

# CHAPTER 23: HOW HUMANS EVOLVED

## CHAPTER SYNOPSIS

Human evolution is supported by analysis of comparative anatomy, development, and behavior as well as substantial fossil evidence, primarily from continental Africa. Primates are the first distinctive step on the stairway to genus *Homo*. The earliest primates, the prosimians, that existed 40 million years ago possessed both binocular vision and grasping fingers and toes. Lemurs are one of the present day examples of this group. Several million years later diurnal primates, the anthropoids, evolved. They had color vision and improved senses that correlated with daytime foraging. New World monkeys evolved first in Central Africa and migrated to South America. They evolved in isolation when the two continents separated and only they have grasping prehensile tails. The next step in human evolution is the apes, evolving from Old World monkeys 25 million years ago. A clear advancement with their large size and increased brain capacity, apes also possess the most adaptable behavior of all mammals, with the exception of humans. Gibbons are least related to humans, chimpanzees are most related. Human and chimpanzee hemoglobin differ in only a single amino acid. Humans and their direct ancestors are placed in the group hominids. The larger group that includes apes is called hominoids. The differences between evolving apes and hominids were associated with locomotion. Hominids became bipedal, exhibiting changes in the spinal column, pelvis, hips, knees, and feet. Human body weight is carried on the lower limbs while African apes equally distribute their weight between upper and lower limbs.

There are two major groups of hominids: seven species of *Australopithecus* and 3 to 7 species within the genus *Homo*. The genus *Australopithecus* is stockier in build than humans, but with larger brain cases than apes. The jaws and teeth are more like humans and the structure of their feet and pelvis indicates that they all walked upright. The most famous of these fossils is "Lucy," determined to be nearly 3 million years old. Fossil evidence indicates that bipedalism preceded development of larger brains. The former is evident in fossils that are 4

million years old, while the latter does not appear in fossils for another 2 million years. Why bipedalism evolved is still a controversy.

About 2 million years ago a new genus, *Homo*, replaced the australopithecines. The most primitive species is *H. habilis* for which only a few specimens exist. *H. rudolfensis* and *H. ergaster* are the two other early *Homo* species. Since few fossils of each species exist, it is difficult to ascertain whether they are truly separate or if they all belong to *H. habilis* and merely show individual variation. Most researchers support the 3 species model with *H. rudolfensis* being most ancient and *H. ergaster* being most recent. *H. erectus* evolved 1.5 million years ago and includes Java man and Peking man. This species spread through Africa and migrated into Europe and Asia. They were human in appearance, used tools, fire, and had a developed social structure. They are different from modern humans primarily in the size of their brains.

One of the current debates in human evolution surrounds whether there were three species of modern *Homo* or just one. The oldest *Homo* species is *H. heidelbergensis*, the more likely direct ancestor of *H. sapiens*. Although some of its anatomical features are like early *Homo* specimens, it has forehead and nasal bones like *H. sapiens*. *H. neanderthalensis* appeared in Europe from Africa 130,000 years ago, with *H. erectus* becoming rare. The oldest specimen of *H. sapiens*, the only surviving species of *Homo*, is a 130,000 year old fossil from Ethiopia. The Out-of-Africa model states that this final species of humans evolved in Africa and re-migrated to Europe and Asia. The opposing Multiregional model purports that the various human races evolved independently from *H. erectus*. A recent examination of the CD4 gene strongly supports the former model. Cro-Magnons appeared in Europe about 34,000 years ago and coexisted with Neanderthals. Examination of burial sites indicates that Neanderthals were capable of human thought, yet they were replaced by Cro-Magnons. This group exhibited more complex social organization and perhaps possessed the first true language capabilities.

## CHAPTER OBJECTIVES

- ä Know which primate characteristics encouraged their intellectual development over other mammals.
- ä Explain the importance of anthropoids and their divergence from prosimians.
- ä Differentiate between primates and hominoids with respect to evolutionary relationships, physical and behavioral adaptations.
- ä Differentiate between hominoids and hominids with respect to evolutionary relationships, physical and behavioral adaptations.
- ä Understand the importance of bipedalism to human evolution.
- ä Explain why australopithecines are considered to be the root genus of the human evolutionary tree.
- ä Compare and contrast the seven species of *Australopithecus*.
- ä Compare the species of the genus *Homo* in terms of time, location, physical appearance, and major behavioral characteristics.
- ä Understand the patterns of migration and evolution associated with *Homo erectus*.
- ä Explain the evidence supporting the Out-of-Africa model of *H. sapiens* evolution.

## KEY TERMS

ape  
bipedalhominid  
hominoidNew World monkey  
Old World monkey

## CHAPTER OUTLINE

**23.0 Introduction**

## I. THE DESCENT OF MAN

## A. Darwin Supported Idea of Human Evolution

1. Used arguments from anatomy, development, and behavior
2. Evolved from same ancestors that gave rise to gorilla and chimpanzee
3. Fossil evidence stronger now

fig 23.1

## B. Human Evolution Still Controversial Topic

**23.1 The evolutionary path to humans starts with the advent of primates**

## I. THE EVOLUTIONARY PATH TO APES

## A. Archonta Were the Ancestors of the First Primates

1. Occurred around 65 million years ago
2. Nocturnal, large-eyed insectivorous mammals
3. Radiation gave rise to bats, tree shrews, and primates

## B. The Earliest Primates

1. Two distinct features associated with primates
  - a. Grasping fingers and toes
    - 1) First digit is usually opposable

- 2) Digits usually have nails
    - b. Binocular vision
      - 1) Both eyes at front of face
      - 2) Allows for precise judgement of distance
  - 2. Characteristics possessed by other animals, but not together
  - 3. Dentition began to change to support plant eating
  - 4. Reduction in length of snout and number of teeth
- C. The Evolution of Prosimians
- 1. Split of prosimians and anthropoids 40 million years ago
  - 2. Prosimians were first primates
    - a. Lemurs, lorises, and tarsiers are surviving examples fig 23.2
    - b. Have very large eyes, increased visual acuity
    - c. Are nocturnal animals, feed on fruits, leaves, flowers
    - d. Lemurs may have long tails for balancing
- D. Origin of the Anthropoids fig 23.3
- 1. Higher primates include monkeys, apes, and humans
  - 2. Primates became diurnal (day active), fed on fruits and leaves
  - 3. Evolution favored many changes
    - a. Changes in eye design, color vision, adaptations to daytime foraging
    - b. Improved senses governed by expanded brain
    - c. Live in groups with complex social interactions
    - d. Long childhood associated with development of large brains
  - 4. Identity of first anthropoid is still under contention
  - 5. Evolved first in Africa, now extinct but monkeys are direct descendants
  - 6. New World monkeys
    - a. Some anthropoid apes migrated to South America, evolved in isolation
    - b. Are arboreal with flat-spreading noses
    - c. Many have grasping, prehensile tails fig 23.4a
  - 7. Old World monkeys
    - a. Apes remaining in Africa split into two lineages 25 million years ago
      - 1) One gave rise to Old World monkeys
      - 2) Other gave rise to hominids
    - b. Include ground-dwelling and arboreal species
    - c. None have prehensile tails
    - d. Nostrils are close together, noses point downward
    - e. Some have toughened pads of skin for prolonged sitting fig 23.4b

## II. HOW THE APES EVOLVED

- A. African Anthropoid Evolution
- 1. Include hominoids = apes + hominids
  - 2. Living apes include gibbon, gorilla, chimpanzee fig 23.5
    - a. Have larger brains than monkeys, but lack tails
    - b. Generally larger size
    - c. Exhibit most adaptable behavior of all mammals, excluding humans
    - d. Becoming rare
    - e. Never existed in North or South America
- B. The First Hominoid
- 1. A controversial topic
  - 2. In 1980s thought to be *Ramapithecus*
    - a. Late Miocene ape lived 5 to 10 million years ago

- b. 8-million-year-old fossil jaw found in India in 1932
  - c. Fossils not found in Africa
  - d. More complete fossils found in 1981 showed closer relationship to orangutans
  - 3. Best candidate now considered to be *Proconsul*
    - a. Earlier Miocene ape with characteristics of Old World monkeys
    - b. Lacks a tail, has apelike hands, feet, and pelvis
  - 4. Very few fossils from 5 to 10 million years ago exist
  - 5. Difficult to identify first hominoid ancestor
- C. Which Ape Is Our Closest Relative fig 23.3
- 1. DNA studies explain ape evolution
  - 2. Asian apes evolved first, not closely related to humans
    - a. Gibbons diverged 15 million years ago
    - b. Orangutans split off 10 million years ago
  - 3. African Apes evolved between 6 and 10 million years ago
    - a. Closest living relatives to humans
    - b. African apes often placed in same zoological family as humans (Hominidae)
    - c. Hominid common ancestor more like chimpanzee than gorilla
    - d. Gorillas diverged from line 8 million years ago according to genetic differences
  - 4. Common ancestor of hominid line then split off chimpanzee line
    - a. Split between chimpanzees and humans very recent
    - b. Few genetic differences in DNA
    - c. Human and chimpanzee hemoglobin differs in only one amino acid
    - d. Genetic difference comparable to sibling species of same genus
- D. Comparing Apes to Hominids fig 23.6
- 1. Common ancestor of apes and hominids was an arboreal climber
  - 2. Differences between evolving apes and hominids associated with locomotion
    - a. Hominids became bipedal, walked upright
    - b. Apes evolved knuckle-walking (monkeys use palms of hands)
  - 3. Bipedal hominids have distinct skeletal anatomy
    - a. Vertebral column more curved than ape's
    - b. Spinal cord exits from bottom not back of skull
    - c. Pelvis is broader, more bowl-shaped
    - d. Hip, knee, and foot have altered proportions
  - 4. Human body weight carried on lower limbs
    - a. Comprise 32 to 38% of body's weight
    - b. Lower limbs are longer than upper limbs
    - c. Upper limbs comprise 7 to 9% of body weight
  - 5. African ape body weight carried by upper and lower limbs
    - a. Upper limbs longer, comprise 14 to 16% of body weight
    - b. Lower limbs are shorter account for 18% of body weight

## 23.2 The first hominids to evolve were australopithicines

### I. AN EVOLUTIONARY TREE WITH MANY BRANCHES

- A. Climatic Changes May Have Spurred Evolution of Bipedal Hominoid
- 1. Occurred between 5 and 10 million years ago
  - 2. Forests replaced with savannas and open woodland
  - 3. Two major groups of hominids
    - a. Three to seven species in genus *Homo*
    - b. Seven species of smaller-brained *Australopithicus*

B. The Discovery of *Australopithecus*

1. Dart discovered first hominid fossil in 1924 in South Africa
  - a. Fossil skull of a five-year old individual
  - b. Jaw was rounded not pointed like ape
  - c. Ventral position of foramen magnum suggested walking upright
2. Fossil now dated at 2.8 million years old
3. Named *Australopithecus africanus*
4. Fossil dating now done via single-crystal laser-fusion dating
  - a. Laser beam melts feldspar crystal, released argon gas
  - b. Amount of gas released reveals age of rock and nearby fossils
  - c. Less than 1% margin of error

C. Other Kinds of *Australopithecus*

1. *A. robustus* fossil discovered in 1938 in South Africa
  - a. Stockier build
  - b. Massive teeth and jaws
2. *A. boisei* fossil discovered by Mary Leakey in 1959 in East Africa
  - a. Even more stockily built
  - b. Almost 2 million years old
  - c. Massive bony ridge on crest of skull to anchor jaw muscles
3. Johanson discovered oldest prehuman hominid fossil in 1974 fig 23.7
  - a. Nicknamed "Lucy"
    - 1) 40% complete, 3 million years old
    - 2) Given scientific name *A. afarensis* (found in the Afar Desert)
    - 3) Shape of pelvis revealed sex and that she walked upright
    - 4) Head more similar to ape and brain chimpanzee-sized
    - 5) Skulls are obviously apelike, but teeth distinctly hominid
    - 6) Brain size of 400 cc, about the size of an orange
  - b. Over 300 specimens subsequently found
4. Three additional kinds of australopithecines reported, indicate genus is very diverse

## D. Early Australopithecines Were Bipedal

1. Numerous fossils clearly indicate bipedalism
2. Other physical characteristics
  - a. Weighed about 18 kilograms, were about 1 meter tall
  - b. Dentition hominid
  - c. Brains the size of apes
    - 1) Apes brains 500 cc or less
    - 2) *Homo* brains 600 cc
    - 3) Modern *Homo sapiens* brains average 1350 cc
3. Fossils found only in Africa
  - a. Probably lived over a much broader area
  - b. Sediments of proper age exposed only in South and East Africa

## II. THE BEGINNING OF HOMINID EVOLUTION

## A. The Origin of Bipedalism

1. Evolved as ancestors left dense forests for open grasslands, woodlands fig 23.8
2. Two schools of thought
  - a. First says brain enlarged first, bipedalism followed
    - 1) Intelligence necessary to make decision to walk upright
    - 2) Move out of forests to grassland
  - b. Second says bipedalism a precursor to enlarged brains
    - 1) Bipedalism freed forelimbs to manufacture and use tools

- 2) Favored subsequent evolution of bigger brains
  3. Debate settled with fossils found in Africa
    - a. Bipedalism extended back 4 million years ago
    - b. Brain expansion did not appear until 2 million years ago
  4. Upright walking clearly preceded large brains
  5. Evidence for bipedalism includes series of footprints from Laetoli, East Africa
    - a. Two individuals walked side-by-side for 27 meters fig 23.1
    - b. Footprints preserved in 3.7-million-year-old volcanic ash
    - c. Impression shows strong heel strike, deep indentation by big toe
    - d. Big toe not splayed out to side like monkey or ape – clearly hominid
  6. Why bipedalism evolved is still matter of controversy
    - a. Tool-making unlikely, no tools appear until 2.5 million years ago
    - b. Alternative ideas
      - 1) Upright walking faster, uses less energy
      - 2) Upright posture permits picking fruit from trees, seeing over grasses
      - 3) Posture reduces body surface exposed to sun's rays
      - 4) Upright stance aids wading of aquatic hominids
      - 5) Frees forelimbs of males to carry food back to females, encourages pair-bonding
    - c. None of ideas are universally accepted
    - d. Origin of bipedalism still a mystery
- B. The Root of the Hominid Tree
1. The oldest known hominid
    - a. Near complete skeleton discovered in 1994
      - 1) Clearly bipedal, forward foramen magnum
      - 2) Most ancient specimen yet found, 4.4 million years old
      - 3) More apelike than australopithicines
    - b. Assigned new genus *Ardipithecus* fig 23.9a
  2. The first Australopithicine
    - a. Hominid fossils 4.2 million years old found in Kenya in 1995
    - b. Species named *Australopithecus anamensis* fig 23.9b
      - 1) Include partial tibia with bipedal characteristics
      - 2) Assigned to genus *Australopithecus* less apelike than *Ardipithecus*
      - 3) Fossils are intermediate in many ways
    - c. Additional fragmentary specimens found
      - 1) Slightly built individuals
      - 2) First members of genus, ancestral to *A. afarensis*
- C. Differing Views of the Hominid Family Tree
1. Lumpers and splitters
    - a. Lumpers focus on common elements in different fossils
      - 1) Lumps together fossils that share key characteristics
      - 2) Differences attributed to diversity within group
      - 3) Lumper hominid phylogenetic tree, three species
    - b. Splitters focus on differences between groups
      - 1) Assign fossils with different characteristics into different species
      - 2) Splitter phylogenetic tree, seven species fig 23.10
  2. More fossils needed to determine most accurate representation
    - a. Are differences due to within-species variation?
    - b. Are differences due to between-species characteristics?

23.3 The genus *Homo* evolved in Africa

I. AFRICAN ORIGIN: EARLY *HOMO*

A. First Humans Evolved 2 Million Years Ago

1. Ancestor thought to be *A. africanus*
2. Numerous fossils of *Homo* discovered only within last 30 years
3. New fossils discovered yearly, evolutionary picture changes

B. *Homo habilis*

1. Stone tools and hominid bones found near *A. boisei* site in 1960s
2. Skull had brain volume of 680 cc
3. Specimen called *Homo habilis* (meaning “handy man”)
4. Partial skeletons found in 1986
  - a. Individuals small in stature
  - b. Arms longer than legs, australopithicine in appearance
  - c. Human identity initially questioned

C. *Homo rudolfensis*

1. Fossil skull discovered by Richard Leakey in 1972 near Lake Rudolf in Kenya
  - a. 1.9 million years old, clearly human in characteristics
  - b. Brain volume 750 cc
  - c. Clearly human, not australopithicine
2. Some anthropologists considered it a large male of *H. habilis*

D. *Homo ergaster*

1. Some early *Homo* fossils do not fit into either species fig 23.11
  - a. Larger brains than *H. rudolfensis*
  - b. Skeletons less australopithicine, more modern in size and proportion
  - c. Have small cheek teeth like modern humans
2. Placed in third species of early *Homo* (species name means “workman”)

E. How Diverse Was Early *Homo*?

1. Very few specimens found
  - a. Debate if they are all *H. habilis* or three separate species
  - b. More researchers accepting three species designation
2. Indicates *Homo* underwent early adaptive radiation
  - a. *H. rudolfensis* most ancient, then *H. habilis*
  - b. *H. ergaster* most recent, likely ancestor to later species of *Homo* fig 23.10

II. OUT OF AFRICA: *HOMO ERECTUS*

A. Java Man

1. Interest in finding “missing link” between apes and humans in 1860s
  - a. Dubois sought fossil evidence
  - b. Looked in home country of orangutans: Java
2. Dubois found fossil skull cap and thigh bone in 1891
  - a. Long, straight legs, excellent walker
  - b. Very large, 1000 cc brain
  - c. Judged to be 500,000 years old

- B. Peking Man
  - 1. 14 skulls discovered in China in 1920s near Peking (now Beijing)
  - 2. Also found crude tools and ashes from campfires
    - a. Casts made and sent to laboratories
    - b. Originals lost to World War II
    - c. Numerous additional specimens found
  
- C. A Very Successful Species
  - 1. Java man and Peking man belong to same species *Homo erectus*
  - 2. Comparison to *H. habilis*
    - a. Taller, large brain about 1000 cc fig 23.12
    - b. Skull has prominent brow ridges, rounded jaw
    - c. Shape of skull interior suggests ability to talk
  - 3. *H. erectus* migrated out of Africa
    - a. 1.5 million years old *H. erectus* fossil found in Africa in 1976
    - b. Spread through Africa, migrated to Asia and Europe within 1 million years
  - 4. Developed social structure
    - a. Lived in tribes of 20 to 50 individuals
    - b. Inhabited caves, built crude, wooden shelters
    - c. Hunted and butchered large animals, cooked with fire
  - 5. Species survived for over 1 million years
    - a. Disappeared in Africa and Europe 500,000 years ago
    - b. Lasted longer in Asia, until 250,000 years ago

### 23.4 Modern humans evolved quite recently

#### I. THE LAST STAGE OF HOMINID EVOLUTION

- A. Three Species of Modern Humans
  - 1. *H. heidelbergensis*, *H. neanderthalensis*, *H. sapiens* fig 23.10
  - 2. Other researchers consider them as just one species, *H. sapiens*
  - 3. Oldest modern humans: *Homo heidelbergensis*
    - a. Oldest fossil from Ethiopia 600,000 years old
    - b. Coexisted with *H. erectus* in Africa
    - c. More advanced anatomical features
      - 1) Has bony keel running along midline of skull
      - 2) Thick ridge over eye sockets, large brain
      - 3) Forehead and nasal bones like *H. sapiens*
  - 4. *Homo neanderthalensis*
    - a. New species in Europe from Africa 130,000 years ago, *H. erectus* becoming rare
    - b. Branched from ancestral line 500,000 years ago
    - c. Physical characteristics of neanderthals fig 23.13
      - 1) Short, stocky, powerfully built individuals
      - 2) Massive skulls, protruding faces, heavy bony brow ridges
      - 3) Larger brains
  
- B. Out of Africa – Again?
  - 1. Oldest *Homo sapiens* fossil from Ethiopia, 130,000 years old
    - a. Other fossils found in Israel, dated at 100,000 to 120,000 years old
    - b. No fossils outside of Africa and Middle East older than 40,000 years
      - 1) Implies *H. sapiens* evolved in Africa, migrated to Europe and Asia
      - 2) Called the Out-of-Africa model
      - 3) Other view is the Multiregional model, human races evolved independently



2. The mitochondrial DNA data adds to controversy
  - a. Greatest number of mutations should occur in oldest DNA
  - b. Consistent with oldest humans living in Africa longer than any place else
  - c. *H. sapiens* evolved in Africa and remigrated to rest of world fig 23.14
3. A clearer picture from nuclear DNA
  - a. Examine highly variable marker segments of nuclear DNA
  - b. In 1996, analyzed CD4 gene on chromosome 12 in populations all over the world
    - 1) 24 different versions of the two CD4 segments found
    - 2) 21 versions found in Africa
    - 3) Three versions found in Europeans
    - 4) Two versions found in Asians and Americans
  - c. Indicates chromosome 12 has existed in Africans longer than non-Africans
  - d. Strongly supports African origin of humans

## II. OUR OWN SPECIES: HOMO SAPIENS

### A. *Homo sapiens*

1. Only surviving species of genus *Homo*
2. Best evidence in skeletons found in Israel
  - a. Dated at 90,000 to 100,000 years old
  - b. Modern appearance, high, short brain-cases
  - c. Vertical foreheads, slight brow ridges
  - d. Cranial capacity of 1550 cc, within range of modern humans

### B. Cro-Magnons Replace the Neanderthals

1. Fossils of *Homo neanderthalensis* found in Germany in 1856
  - a. Became abundant in Europe and Asia by 70,000 years ago
  - b. Social characteristics
    - 1) Made diverse tools
    - 2) Common by 70,000 years ago in Europe and Asia
    - 3) Cared for sick and injured, attention given to the dead
    - 4) Symbolic thinking of modern humans
2. Cro-Magnons replaced European Neanderthals about 34,000 years ago
  - a. Came first from Africa, replaced Neanderthals in Middle East 40,000 years ago
  - b. Spread across Europe, coexisting with, possibly interbreeding with Neanderthals
3. Characteristics of Cro-Magnons
  - a. Had complex social organization
  - b. May have been first humans with fully modern language capabilities
  - c. Responsible for elaborate cave paintings of herd animals fig 23.15
4. Modern humans spread into North America via Siberia 13,000 years ago

### C. *Homo sapiens* Are Unique

1. Evolution marked by continual increase in brain size
2. Use symbolic language, transmit accumulation of experience to next generation
3. Have experienced cultural evolution

## III. HUMAN RACES

### A. Humans Are Like All Other Species

1. Have differentiated in characteristics as they have spread through the world
  - a. Differences in hair, skin, eye color
  - b. Differences in proportions of ABO blood groups
2. Traits may better adapt inhabitants to certain environments
  - a. Blood groups may confer immunity to diseases

- b. Dark skin shields body from damaging effects of UV radiation
- 3. All humans capable of mating with one another, producing fertile offspring
  - a. Choice to associate with other races is psychological and behavioral(cultural)
  - b. Division into human races inconsistent, as many as 30 or as few as three
- 4. Characteristics defining races in organisms do not always correlate with each other
  - a. Humans are visually-oriented, visual cues (skin color) used to define races
  - b. Other characters do not correspond well to race delineation
  - c. Genetic similarity groupings different from visual feature grouping fig 23.16
- 5. Difficult to delimit clearly defined races from biology point of view
  - a. Intermingling of groups of people confound the distinctions
  - b. Classic example of antagonism between gene flow and natural selection
    - 1) Dark coloration selection in tropics
    - 2) Gene flow ensures populations remain homogeneous at other loci
- 6. Little human variation represents differences among races
  - a. Accounts for only 8% according to one study
  - b. Modern biologists reject human racial classifications

## INSTRUCTIONAL STRATEGY

### PRESENTATION ASSISTANCE:

Stress that humans did not evolve from chimpanzees or gorillas. The three hominoids evolved from a common ancestor. Each has become significantly and independently specialized over the last 4 million years. Too frequently evolution is explained in terms of current forms evolving from one another; presenting diversity from an evolutionary standpoint must be done very carefully. Most life on Earth today is highly specialized and quite

different in appearance from any postulated ancestors, with the exception of certain forms. Sharks and lungfish are two of the few organisms that have changed only slightly since their initial appearance in the fossil record.

A recent poll of U.S. high school biology teachers reports that a full 20% believe that man and dinosaurs existed at the same time!

### VISUAL RESOURCES:

Obtain plastic casts of various kinds of hominid, hominoid, and mammal skulls to show more obvious external characteristics. Brain size is

more clearly represented by filling the skulls with BB shot or small beans and pouring into individual beakers and comparing the volumes.