

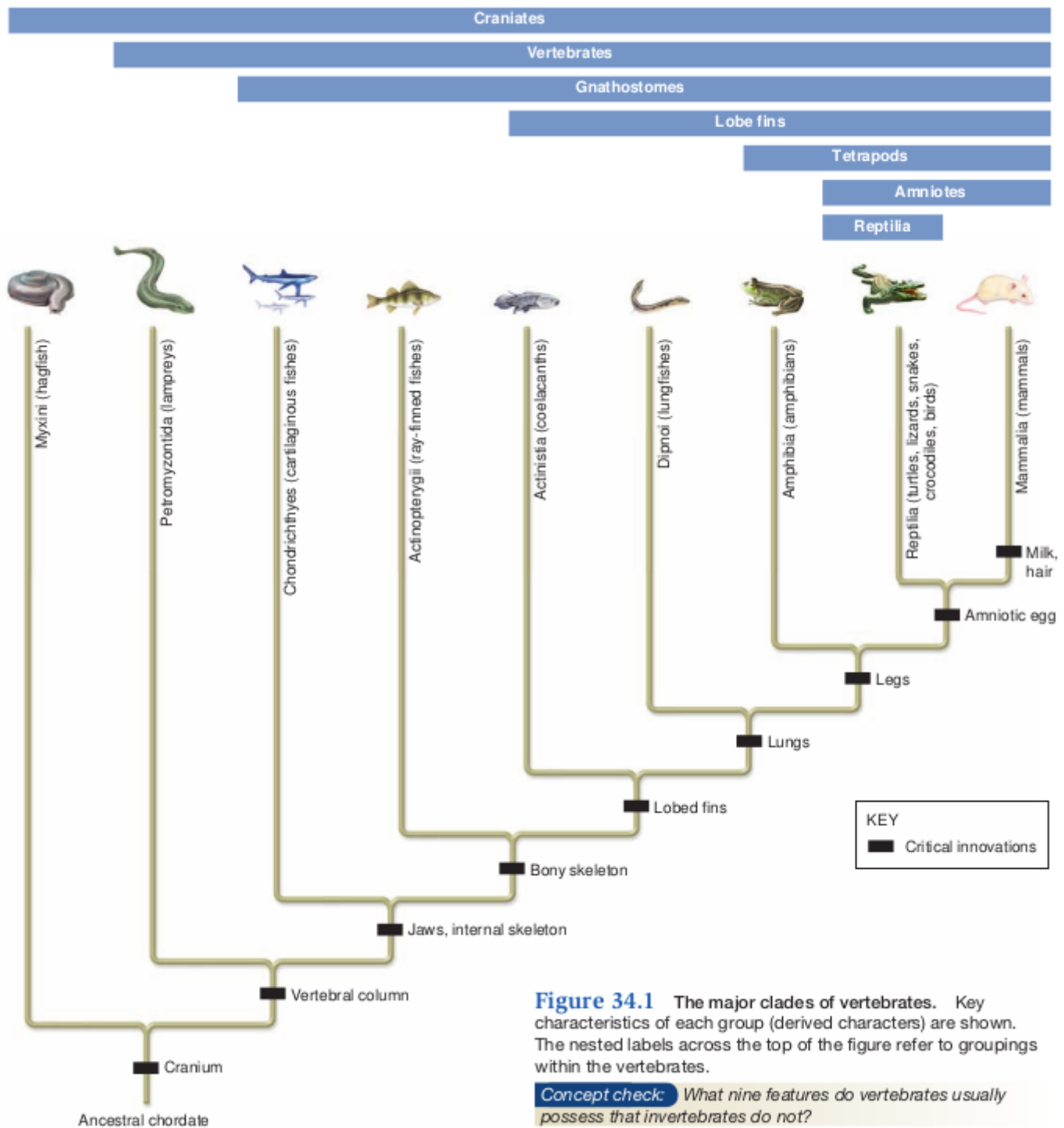
# Chapter 34

## 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

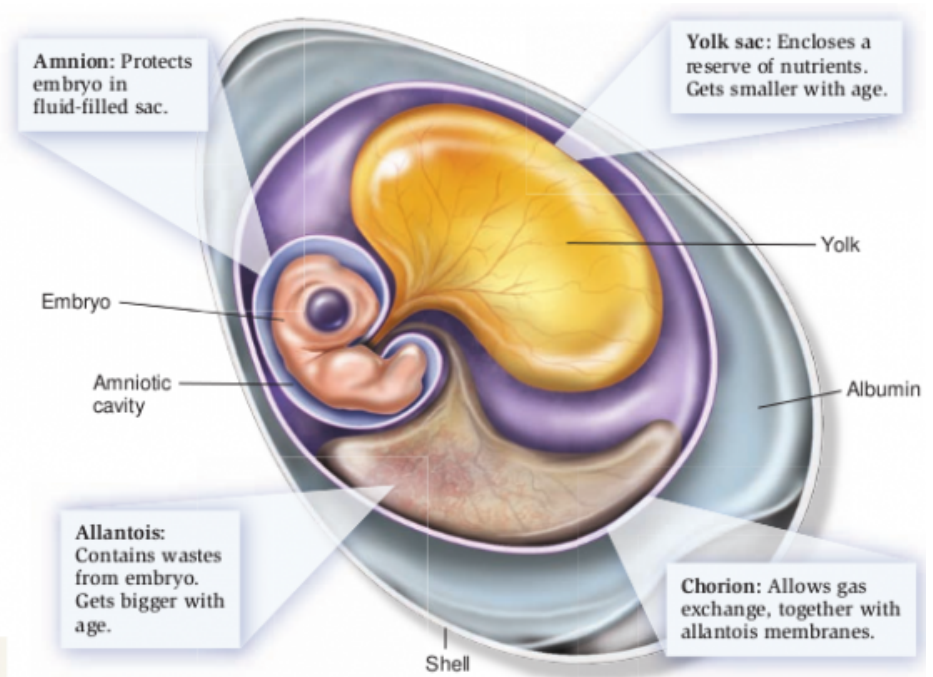


(c) Mud salamander

**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 CO<sub>2</sub>
  - 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, crocodilians, 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



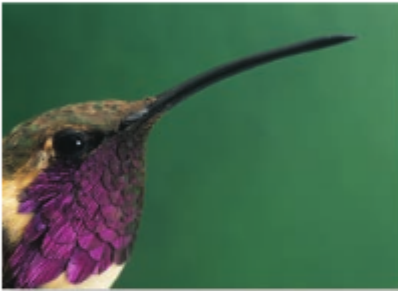
(b) Scooping beak



(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

**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*).



(b) Camouflaged coat

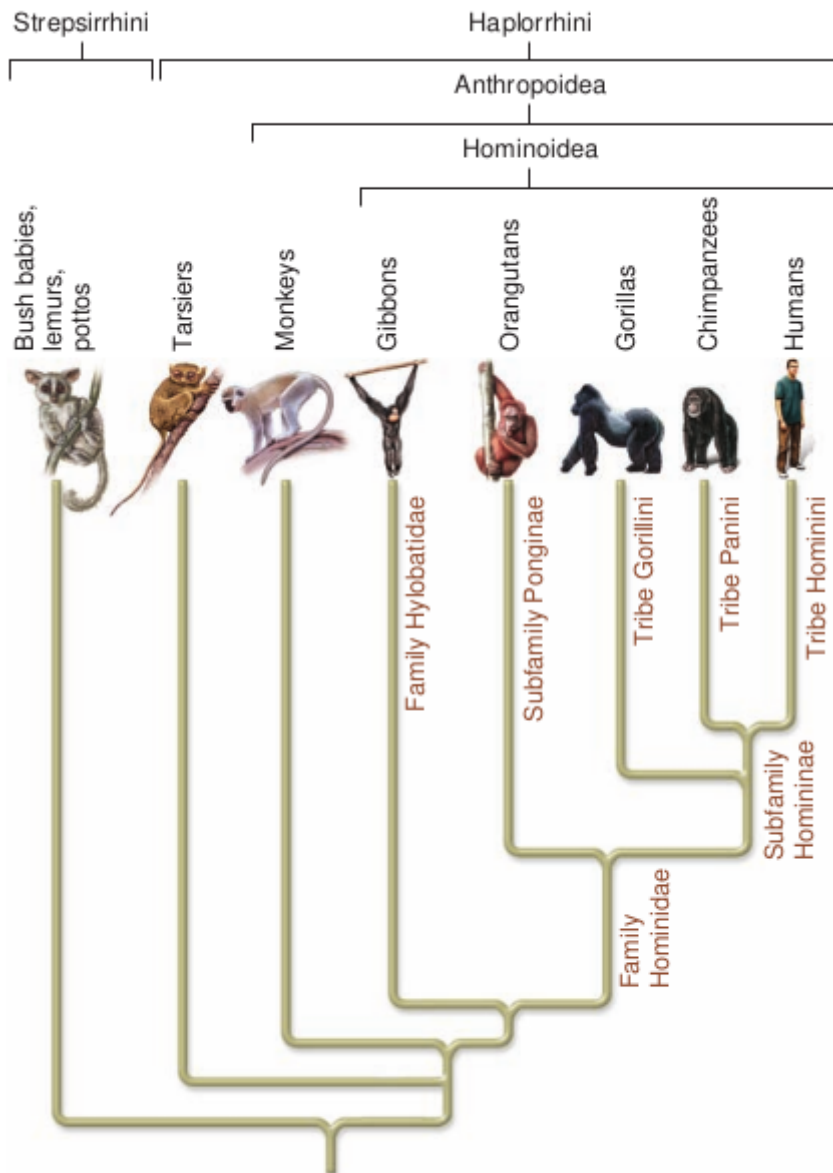


(c) Defensive quills

## Order Primates

- Primarily tree dwelling species
- grasping hands with opposable thumbs

- Large brain
- Some digits with flat nails
  - Not claws
- Binocular vision
- Complex social behavior and well-developed parental care
- Enhanced sense of touch



**Figure 34.27** Evolutionary tree of the primates.

# Taxonomy of Humans

- **Kingdom** *Animalia*
  - **Phylum** *Chordata*
    - **Subphylum** *Vertebrata*
      - **Class** *Mammalia*
        - **Order** *Primates*
          - **Suborder** *Anthropoidea*

- **Superfamily** *Hominoidae*
  - **Family** *Hominidae*
  - **Subfamily** *Homininae*
  - **Tribe** *Hominini*
  - **Genus** *Homo*
  - **Species** *Homo sapiens*
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