

Chapter 34

Subphylum Vertebrata

- Vertebrates
- Chordates with a backbone

Chordate features as well as:

1. Vertebral column
 - Series of cartilaginous or bony elements
2. Cranium
3. Endoskeleton or cartilage or bone
4. Hox genes (lots of them)
5. Neural crest

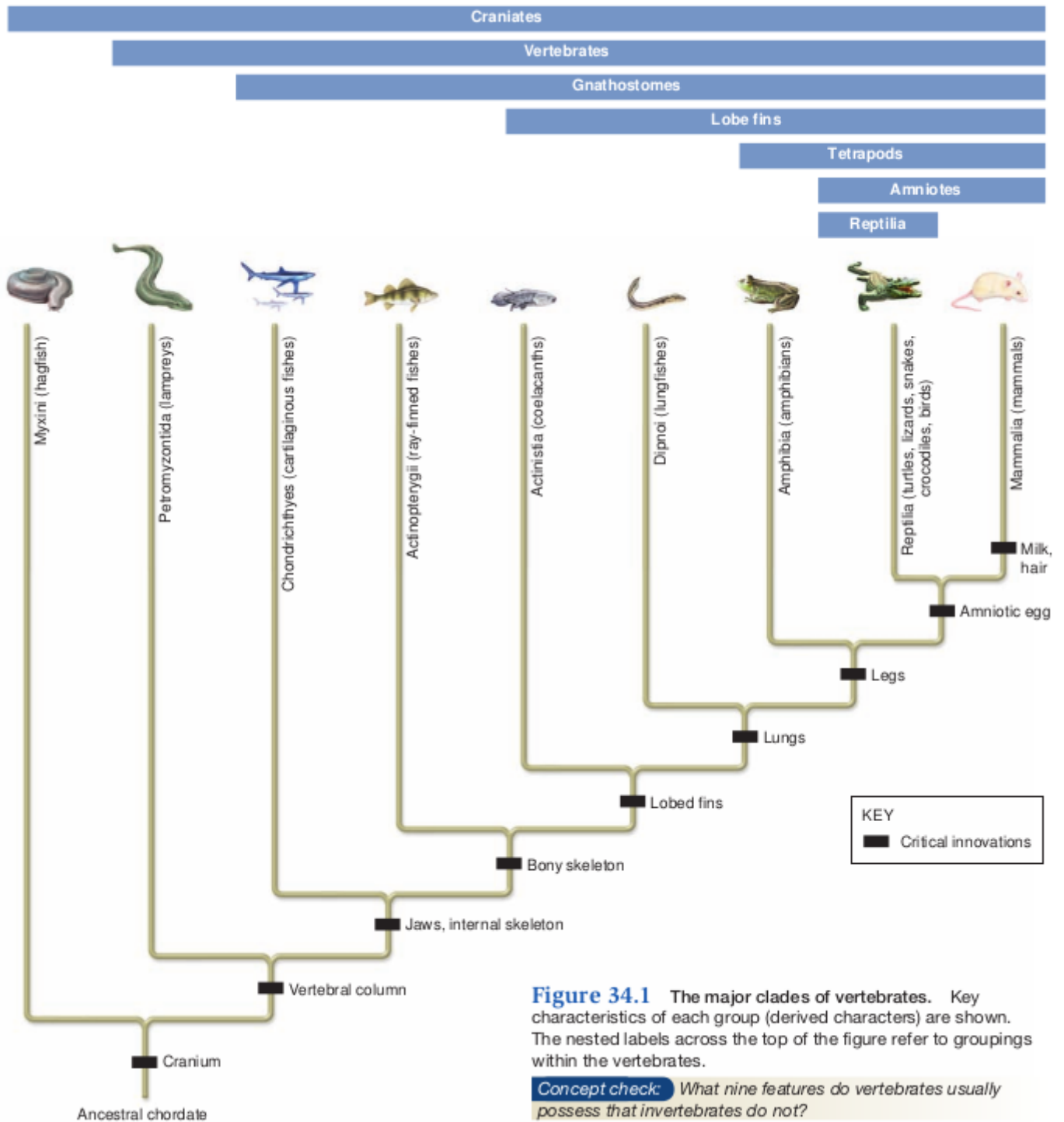













Figure 34.1 The major clades of vertebrates. Key characteristics of each group (derived characters) are shown. The nested labels across the top of the figure refer to groupings within the vertebrates.

Concept check: What nine features do vertebrates usually possess that invertebrates do not?

Table 34.1 The Main Classes and Characteristics of Living Vertebrates

Class		Examples (approx. # of species)	Main characteristics
Petromyzontida		Lampreys (41)	Early-diverging fishes with jawless sucking mouth; no appendages, that is, fins; parasitic on fishes
Chondrichthyes		Sharks, skates, rays (850)	Fishes with cartilaginous skeleton; teeth not fused to jaw; no swim bladder; well-developed fins; internal fertilization; single blood circulation
Actinopterygii		Ray-finned fishes, most bony fish (24,600)	Fishes with ossified skeleton; single gill opening covered by operculum; fins supported by rays, fin muscles within body; swim bladder often present; mucous glands in skin
Actinistia		Lobe-finned fishes, of which coelacanths are the only living members (2)	Fishes with ossified skeleton; bony extensions, together with muscles, project into pectoral and pelvic fins; swim bladder filled with oil
Dipnoi		Lungfishes (6)	Fishes with ossified skeleton; rudimentary lungs allow fishes to come to the surface to gulp air; limblike appendages
Amphibia		Frogs, toads, salamanders (4,000)	Tetrapods; adults able to live on land; fresh water needed for reproduction; development usually involving metamorphosis from tadpoles; adults with lungs and double blood circulation; moist skin; shell-less eggs
Testudines		Turtles (330)	Body encased in hard shell; no teeth; head and neck retractable into shell; eggs laid on land
Lepidosauria		Lizards, snakes (7,800)	Lower jaw not attached to skull; skin covered in scales
Crocodylia		Crocodiles, alligators (23)	Four-chambered heart; large aquatic predators; parental care of young
Aves		Birds (9,600)	Feathers; hollow bones; air sacs; reduced internal organs; endothermic; four-chambered heart
Mammalia		Mammals (5,500)	Mammary glands; hair; specialized teeth; enlarged skull; external ears; endothermic; highly developed brains; diversity of body forms

Cyclostomes

- Jawless Fishes

Class Myxini

- Hagfishes
- lack jaws, eyes, fins vertebrae
- skeleton comprised of notochord and cartilaginous skull
- covered in slime

Class Cephalospidomorphi

- Lampreys
- Has notochord, and cartilaginous vertebral column
- lacks jaws and appendages (fins)
- Oldest fossil records 510 mybp

Class Chondrichthyes

- Cartilaginous fishes
- Sharks, skates, rays
- Cartilaginous skeleton and notochord as adults
- jawed fishes
- paired appendages (fins)
- < 900 species

Class Osteichthyes

- Bony fishes
- Most diverse vertebrate group with < 26,000 species
- Bony skeleton (most do have this)
- Jawed
- paired appendages (fins)

Tertapod: Gnathastomes

- Four limbs with jawed mouth
- Transition to land involved adaptations for locomotion, reproduction, desiccation (drying out) prevention, and gas exchange
- Sturdy lobe-finned fishes became animals with four limbs
- Vertebral column strengthened, hip and shoulder bones braced against backbone
- relatively simple changes in gene expression, especially Hox genes

Class Amphibia

- >4000 species
- Amphibios
 - greek - "living double life"
 - split their life between aquatic and terrestrial stages
- Successfully invaded land but reproduce in water
- Lungs are an adaptation to semi-terrestrial lifestyle
- Three chambered heart
 - Fishes only have a two chambered heart
- External Fertilization
- Larval stages are aquatic
 - Undergo metamorphosis
- Not completely separated from water



(a) Gelatinous mass of amphibian eggs



(b) Tadpole



(c) Tadpole undergoing metamorphosis

Figure 34.13 Amphibian development in the wood frog (*Rana sylvatica*). (a) Amphibian eggs are laid in gelatinous masses in water. (b) The eggs develop into tadpoles, aquatic herbivores with a fishlike tail that breathe through gills. (c) During metamorphosis, the tadpole loses its gills and tail and develops limbs and lungs.

Order Anura

- Frogs and toads
- Nearly 90% of amphibians
- Carnivorous adults
 - Herbivorous tadpoles

Order Apoda

- Caecilians
- Nearly blind tropical burrowers
- Secondarily legless

Order Urodela

- Salamanders
- Often have colorful skin patterns
- Most have four limbs



(a) Tree frog



(b) A caecilian



(c) Mud salamander

Figure 34.14 Amphibians. (a) Most amphibians are frogs and toads of the order Anura, including this red-eyed tree frog (*Agalychnis callidryas*). (b) The order Gymnophiona includes wormlike caecilians such as this species from Colombia, *Caecilia nigricans*. (c) The order Caudata includes species such as this mud salamander (*Pseudotriton montanus*).

Amniotes

- Tetrapods with a desiccation resistant egg
- Critical innovation
 - Development of a shelled egg
- Amniotic egg
 - Broke the tie to water
 - Three internal membranes
- Shell is permeable to Oxygen and CO₂
 - Birds
 - Hard and Calcareous
 - Reptiles
 - Soft and Leathery
 - Most Mammals
 - Embryo embeds in uterine wall
 - Only three species lay eggs
 - These eggs are soft and leathery

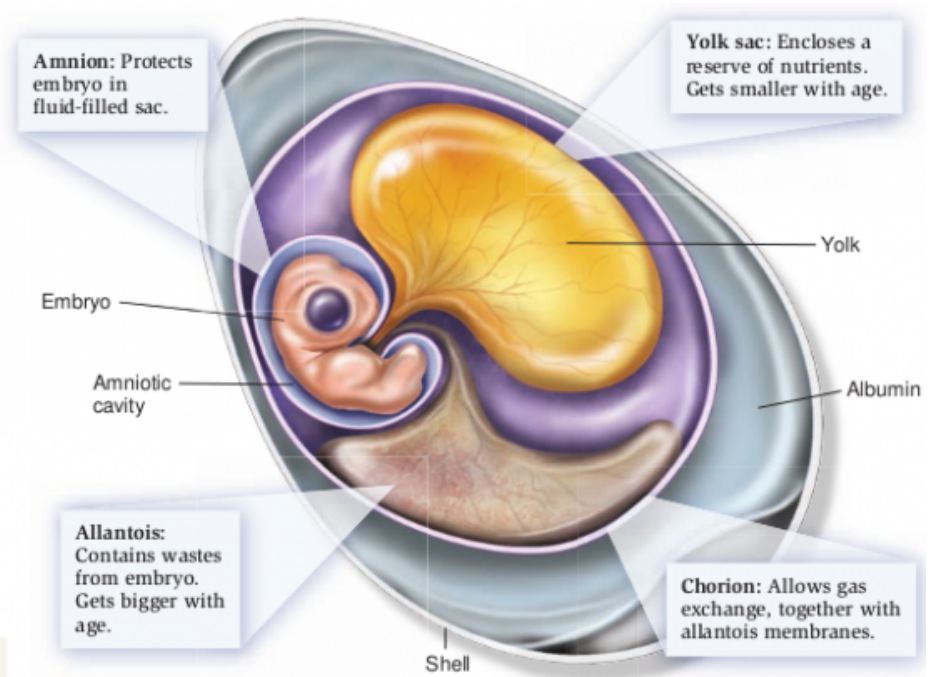


Figure 34.15 The amniotic egg.

Concept check: What are some of the other critical innovations of amniotes?

Other Key Innovations of the Amniotes

- Desiccation resistant skin
 - contains keratin
- Thoracic breathing
 - Negative pressure sucks air in
- Water conserving Kidneys
 - Concentrate waste prior to elimination
- Internal fertilization

Class Reptilia

- >8000 living species
- turtles, crocodylians, lizards, snakes
- Can live away from water
- thicker skin and scales
- larger brain
- larger limbs with muscles
- enhanced kidneys
- Amniotic egg
 - "indoor pond"

Vertebrate Reproductive Modes

1. Oviparous
 - Egg laying outside of the body

2. Ovoviviparous
 - live bearing with retention of eggs
 - No maternal connection
3. Viviparous
 - live bearing with egg retained
 - Maternal connection

Class Aves

- Birds
- Evolved from small dinosaurs
- Fossils 150mybp
- Adaptions for flight
 - Feathers
 - Modified front limbs
 - Lightweight skeleton
 - Organ reduction
 - Lungs and air sacs
 - more gas exchange
- Oviparous
 - all leg layers
- Bill beak
 - Encloses mouth and nasal cavity
 - Adapted for environment



(a) Cracking beak



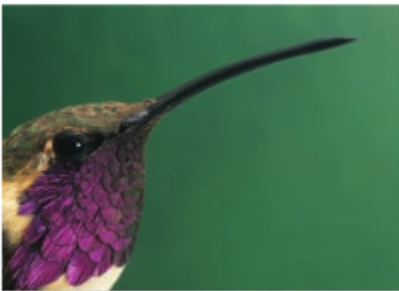
(b) Scooping beak



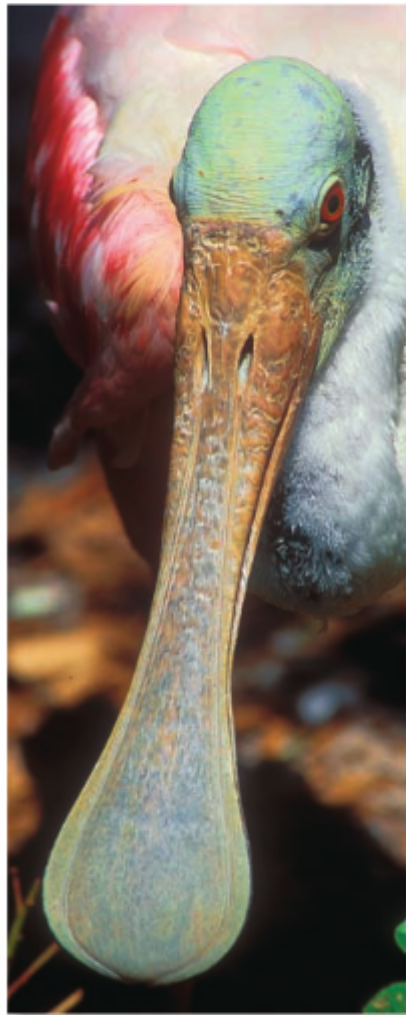
(c) Tearing beak



(d) Probing beak



(e) Nectar-feeding beak



(f) Sieving beak

Figure 34.22 A variety of bird beaks. Birds have evolved a variety of beak shapes used in different types of food gathering. (a) Hyacinthe macaw (*Anodorhynchus hyacinthinus*)—cracking. (b) White pelican (*Pelecanus onocrotalus*)—scooping. (c) Verreaux's eagle (*Aquila verreauxii*)—tearing. (d) American avocet (*Recurvirostra americana*)—probing. (e) Lucifer hummingbird (*Calothorax lucifer*)—nectar feeding. (f) Roseate spoonbill (*Ajaia ajaia*)—sieving.

Endothermic

- "Internal temperature"
- Body temperature is primarily controlled by trapped metabolic heat.
- Birds and mammals

Ectothermic

- "External temperature"
- Body temperature is primarily related to external temperature
- Metabolic heat is generated but difficult to capture/maintain the heat
- Fishes, amphibious, reptiles

Class Mammalia

- Milk producing Amniotes
- Evolved from amniote ancestors (reptiles) earlier than birds
- >6000 species
- Appeared ~ 225mybp
 - Evolved from small mammal-like reptiles
- After dinosaur extinction, mammals flourished
- Range of sizes, body forms, and complexity unmatched



(a) Prototherian (duck-billed platypus)



(c) Eutherian (orangutan)



(b) Metatherian (rock wallaby)

Figure 34.26 Diversity among mammals. (a) Prototherians, such as this duck-billed platypus (*Ornithorhynchus anatinus*), lay eggs, lack a placenta, and possess mammary glands with poorly developed nipples. (b) Metatherians, or marsupials, such as this rock wallaby (*Petrogale assimilis*), feed and carry their developing young, or "joeys," in a ventral pouch. (c) Gestation lasts longer in eutherians, and their young are more developed at birth, as illustrated by this young orangutan (*Pongo pygmaeus*).

- Fish-like mammals
 - Marine mammals
- Bird-like mammals
 - Bats
- Reptile-like mammals

- Three egg layers

Distinguishing Characteristics

- Mammary Glands
 - Secrete milk
- All have hair
 - In varying amounts
- Only vertebrate with multiple dentitions
 - Heterodont
 - Different types of teeth
 - incisors, canines, molars, premolars
 - Thecodont
 - Teeth with long roots embedded in sockets of jawbone
 - Diphyodont
 - Milk teeth that are mostly replaced by "adult" teeth later in life
- Pinna
 - Flap of cartilage and loose connective tissue to channel and funnel sound
 - The "outer ear"
- Three middle ear ossicles (bones)
- Enlarged Skull
 - Brain enlarged in large skull
 - Larger Cerebrum
 - Single lower jawbone (Dentary)
- Anucleate red blood cells



(a) Sensory hairs



(b) Camouflaged coat



(c) Defensive quills

Figure 34.23 Mammalian hair. (a) The sensory hairs (vibrissae) of the walrus (*Odobenus rosmarus*). (b) The camouflaged coat of a bobcat (*Lynx rufus*). (c) The defensive quills of the crested porcupine (*Hystrix africaeaustralis*).

Order Primates

- Primarily tree dwelling species
- grasping hands with opposable thumbs
- Large brain
- Some digits with flat nails

- **Subfamily** *Homininae*
 - **Tribe** *Hominini*
 - **Genus** *Homo*
 - **Species** *Homo sapiens*
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Revision #9

Created 2019-01-28 06:45:47 UTC by Aaron Kimbrell

Updated 2019-04-01 05:09:42 UTC by Aaron Kimbrell