

PowerLecture:
Chapter 26
Animal Evolution – The Vertebrates
Section 26.0: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 26.0: Archaeopteryx FAQ's
- Section 26.0: DinoBuzz—Are Birds Really Dinosaurs?
- Section 26.0: In Quest of the Origin of Birds. Roger DiSilvestro. *BioScience*. Sept. 1997.
- Section 26.0: Archaeoraptor Fossil Trail (uncovering “archaeoraptor” fraud). *National Geographic*. Oct. 2000.

How Would You Vote?

The following is the question for this chapter. See national results below.

- Should private ownership of important fossils be banned?

Impacts, Issues: Interpreting and Misinterpreting the Past

- Archaeopteryx lived 150 million years ago – an important link in the fossil record
- Between 1860 and 1988, six Archaeopteryx specimens and a fossilized feather were found

Impacts, Issues: Interpreting and Misinterpreting the Past

- No one was around to witness the transitions in the history of life
- Fossils allow us glimpses into the past, giving us opportunities to improve our understanding of the story of life on earth and own origins

Section 26.1: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 26.1: Carl Zimmer—In Search of Vertebrate Origins: Beyond Brain and Bone

- Section 26.1: Sea Squirt Immunity—The AIDS Connection
- Section 26.1: The Animal Axis. Stephen Wainwright. *American Zoologist*, Feb. 2000.
- Section 26.1: As the Worm Turns. Stephen Jay Gould. *Natural History*, Feb. 1997.
- Section 26.1: Students Pursue One of the Ocean's Slimy Mysteries (hagfish). Carey Goldberg. *The New York Times*, Jan. 2, 2001.
 - Something Old,
 - Something New
- Every animal is a combination of traits
- Some traits are conserved from remote ancestors
- Other traits are unique to its branch of the family tree

Chordate Features

- Deuterostomes
- All share four features:
 - Notochord supports body
 - Nervous system develops from dorsal nerve cord
 - Embryos have pharynx with slits
 - Embryos have tail that extends past anus

Chordate Groups

- Urochordata
 - Salps and tunicates
 - Cephalochordata
 - Lancelets
 - Craniates
 - Fishes, amphibians, reptiles, birds, mammals
- Tunicates (Urochordates)

- Larva is free-swimming
- Adult is sessile and baglike with no coelom
- Both stages are filter feeders
- Pharynx serves in both feeding and respiration

Tunicate Life History

Larva undergoes metamorphosis to adult form

Lancelets (Cephalochordates)

- Fish-shaped filter feeders
- Simple brain
- Segmented muscles
- Chordate characteristics of adult:
 - Notochord lies under dorsal nerve cord

- Pharynx has gill slits
- Tail extends past anus

Lancelet Body Plan

Section 26.2: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 26.2: AMNH—Vertebrate Evolution Timeline
- Section 26.2: Introduction to the Vertebrates
- Section 26.2: Evolution of the Early Vertebrates. Peter Forey et al. *American Scientist*, Nov.–Dec. 1994.
- Section 26.2: Out of the Swamps. Richard Monastersky. *Science News*, May 22, 1999.

Early Craniates

Trends in the Evolution of Vertebrates

- Shift from notochord to vertebral column
- Nerve cord expanded into brain
- Evolution of jaws
- Paired fins evolved, gave rise to limbs
- Gills evolved, gave rise to lungs

Evolution of Jaws

- First fishes lacked jaws
- Jaws are modifications of anterior gill supports

Existing Jawless Fishes

- Cylindrical body
- Cartilaginous skeleton

Section 26.3: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 26.3: NOVA—Ancient Creature of the Deep (the coelacanth & fossil fish)
- Section 26.3: The Latest Pisces of an Evolutionary Puzzle (live coelacanths found). Sid Perkins. *Science News*, May 5, 2001.

Jawed Fishes

- Most diverse and numerous group of vertebrates

- Two classes:
 - Chondrichthyes (cartilaginous fishes)
 - Osteichthyes (bony fishes)
- Cartilaginous Fishes:
Class Chondrichthyes
- Most are marine predators
 - Cartilaginous skeleton
 - Main groups:
 - Skates and rays
 - Sharks
 - Chimaeras (ratfishes)

Bony Fishes:
Class Osteichthyes

- Includes 96 percent of living fish species
- Three subclasses:
 - Ray-finned fishes
 - Lobe-finned fishes
 - Lung fishes

Body Plan of a Bony Fish
Lobe-Finned Fishes

- Coelocanths
 - Lunglike sacs do not function in gas exchange
- Lungfishes
- Have gills and one lung or a pair
 - Must surface to gulp air

Section 26.4: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 26.4: [AmphibiaWeb](#)
- Section 26.4: [Focus on Amphibians](#)

- Section 26.4: Coming Onto the Land. Carl Zimmer. *Discover*, June 1995.
- Section 26.4: Fish Out of Water. Caroline Harding. *National Wildlife*, Oct.–Nov. 1994.

Early Amphibians

- Fishlike skull and tail
- Four limbs with digits
- Short neck

Modern Amphibians

- All require water at some stage in the life cycle; most lay eggs in water
- Lungs are less efficient than those of other vertebrates
- Skin serves as respiratory organ

From Fins to Limbs

- Genetic enhancer controls genes involved in formation of digits on limb bones
- Change in a single master gene can drastically alter morphology

Living Amphibian Groups

- Frogs and toads
- Salamanders
- Caecilians

Section 26.5: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 26.5: Amphibian Declines & Malformations
- Section 26.5: CGEE—Global Amphibian Declines
- Section 26.5: Amphibia Fading. Ashley Mattoon. *World Watch*, May 2000.
- Section 26.5: The Global Decline of Reptiles, Deja Vu Amphibians. J. Whitfield Gibbons et al. *BioScience*, Aug. 2000.

Amphibians on the Decline

- Of about 5,500 known species of amphibians, 200 have plummeting populations - attributed to habitat deterioration
- Amphibians are losing standing water pools (where they deposit their eggs) to development and farming

Amphibians on the Decline

Threats to Amphibians:

- introduction of new species
- long-term climate changes
- increases in ultraviolet radiation
- spread of fungal and parasitic disease
- chemical contamination of aquatic habitats

Section 26.6: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 26.6: Smithsonian NMNH—Dinosaurs
 - Section 26.6: A Daring Gamble in the Gobi Desert Took the Jackpot (discovery that dinosaurs had eggs). Douglas Preston. *Smithsonian*, Dec. 1987.
- Rise of Amniotes
- Arose during Carboniferous
 - Adaptations to life on land
 - Tough, scaly skin
 - Internal fertilization
 - Amniote eggs
 - Water-conserving kidneys
- Adaptive Radiation
- Produced numerous lineages
 - Extinct groups include:
 - Therapsids (ancestors of mammals)
 - Marine plesiosaurs & ichthyosaurs
 - Dinosaurs and pterosaurs

Living Reptiles

Not a monophyletic group

Crocodilians

Turtles

Tuataras

Snakes and lizards

Evolutionary History of Amniotes

Section 26.7: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 26.7: What Killed the Dinosaurs? The Great Mystery
- Section 26.7: A Tale of Two Rocks. Valerie Jablow. *Smithsonian*, Apr. 1998.

So Long, Dinosaurs

- Mass extinction between the Cretaceous-Tertiary boundary
- K-T asteroid impact theory
- Global broiling hypothesis

Section 26.8: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 26.8: When Crocodiles Ruled
- Section 26.8: San Diego Natural History Museum—Reptiles!
- Section 26.8: Endangered Sea Turtles
- Section 26.8: He Cries Crocodile Tears (evolution of alligator eyes). Ivan Schwab et al. *British Journal of Ophthalmology*. Jan. 2002.
 - Crocodile Body Plan
 - Turtles
- Armorlike shell
- Horny plates instead of teeth
- Lay eggs on land

Lizards and Snakes

- Largest order (95 percent of living reptiles)
- Most lizards are insectivores with small peglike teeth
- All snakes are carnivores with highly movable jaws

Tuataras

- Only two living species
- Live on islands off coast of New Zealand
- Look like lizards, but resemble amphibians in some aspects of their brain and in their way of walking

Section 26.9: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 26.9: Bird Skulls & Skeletons
- Section 26.9: Vertebrate Flight Exhibit

- Section 26.9: The Journey North—Migration
- Section 26.9: Wings over Spain (bird fossils). Luis Chiappe. *Natural History*. Sept. 1998.
- Section 26.9: Fashioned for Flight. Dwight Smith. *World and I*. Mar. 2001.
- Section 26.9: How Did Vertebrates Take to the Air? Roger Lewin. *Science*. July 1, 1983.

Birds

- Diverged from small theropod dinosaurs during the Mesozoic
- Feathers are a unique trait
 - Derived from reptilian scales
 - Serve in insulation and flight

Confuciusornis sanctus

Amniote Egg

Adapted for Flight

- Four-chambered heart
- Highly efficient respiratory system
- Lightweight bones with air spaces
- Powerful muscles attach to the keel

Section 26.10: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 26.10: Paleocene Mammals of the World
- Section 26.10: The Fossil Mammal Hall
- Section 26.10: New Views of the Origins of Mammals. Dennis Normile. *Science*. Aug. 7, 1998.

Mammals: Phylum Mammalia

- Hair
- Mammary glands
- Distinctive teeth
- Highly developed brain
- Extended care for the young

Mammal Origins & Radiation

- During Triassic, synapsids gave rise to therapsids (ancestors of mammals)
- By Jurassic, mouselike therians had evolved

- Therians coexisted with dinosaurs through Cretaceous
- Radiated after dinosaur extinction

Three Mammalian Lineages

- Monotremes
 - Egg-laying mammals
- Marsupials
 - Pouched mammals
- Eutherians
 - Placental mammals

Role of Geologic Change

- Monotremes and marsupials evolved while Pangea was intact
- Placental mammals evolved after what would become Australia had split off
- No placental mammals in Australia
- Elsewhere, placental mammals replaced most marsupials

Section 26.11: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 26.11: [UCMP Hall of Mammals](#)
- Section 26.11: [Mammal's Planet](#)
- Section 26.11: [Articles about Mammals](#)
- Section 26.11: [Playing Possum Is Serious Business for Our Only Marsupial \(opossum\). John Seidensticker et al. *Smithsonian*, Nov. 1989.](#)

Living Monotremes

- Three species
 - Duck-billed platypus
 - Two kinds of spiny anteater
- All lay eggs

Living Marsupials

- Most of the 260 species are native to Australia and nearby islands
- Only the opossums are found in North America

- Young are born in an undeveloped state and complete development in a permanent pouch on mother
 - Living Placental Mammals
- Most diverse mammalian group
- Young develop in mother's uterus
- Placenta composed of maternal and fetal tissues; nourishes fetus, delivers oxygen, and removes wastes
- Placental mammals develop more quickly than marsupials

Section 26.12: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 26.12: [The eSkeletons Project](#)
- Section 26.12: [The Long Foreground—Human Prehistory](#)
- Section 26.12: [The Evolution of Human Childhood. Barry Bogin. *BioScience*. Jan. 1990.](#)

Earliest Primates

- Primates evolved more than 60 million years ago during the Paleocene
- First primates resembled tree shrews
 - Long snouts
 - Poor daytime vision

From Primates to Humans

“Uniquely” human traits evolved through modification of traits that evolved earlier,

in ancestral forms

Hominoids

- Apes, humans, and extinct species of their lineages
- In biochemistry and body form, humans are closer to apes than to monkeys
- Hominids
 - Subgroup that includes humans and extinct humanlike species

Trends in Lineage

Leading to Humans

- Less reliance on smell, more on vision
- Skeletal changes to allow bipedalism
- Modifications of hand allow fine movements

- Bow-shaped jaw and smaller teeth
- Longer lifespan and period of dependency
 - Adaptations to an Arboreal Lifestyle
- Better daytime vision
- Shorter snout
- Larger brain
- Forward-directed eyes
- Capacity for grasping motions

Section 26.13: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 26.13: [Smithsonian Human Origins Program](#)
- Section 26.13: [Early Hominid Evolution](#)
- Section 26.13: [Becoming Human](#)
- Section 26.13: [In Search of the First Hominids. Ann Gibbons. *Science*, Feb. 15, 2002.](#)

The First Hominoids

- Appeared during Miocene
- Arose in Central Africa
- Spread through Africa, Asia, Europe
- Climate was changing, becoming cooler and drier

The First Hominids

- *Sahelanthropus tchadensis* arose 6-7 million years ago
- Bipedal australopiths evolved during Miocene into Pliocene

- Exact relationships are not known

Section 26.14: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 26.14: Handprint—Ancestral Lines
- Section 26.14: Pittdown Unmasked (hoax human fossil). Phillip Tobias. *The Sciences*. Jan.–Feb. 1994.
- Section 26.14: The Old Man of Olduvai Gorge (Louis Leakey). Roger Lewin. *Smithsonian*. Oct. 2002.

Homo Habilis

1.9-1.6 million years ago

- May have been the first member of genus
- Lived in woodlands of eastern and southern Africa

Section 26.15: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 26.15: Great Archaeological Sites, & Lascaux Cave Paintings
- Section 26.15: Neandertals—A Cyber Perspective
- Section 26.15: The Prehistoric Imagination (rock art). Denis Vialou. *UNESCO Courier*. Apr. 1998.
- Section 26.15: Ian Tattersall: The Humans We Left Behind. Amy Otchet. *UNESCO Courier*. Dec. 2000.

Homo erectus

2 million-53,000? years ago

- Evolved in Africa
- Migrated into Europe and Asia

- Larger brain than *H. habilis*
- Creative toolmaker
- Built fires and used furs for clothing

Homo sapiens

- Modern man evolved by 100,000 years ago
- Compared to *Homo erectus*:
 - Smaller teeth and jaws
 - Chin
 - Smaller facial bones
 - Larger-volume brain case

Neanderthals

- Early humans that lived in Europe and Near East
- Massively built, with large brains
- Disappeared when *H. sapiens* appeared
- DNA evidence suggests that they did not contribute to modern European populations

Earliest Fossils Are African

- Africa appears to be the cradle of human evolution
- No human fossils older than 2 million years exist anywhere but Africa
- *Homo erectus* left Africa in waves from 2 million to 500,000 years ago

Where Did *H. sapiens* Arise?

- Two hypotheses:
 - Multiregional model
 - African emergence model
- Both attempt to address biochemical and fossil evidence

Multiregional Model

- Argues that *H. erectus* migrated to many locations by about 1 million years ago
- Geographically separated populations gave rise to phenotypically different races of *H. sapiens* in different locations
- Gene flow prevented races from becoming species

African Emergence Model

- Argues that *H. sapiens* arose in sub-Saharan Africa
- *H. sapiens* migrated out of Africa and into regions where *H. erectus* had preceded them
- Only after leaving Africa did phenotypic differences arise

Genetic Distance Data

