New York, specializes in forensic anthropology, bioarchaeology, paleopathology, and the application of forensics to human rights investigations. Her current research includes the interpretation of skeletal trauma and healing rates, the coevolution of humans and tuberculosis, and the impact of warfare on prehistoric community health. Her edited volume, *Hard Evidence: Case Studies in Forensic Anthropology* (2003), illustrates the interdisciplinary nature of modern forensic anthropology.

Dr. Dean Falk is a professor of anthropology at Florida State University. Her primary research interest is the evolution and comparative anatomy of primate brains, including the human brain. Dr. Falk is an expert in the field of paleoneurology, which involves the reconstruction of brain anatomy from fossil evidence. Her recent research deals with how the brain cools itself, including implications for human evolution and the origin of an enlarged brain in our early ancestors. Her model of brain evolution is described in *Braindance* (2004).

Barry Bogin

Michael Crawford

Dawnie Steadman

Dean Falk

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Dr. Lyle Konigsberg, a professor of anthropology at the University of Tennessee, is particularly interested in integrating the study of prehistoric human skeletal remains with genetic and demographic theory. Dr. Konigsberg investigates patterns of prehistoric biological variation across space and time. His current work involves an analysis of prehistoric Native American populations, dating between 500 and 6,000 years ago.

Dr. Rachel Caspari is an assistant professor at Central Michigan University. Her primary research interest is the anatomy of recent humans and their evolutionary relationship with earlier humans. Her most recent research has focused on the skeletal morphology of the neck region in central European human fossils. She is also interested in the history of biological anthropology and is coauthor of the book *Race and Human Evolution* (Wolpoff and Caspari 1997).

Dr. Lorena Madrigal, a professor of anthropology at the University of South Florida, studies the biology and microevolution of human populations in Costa Rica, particularly through their demography and genetics. Together with her colleagues from the University of Costa Rica, she is working with the Cuills of Limón, Costa Rica, a group descended from East-Indian indentured workers. The project focuses on obesity, high blood pressure, and the population genetics of this group. In addition, Dr. Madrigal has researched the historical demography of Escazú, Costa Rica, by looking at its mortality and fertility cycles.

Dr. Karen Strier is a professor of anthropology at the University of Wisconsin at Madison. Her primary research interests are in comparative primate behavioral ecology and its links to conservation biology. Since 1982, Dr. Strier has studied the endangered muriqui monkeys of Brazil's Atlantic forest. Her research has demonstrated that muriquis differ from most other primates in their nonaggressive, egalitarian societies. More recently, she has expanded her behavioral studies to include investigations into muriqui reproductive and life history strategies.

Lyle Konigsberg

Rachel Caspari

Karen Strier

Lorena Madrigal

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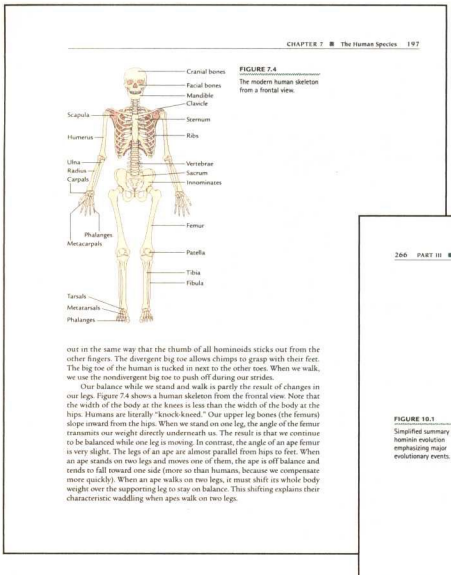
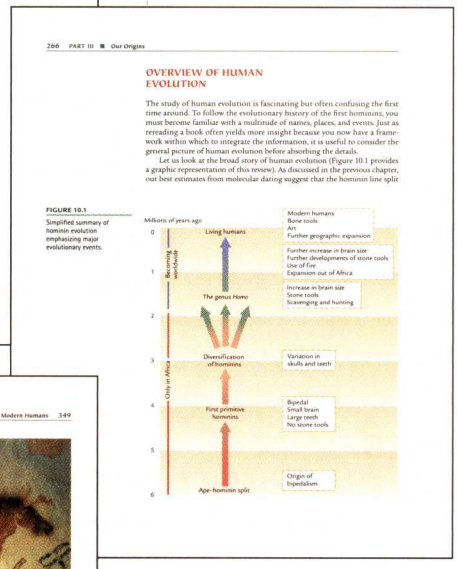
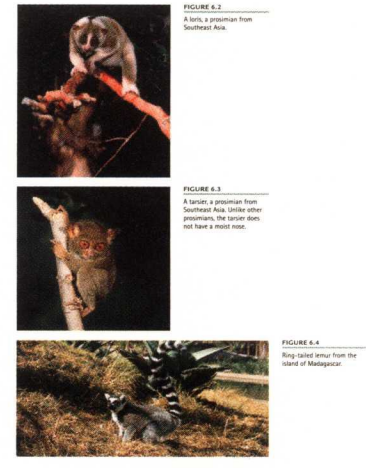
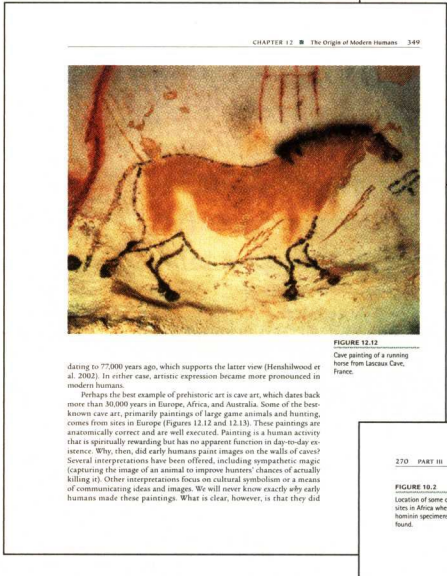
EXTENSIVE VISUAL PROGRAM

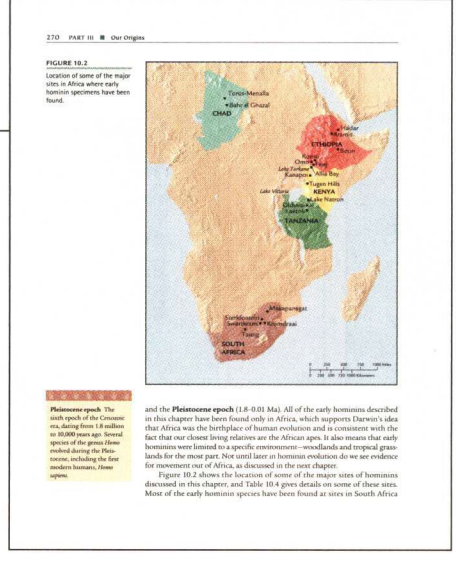
To make this text accessible and visually interesting, we have included abundant color illustrations, photographs, and maps.

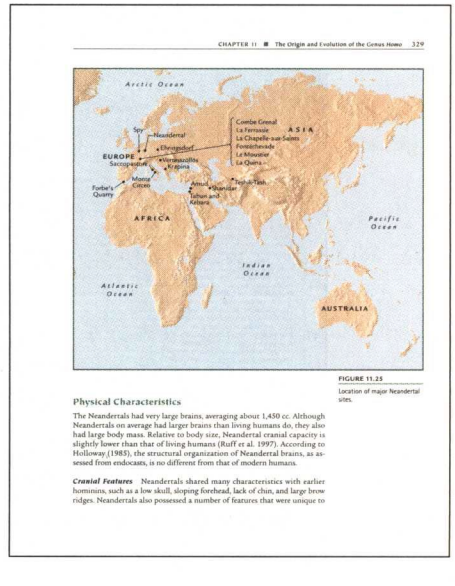






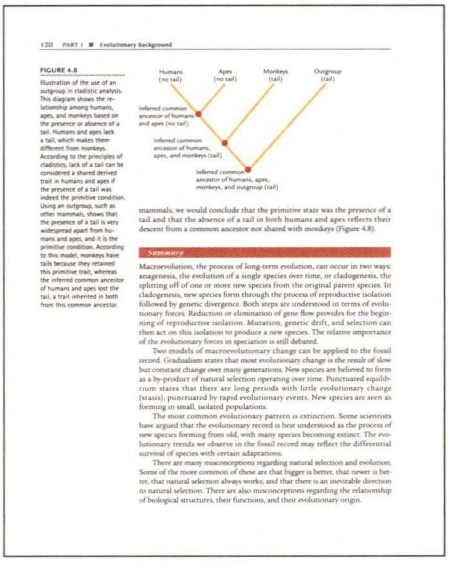






END-OF-CHAPTER AIDS

Each chapter concludes with a summary, a list of supplemental readings, and a list of Virtual Explorations, which provide hands-on exercises and activities for real-time applications of text material.



120 PART 1 ■ Evolutionary Background

FIGURE 4.8
Illustration of the use of an outgroup in cladistic analysis. This diagram shows the relationship among humans, apes, and monkeys based on the presence or absence of a tail. Humans and apes lack a tail, which makes them different from monkeys. According to the principles of cladistics, lack of a tail can be considered a shared derived trait in humans and apes if the presence of a tail was indeed the primitive condition. Using an outgroup, such as other mammals, shows that the presence of a tail is very widespread apart from humans and apes, and it is the primitive condition. According to this model, monkeys have tails because they retained this primitive trait, whereas the inferred common ancestor of humans and apes lost the tail, a trait inherited in both from this common ancestor.

mammals, we would conclude that the primitive state was the presence of a tail and that the absence of a tail in both humans and apes reflects their descent from a common ancestor not shared with monkeys (Figure 4.8).

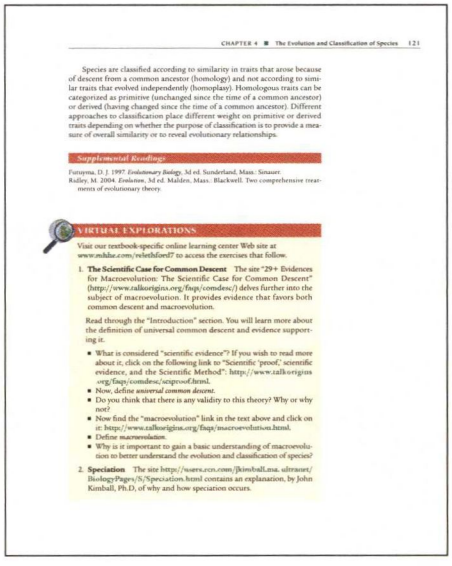
Summary

Macroevolution, the process of long-term evolution, can occur in two ways: anagenesis, the evolution of a single species over time, or cladogenesis, the splitting off of one or more new species from the original parent species. In cladogenesis, new species form through the process of reproductive isolation followed by genetic divergence. Both steps are understood in terms of evolutionary forces. Reduction or elimination of gene flow provides for the beginning of reproductive isolation. Mutation, genetic drift, and selection can then act on this isolation to produce a new species. The relative importance of the evolutionary forces in speciation is still debated.

Two models of macroevolutionary change can be applied to the fossil record. Gradualism states that most evolutionary change is the result of slow but constant change over many generations. New species are believed to form as a by-product of natural selection operating over time. Punctuated equilibrium states that there are long periods with little evolutionary change (stasis), punctuated by rapid evolutionary events. New species are seen as forming in small, isolated populations.

The most common evolutionary pattern is extinction. Some scientists have argued that the evolutionary record is best understood as the process of new species forming from old, with many species becoming extinct. The evolutionary trends we observe in the fossil record may reflect the differential survival of species with certain adaptations.

There are many misconceptions regarding natural selection and evolution. Some of the more common of these are that bigger is better, that newer is better, that natural selection always works, and that there is an inevitable direction to natural selection. There are also misconceptions regarding the relationship of biological structures, their functions, and their evolutionary origin.



CHAPTER 4 ■ The Evolution and Classification of Species 121

Species are classified according to similarity in traits that arose because of descent from a common ancestor (homology) and not according to similar traits that evolved independently (homoplasy). Homologous traits can be categorized as primitive (unchanged since the time of a common ancestor) or derived (having changed since the time of a common ancestor). Different approaches to classification place different weight on primitive or derived traits depending on whether the purpose of classification is to provide a measure of overall similarity or to reveal evolutionary relationships.

Supplemental Readings

Futuyma, D. J. 1997. *Evolutionary Biology*, 3d ed. Sunderland, Mass.: Sinauer.
Ridley, M. 2004. *Evolution*, 3d ed. Malden, Mass.: Blackwell. Two comprehensive treatments of evolutionary theory.

VIRTUAL EXPLORATIONS

Visit our textbook-specific online learning center Web site at www.mhhe.com/relethford7 to access the exercises that follow.

1. **The Scientific Case for Common Descent** The site "29+ Evidences for Macroevolution: The Scientific Case for Common Descent" (http://www.talkorigins.org/faqs/comdesc/) delves further into the subject of macroevolution. It provides evidence that favors both common descent and macroevolution.

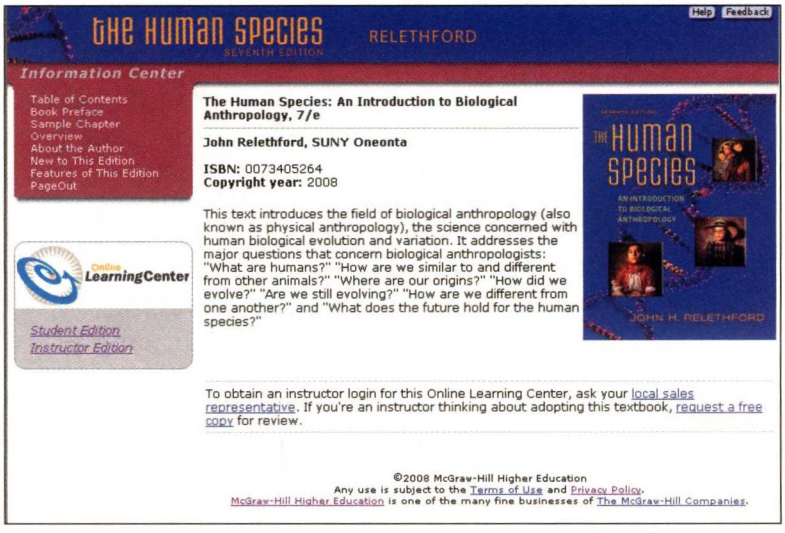
   Read through the "Introduction" section. You will learn more about the definition of universal common descent and evidence supporting it.

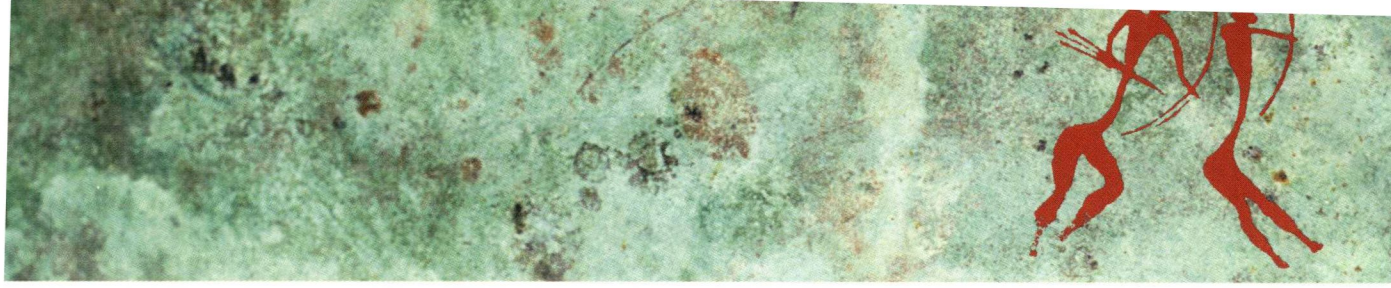
   - What is considered "scientific evidence"? If you wish to read more about it, click on the following link to "Scientific 'proof,' scientific evidence, and the Scientific Method": http://www.talkorigins.org/faqs/comdesc/sciproof.html.
   - Now, define *universal common descent*.
   - Do you think that there is any validity to this theory? Why or why not?
   - Now find the "macroevolution" link in the text above and click on it: http://www.talkorigins.org/faqs/macroevolution.html.
   - Define *macroevolution*.
   - Why is it important to gain a basic understanding of macroevolution to better understand the evolution and classification of species?

2. **Speciation** The site https://users.rcn.com/jkimball.ma.ultranet/BiologyPages/S/Speciation.html contains an explanation, by John Kimball, Ph.D, of why and how speciation occurs.

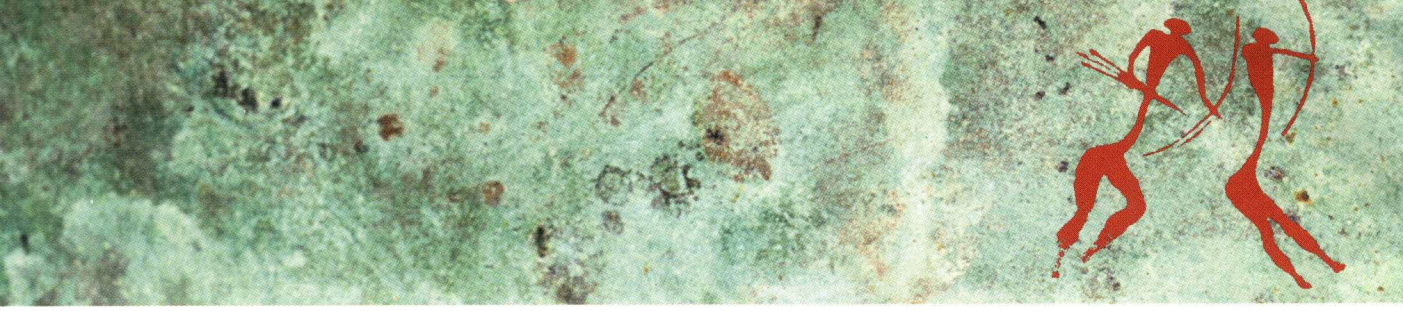
SUPPLEMENTS

Visit our Online Learning Center (www.mhhe.com/relethford7) for student and instructor resources. Student resources include self-quizzes (multiple-choice, true or false, essay), internet links and exercises, flashcards, and chapter study aides. The password-protected instructor portion of the Web site includes the instructorís manual, a comprehensive computerized test bank, PowerPoint lecture slides, and a variety of additional instructor resources.





BRIEF CONTENTS



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