CHAPTER 19

Human Evolution

Objectives

Introduction Describe the evidence supporting and opposing a direct relationship between Neanderthals and modern humans.

Primate Diversity

19.1 Compare the prosimian and anthropoid groups and list characteristics shared by both. Describe the evolution of both groups.

19.2 Distinguish between monkeys and apes. Compare the different groups of apes to each other and to humans.

Hominid Evolution

19.3 Distinguish between hominids, hominoids, australopithecines, and members of the genus *Homo.*

19.3 Describe the five major features that emerged in the evolution of humans.

19.4 Describe the evidence that suggests when upright posture first evolved in humans.

19.5 Describe and compare the species of *Homo.*

19.6 Describe the multiregional and replacement hypotheses for the evolution of *Homo sapiens.* Describe the evidence and explain which hypothesis is best supported by the data.

Our Cultural History and Its Consequences

19.7 Describe the three major milestones that highlight the evolution of *Homo sapiens.* Explain the significance of human culture.

19.8–19.10 Describe the three major stages of culture. Note how each gave humans increasing power over their environment.

Key Terms

prosimian
anthropoid
gibbon
orangutan
gorilla
chimpanzee
paleoanthropology
hominid
hominoid
australopithecine
multiregional hypothesis
"Out of Africa" hypothesis
replacement hypothesis
culture

Word Roots

homin- = man (*hominid:* a term that refers to mammals that are more closely related to humans than to any other living species)

paleo- = ancient; **anthrop-** = man; **-ology** = the science of (*paleoanthropology:* the study of human origins and evolution)

Lecture Outline

Introduction *Are We Related to the Neanderthals?*

A. Focus on the role of molecular biology in systematics.
   1. *Review:* The role of molecular biology in systematics (Chapter 12 and Module 15.12).
   2. A question was raised recently regarding the possibility of interbreeding between Cro-Magnons and Neanderthals. To help determine the right answer, molecular techniques were used to sequence the mitochondrial DNA (mtDNA) from a piece of Neanderthal bone. The results were compared to mtDNA of modern humans, regardless of location on Earth.
   3. Some scientist questioned the validity of these results because contamination is a major concern when analyzing DNA.
   4. More mtDNA from another Neanderthal bone (this time an infant with mixed characteristics) was analyzed and the previous result was corroborated (no interbreeding occurred). Still, skeptics abound and the debate continues.

B. The central issues of this chapter are tracing the evolutionary roots of humans, the not-entirely-worked-out evolutionary pathway of humans, and the pathway of cultural evolution and its effect on the environment.

I. Primate Diversity

Module 19.1 The human story begins with our primate heritage.

A. *Review:* Geological timeline (Module 15.1), the comparison of human and baboon skeletons (Module 30.3), and the role of paedomorphosis in human evolution (Module 15.7).

B. The earliest primates were small, arboreal creatures similar to modern-day **prosimians** that lived at the end of the Age of Dinosaurs ≈65 million years ago (mya) (Module 15.1.) (Figure 19.1A).

C. Most living primates are arboreal, and humans (never strictly arboreal) retain in their bodies many traits that evolved with our arboreal relatives. Primitive primate characteristics (as exhibited by the slender loris, a prosimian) include flexible shoulder and hip joints, maneuverable hands and feet, opposable thumbs and big toes, sensitivity to touch in the hands and feet, short snout, and eyes close together at the front (enhancing three-dimensional vision) (Figure 19.1B).

D. Modern-day primates include prosimians, monkeys, apes, and humans.

E. Prosimians include lorises, bushbabies, tarsiers, and lemurs. All live in tropical forests, and all are threatened by habitat destruction. Of approximately 50 species of lemur to live on Madagascar, 18 are extinct because of human incursion into their habitat about 2000 years ago.

F. The **anthropoids** include monkeys, apes, and humans. Anthropoids differ from prosimians in having relatively larger brains and depending more on eyesight than on smell. The earliest anthropoids were probably monkeylike primates that evolved from prosimian ancestors in Africa and Asia about 45 million years ago.

G. Monkeys differ from apes and humans in having a tail and equal-length forelimbs and hind limbs. They originated in Africa and migrated to other countries in Asia and the Americas. Old World monkeys can be recognized by their narrow close-set nostrils; many have a tough seat pad; and if a tail is present it is not prehensile (Figure 19.1C).

New World monkeys have nostrils that are wide open and far apart, and they often have prehensile tails (Figure 19.1D).

H. The phylogenetic tree of primates indicates several interesting possibilities.
   1. Prosimians and anthropoids diverged around 50 mya.
   2. Old World monkeys and New World monkeys diverged onto separate paths about 40 mya.
   3. Apes evolved from Old World monkeys around 25–30 mya.
   4. Humans diverged from an ancestor of chimpanzees approximately 5–7 mya.

Module 19.2 Apes are our closest relatives.

A. Apes include the **gibbon, orangutan, gorilla,** and **chimpanzee.** All are tropical, lack tails, and have longer forelimbs than hind limbs.
   Review: Figure 15.12B illustrates a relationship between humans and apes based on molecular data.

B. Gibbons are the only apes that are entirely arboreal and monogamous for life. Nine species are found in Southeast Asia (Figure 19.2A).

C. The orangutan is a shy, solitary ape, mostly arboreal, living in forests in Sumatra and Borneo (Figure 19.2B).

D. The gorilla is the largest of all primates and spends most of its time on the ground in African rain forests (Figure 19.2C).

E. The chimpanzee (and very similar bonobo) inhabits rain forests in central Africa. Many aspects of chimpanzee behavior resemble human behavior. They are fully capable of innovative behavior, can learn human sign language, and very likely have complex self-awareness. Recent biochemical evidence shows that chimpanzees and humans share over 97% of their DNA sequences (Figure 19.2D).
   Preview: In Module 37.16 Jane Goodall discusses dominance hierarchies and cognition in chimpanzees.
   NOTE: Consider how different the classification of humans and chimpanzees might be were humans not doing the classifying, or how the classification scheme might differ if two nonhuman species exhibiting the same evolutionarily close relationship were being considered.

II. Hominid Evolution

Module 19.3 The human branch of the primate tree is only a few million years old.

A. **Hominids** diverged evolutionarily from apelike ancestors, probably about 5–7 mya (Figure 19.1E).

B. The study of human evolution is called **paleoanthropology.** Two words not to confuse are hominids (human species) and **hominoid** (great apes and humans).

C. Five major evolutionary events are significant:
   1. Increased brain size, three times the size of a chimpanzee
   2. Shorter jaws, flatter faces, and more pronounced chins
   3. Bipedal posture and upright position
   4. Reduced size difference between the sexes
   5. Key changes in family structure

   NOTE: Emphasize that humans did not descend from apes but, instead, share a recent common ancestor with apes.

D. There are several different species (and several genera) in the human lineage. Evolutionary connections between the species illustrated (and others not illustrated) are hotly debated. The figure shows when each species lived (as determined from the known fossil record) but does not join them in a phylogenetic tree (Figure 19.3).

E. The relationships of hominids such as *Ardipithecus ramidus* and australopithecines to each other and to the lineage that led to modern humans are still being debated.

F. *Homo sapiens* (that's us) is the only extant hominid.

Module 19.4 Upright posture evolved well before our enlarged brain.

A. In what is now Tanzania, footprints left by *Australopithecus afarensis* indicate that hominids have been bipedal for at least 3.5 million years (Figure 19.4).

B. It is unclear whether or not the 4.4-million-year-old *Ardipithecus* was bipedal. It is clear that *Ardipithecus* and some of the oldest australopithecines were forest dwellers.

C. One of the most complete fossils of an australopithecine *(A. afarensis),* nicknamed Lucy, dates to ≈3 million years ago. *A. afarensis* was a small-brained (and small in stature) hominid that lived mostly on nuts, seeds, bird eggs, and scavenged kills from other predators. Spending most of their time on the ground, they probably became arboreal only to escape predators or to scavenge.

D. Recently a new fossil record was discovered that indicates hominid species as early as 4.0 mya *(A. anamensis).*

E. It is debatable whether the australopithecines, which were extinct about 1.0 mya, were on the direct line to *Homo sapiens.* Regardless, brain enlargement was preceded by bipedalism.

Module 19.5 *Homo* and the evolution of larger brains.

A. Brain enlargement was first evident in fossils from East Africa dated at around 2.5 mya. Skulls that are intermediate in size between *Australopithecus* and *Homo sapiens,* some of which are found with associated stone tools, have been assigned to the species *Homo habilis* ("handy man"). This hominid species coexisted for almost 1 million years with later australopithecines on the African savanna, probably living in much the same way. One of our ancestors, *Homo erectus,* may have evolved from *H. habilis.*

B. *H. erectus* ("Upright man") lived from about 1.8 mya to 250,000 years ago. *H. erectus* was taller and had a larger brain and a more advanced culture than *H. habilis. H. erectus* lived in huts or caves, built fires, wore clothes, and made more complex tools.

C. *H. erectus* spread out of Africa to Eurasia. With its broad geographic distribution, *H. erectus* became regionally diverse. One or more populations probably gave rise to our own species, *Homo sapiens.*
Review: Chapter 14 discusses geographic patterns of speciation.

Module 19.6 When and where did modern humans arise?

A. Debate continues over the classification of human fossils dating from 500,000 to 100,000 years ago. These fossils, from Africa, Asia, and Europe, represent *H. erectus* descendants. These earliest forms are sometimes separated as "archaic *Homo sapiens*" and were generally more heavily boned than modern humans, with thicker skulls and more pronounced brow ridges. We know most about one group of the earlier form, the Neanderthals. They lived in Europe, the Middle East, and parts of Asia from 130,000 to 35,000 years ago. They were short and stocky, were skilled toolmakers, and participated in burials and other rituals that required abstract thought (Figure 19.6).

B. Fossil remains of the oldest representatives of modern *H. sapiens* (identical morphologically to present humans) are known from about 100,000 years ago from Africa (and nearly as old from Israel). They coexisted with the archaic stock until the latter disappeared about 35,000 years ago. The unanswered question is: What happened to the archaic group?

C. The **"multiregional hypothesis"** of our origin states that humans arose from several archaic populations in Africa, Europe, and Asia, that modern races of humans stem from regional diversity and have been partly separate for as much as a million years, but that interbreeding among neighboring populations mixed most genes.

D. The **"replacement hypothesis"** states that modern humans arose from a single population of the archaic stock that lived in Africa about 100,000 years ago. This new group migrated out of Africa and replaced all the other hominid populations. Neanderthals and all other populations of the archaic stock were evolutionary dead ends; they did not interbreed with the modern human line at all.

E. This hypothesis is supported by analyses of the DNA in human (female) mitochondria, which indicate a genetic divergence approximately 100,000 years ago. Nuclear DNA analysis supports the data. Analysis of the *Y* chromosome has also supported the data; thus, the genetic evidence is rather compelling in support of the replacement hypothesis.

III. Our Cultural History and Its Consequences

Module 19.7 Culture gives us enormous power to change our environment.

Preview: Human population growth (Module 35.8), the impact of outside disturbances on community structure (Module 36.6), and the sociobiology of **culture** (Modules 37.13 and 37.16).

A. Three milestones highlight human evolution:

1. Erect stance, requiring skeletal remodeling.
2. Brain enlargement, with prolonged postbirth development of the skull and its contents.
3. Evolution of a prolonged childhood, during which cultural information is passed between generations (Module 15.7).

B. Culture includes the accumulated knowledge, customs, beliefs, arts, crafts, and ideas that are passed between generations. More than any other human feature, culture can change at a faster rate than biological evolution, and therefore has allowed our species to transcend the limitations imposed on other species.
Preview: Population dynamics is discussed in Chapter 35. The impact of human culture on the environment is discussed in Chapter 38.

Module 19.8 Scavenging-gathering-hunting was the first major stage of culture.

A. This way of life began with the earliest hominids and continued to be the way of life for the australopithecines and species of *Homo* until about 100,000 years ago. Hunting became important only with the advent of sophisticated tools 50,000 years ago.

B. Some extant cultures (e.g., the !Kung of southwestern Africa) still practice hunting-gathering (Figure 19.8).

C. The first major impact of human culture on the environment may have been to cause the extinction of some early predators, perhaps by hominids (as early as 1.5 mya) becoming skilled at stealing their killed prey. The use of thrown weapons and cooperative hunting definitely affected populations of prey species in Europe, Australia, and the New World.

D. With the development of more sophisticated hunting tools comes evidence of human-caused decimation of species such as the woolly rhinoceroses and giant deer of Europe.

E. Humans reached Australia about 50,000 years ago, an event that may have been responsible for the extinction of the giant kangaroos.

F. Nomadic hunters migrated from Asia to North America about 30,000 years ago. Their actions are likely to have caused the extinction of many large animal species.

G. Other characteristics of this level of culture include the organization into communal groups that divided labor, the use of semipermanent homes, trading among populations, and (toward the end of the period) the growing of a few simple crops.

Module 19.9 Agriculture was a second major stage of culture.

A. Agriculture developed in Africa, Eurasia, and the Americas 10,000 to 15,000 years ago. Plots of rain forest were cut and burned, and crops were planted. Early Asian farmers domesticated and grew rice and millet.
Review: The effects of slash and burn on tropical forests are discussed in Module 34.11.
NOTE: Shifting (slash-and-burn) cultivation by modern peoples actually makes ecological sense in tropical forest areas, if it weren't for the incredible pressures placed on habitat by human populations that are too large. Small plots are cleared, farmed for a while, and then allowed to return to the native forest, during which time products from the successional stages are gathered. Scattered, small plots protect the land from the erosion that occurs when large areas are cleared. In addition, farmers take advantage of the high productivity of the land during the early stages of succession (Module 36.7), and later stages of the forest return what little fertility the soil can hold.

B. Increases in population size made possible by agriculture, and the use of more advanced plows and overgrazing, probably caused serious soil erosion in the Fertile Crescent, turning a rich forest area into a desert.
Review: The runoff from the use of fertilizers can result in algal blooms (Module 16.13). Also, review soil conservation (Module 32.9) and organic farming (Module 32.10).

C. Agriculture changed forever the relationship between humans and the biosphere. Large areas of native vegetation have been converted to farming use. Agriculture allows the establishment of permanent settlements and cities, and it frees many members of cultures to specialize in other activities.

Module 19.10 The machine age is the third major stage of culture.

Preview: Human population growth (Modules 35.8–35.10).

A. The change from small hand tools to large-scale machines also produced major effects on most human activities.
NOTE: The first industries built up around the fabrication of metal tools for hunting and farming, long before the machine age.

B. Complex machines further reduced the need for agricultural workers. Energy consumption increased. Medical advances reduced deaths.

C. During all these cultural changes, humans have not changed genetically in any significant way. Rapid cultural change has changed environments that humans and other species live in. Nothing is new about this environmental change except the speed of the change, which now vastly outpaces the rate of biological evolution.
Preview: The effects of this on the environment will be discussed in Chapter 38.

Class Activities

1. Have your class consider the following: Humans and chimpanzees are placed in different genera. Why? If any species other than humans were doing the classifying, would humans and chimpanzees be placed within the same genus?
2. Considering that insects are the most successful of all animal taxa in an evolutionary sense, in terms of species diversity and numbers, of what good is the large human brain? Over the long term will the human brain prove to have staying power and enable us to avoid extinction? What does evolution hold for the future of humans—i.e., how might the descendants of modern humans differ both anatomically and physiologically?
3. Has technology placed us in a fourth major stage of human culture? Are we now in the information/computer age?

Transparency Acetates

Figure 19.1E	A phylogenetic tree of primates
Figure 19.3	A timeline for some hominid species

Media

See the beginning of this book for a complete description of all media available for instructors and students. Animations and videos are available in the Campbell Image Presentation Library. Media Activities and Thinking as a Scientist investigations are available on the student CD-ROM and web site.

Animations and Videos	File Name
Gibbons Swinging in a Tree Video	19-02A-GibbonVideo-B.mov
Gibbons Swinging in a Tree Video	19-02A-GibbonVideo-S.mov

Activities and Thinking as a Scientist	Module Number
Web/CD Activity 19A: *Primate Diversity*	19.2
Web/CD Activity 19B: *Human Evolution*	19.6