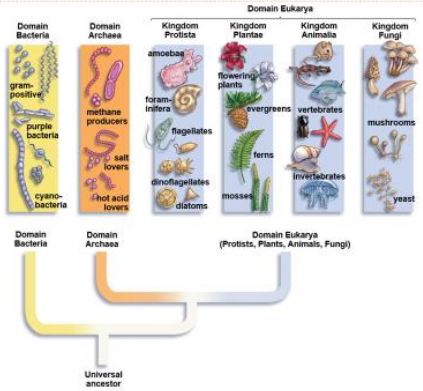
"We exist in a bizarre combination of Stone Age emotions, medieval beliefs, and god-like technology"
-E. O. Wilson

The Diversity of Life

Chapters 21-24

Domains and Kingdoms of Life

- Earth – ____ BYA
- Prokaryotes – 3.8 BYA
- Eukaryotes – 2.0 BYA
- First Animals – 635 MYA

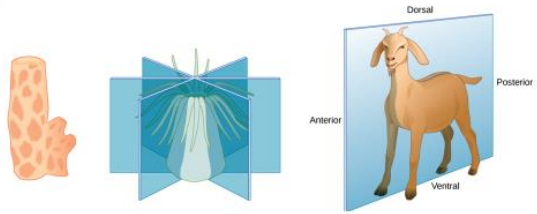


What is an Animal?

- Multicellular, heterotrophic, eukaryotes
- Lack cell walls
  - _____
- Contain muscle and nervous tissue
  - Allow for movement and nerve impulses
- Most reproduce sexually

Animal Symmetry

- **Asymmetrical**: no symmetry
- **Radial symmetry**: body parts distributed evenly around a central point
- _____ **symmetry**: opposite sides of sagittal plane are mirror images of one another



Asymmetry Radial symmetry Bilateral symmetry

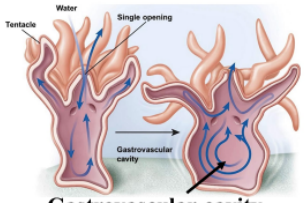
Digestive System

- Animals have diverse nutritional requirements and feeding strategies

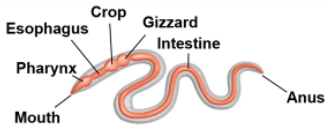
Intracellular digestion: digestion inside cells

_____ **cavity**: central cavity with single opening that functions in both digestion and distribution of nutrients

Alimentary canal: digestive tract with _____ _____ (mouth and anus)



Gastrovascular cavity



Alimentary canal

Skeletal Systems

Hydrostatic skeleton: _____ held under pressure within a closed body compartment
- Cnidarians, Flatworms, Annelids, Roundworms

Exoskeleton: hard covering deposited on the animals surface that provides protection and points for muscle attachment
- Arthropods, Molluscs

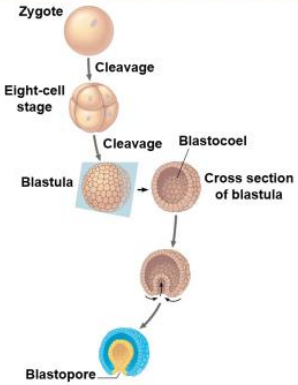
Endoskeleton: hard _____ skeleton buried within soft tissue
- Sponges, Echinodermata, Chordata

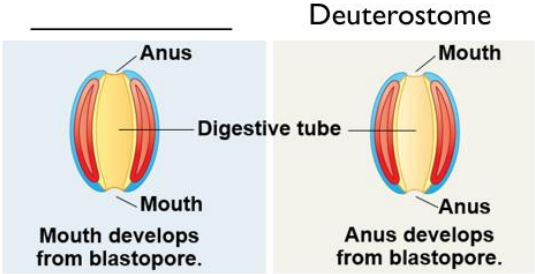
Segmentation

- Series of repeating parts or body segments
  - Efficient movement
  - _____ of parts

Evolved independently in three phyla
- Annelida
- Arthropoda
- Chordata

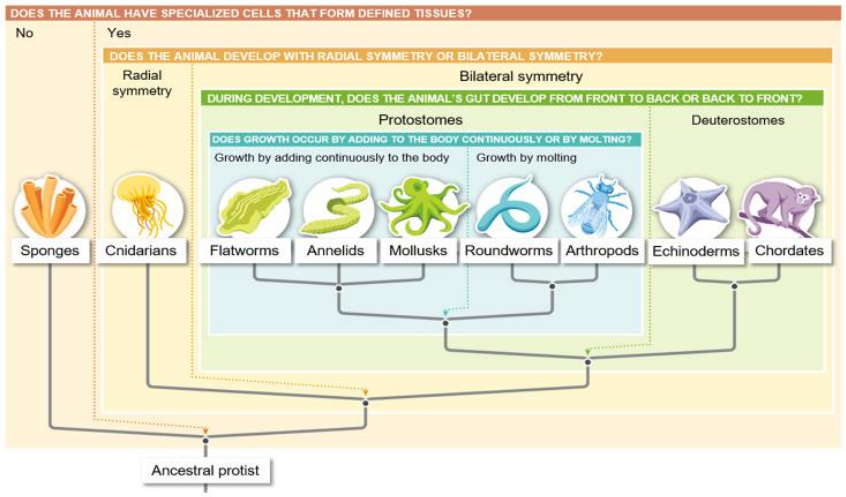
Animal Development





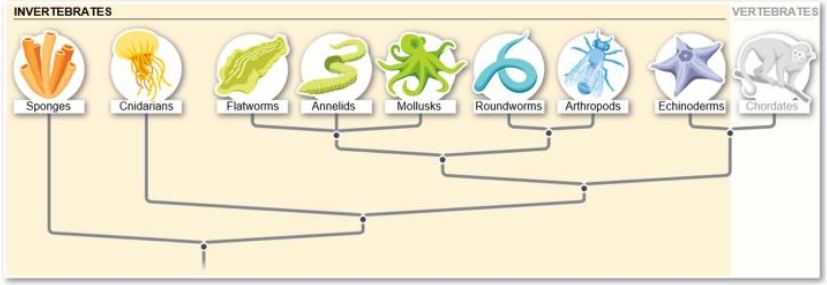
Mouth develops first

Anus develops first



Invertebrates

- **Invertebrates**: animals without a backbone
  - ____% of all animals



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Porifera

Sponges

CHARACTERISTICS

- No tissues or organs
- Intercellular digestion
- _____
- Free-swimming larvae
- Sessile as adults

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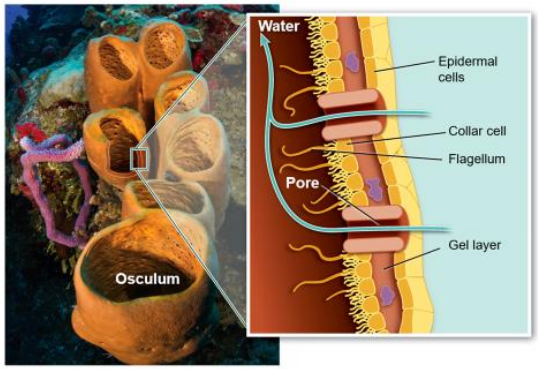
Sponges

- _____: specialized cells with flagella that create water current up through osculum
- **Osculum**: opening at the top of the sponge



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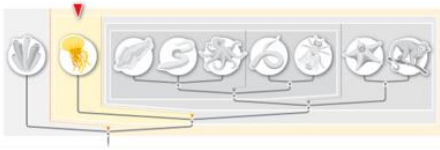
Cnidarians

Sea jellies, Corals and Sea anemones



CHARACTERISTICS

- Protostome development
- _____ symmetry
- Gastrovascular cavity
- **Cnidocytes**: stinging cells
- Two life stages
  - Medusa
  - Polyp

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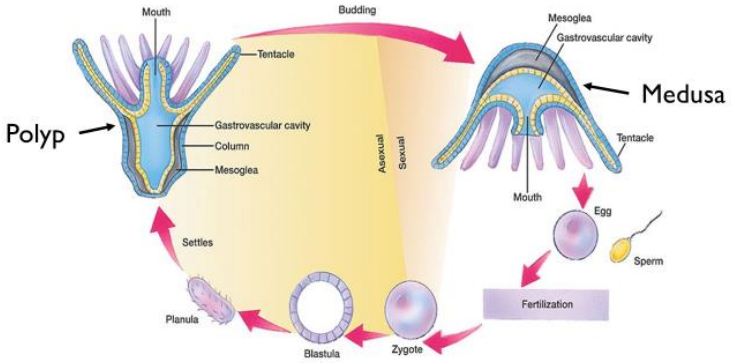
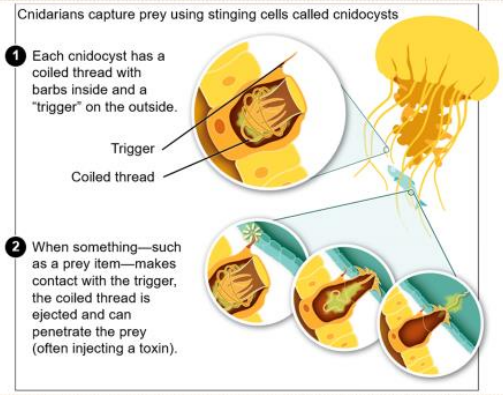
Cnidarians



Cnidarians



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Platyhelminthes

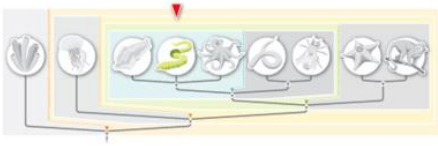
Flatworms, including tape worms and flukes

CHARACTERISTICS

- Protostome development
- Bilateral symmetry
- _____
- Hydrostatic skeleton
- Well-defined head and tail regions
- Hermaphroditic
  - Can engage in both sexual and asexual reproduction

Annelida

Earthworms, leaches and polycheate worms



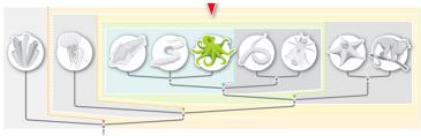
CHARACTERISTICS

- Protostome development
- Hydrostatic skeleton
- Bilateral symmetry
- Segmented bodies
- _____



Molluscs

Includes clams, snails, and octopus



CHARACTERISTICS

- Protostome development
- Bilateral symmetry
- Exoskeleton (shell), Hydrostatic in some
- Alimentary canal
- _____: grading mouth parts
- **Muscular foot**
- **Mantle**
  - Forms shell



Nematoda

Round Worms

CHARACTERISTICS

- Protostome development
- Exoskeleton
  - Molt exoskeleton to grow
- Bilateral symmetry
- Alimentary canal
- Many are _____


Arthropods

Includes barnacles, spiders, insects, millipedes and crustaceans

CHARACTERISTICS

- Protostome development
- Bilateral symmetry
- Alimentary canal
- _____
  - Molt exoskeleton to grow
- _____ appendages
- Segmented bodies
  - Head, thorax, abdomen





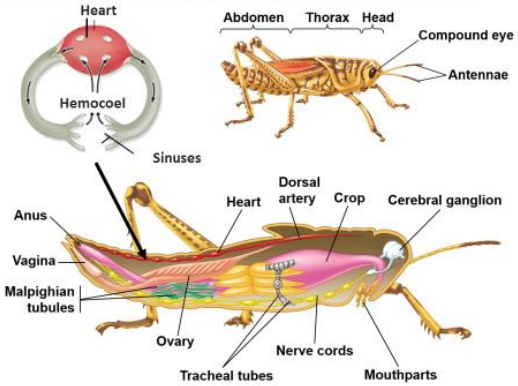
Phylum: Arthropoda, Subphylum: Hexapoda

Class: Insecta

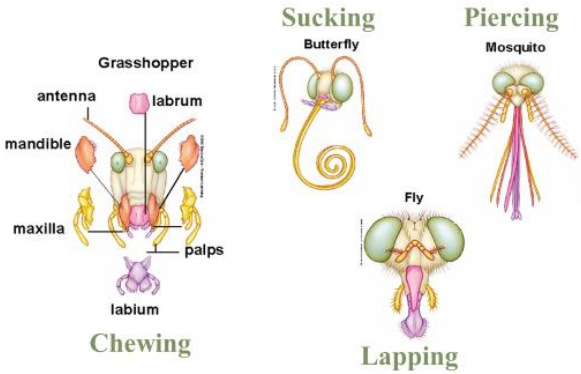
- Most diverse group of arthropods
- Diverged approx. 415 mya
- Mostly terrestrial and freshwater
- _____ of legs on thorax
- _____
  - Head, thorax, abdomen
- Compound eye
- _____ of antennae
- One or two pairs of wings
  - Thorax
  - Extensions of the cuticle

General Anatomy of Arthropods

- Open circulatory system
  - _____: circulatory fluid
- Highly developed sense organs
  - _____ eye
  - Antennae
    - Touch and smell
  - Olfactory receptors
- Specialized mouthparts for various feeding behaviors

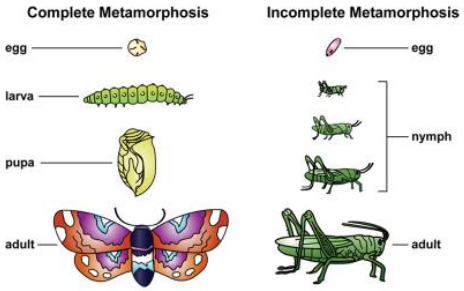


Insect Mouthparts



Metamorphosis

- _____ metamorphosis: four distinct life stages
  - Egg, larvae, pupa, adult
  - Beetles, bees, butterflies, mosquitos
- Incomplete metamorphosis: three distinct life stages
  - Egg, nymph, adult
    - _____ = smaller version of adult
  - Grasshoppers, true bugs, termites



Class: Insecta, Order: Coleoptera

- Beetles
  - Approx. 350,000 species
  - Largest order of insects
- Two pairs of wings
  - One pair of _____ wings
    - Elytra
  - One pair of _____ wings
- _____ mouth parts
- One pair of antennae
  - Used for smell
- Complete metamorphosis

Class: Insecta, Order: Diptera

- Flies and mosquitos
  - Approx. 150,000 species
- Scavengers, predators, parasites
- One pair of membranous wings
- _____ mouth parts
- _____ metamorphosis
  - Maggots used by forensic entomologists

Class: Insecta, Order: Lepidoptera

- Butterflies and Moths
  - Approx 120,000 species
- Two pairs of wings with _____
- Long proboscis
- Complete metamorphosis
  - Caterpillars – chewing mouthparts
  - Butterflies – proboscis, sucking mouthparts

Class: Insecta, Order: Hemiptera

- True bugs
  - Approx 85,000 species
- Two pairs of wings
  - One half wing
    - Thick in front, membranous in back
  - One membranous wing
- Piercing or sucking mouthparts
  - Most feed on plants
- _____ metamorphosis

Class: Insecta, Order: Homoptera

- Cidadas, Aphids
- _____
- Wings held roof-like over body
  - Some wingless as adults
- Piercing – sucking mouth parts
- _____ metamorphosis

Class: Insecta, Order: Hymenoptera

- Ants, Bees, Wasps
- _____
- Two pairs of membranous wings
- _____ and thin waist
- Chewing or sucking mouthparts
- Complete metamorphosis

Class: Insecta, Order: Odonata

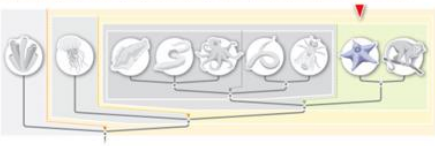
- Dragonflies and damselflies
- Long, narrow membranous wings
  - Transparent
- Long, slender body
- Large head with highly developed _____
- _____
- Chewing mouthparts
- Incomplete metamorphosis
- Aquatic or semi-aquatic as juveniles

Class: Insecta, Order: Orthoptera

- Grasshoppers and crickets
- Large hind legs for _____
- Two pairs of wings
  - One leathery
  - One membranous
- _____ mouthparts
- Incomplete metamorphosis
- Produce sound by rubbing wings or legs together

Echinoderms

Sea stars, sea urchins, sand dollars, and sea cucumbers

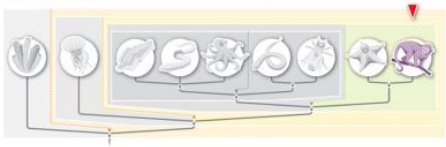


CHARACTERISTICS

- _____ development
  - Closest relative of chordates
- Radial symmetry evolved from bilateral symmetry
- Alimentary canal
- Endoskeleton
- _____ feet
  - Locomotion and sensory system

Chordates

Includes fish, reptile, birds, and mammals



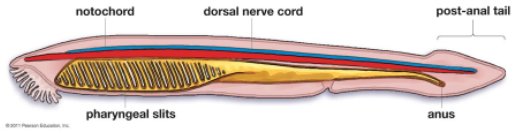
CHARACTERISTICS

- Deuterostome development
- Bilateral symmetry
- Alimentary canal
- Endoskeleton
- Dorsal hollow nerve cord
- _____
- Pharyngeal gill slits
- Post anal tail

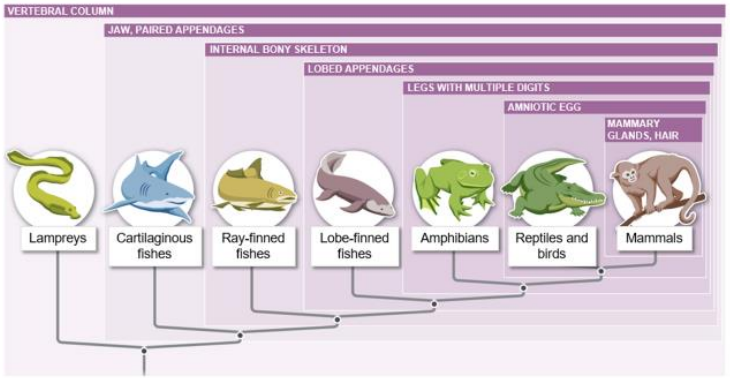
Chordates

Includes fish, amphibians, reptiles, birds, and mammals

- **Notochord**: develops into vertebrate column in vertebrate
- **Dorsal nerve cord**: develops into _____ and spinal cord in vertebrates
- **Pharyngeal slits**: gills in fish, present in embryos of terrestrial vertebrates but disappears during development
- **Post-anal tail**: present in embryo of humans, becomes tail bone



Vertebrate Phylogeny

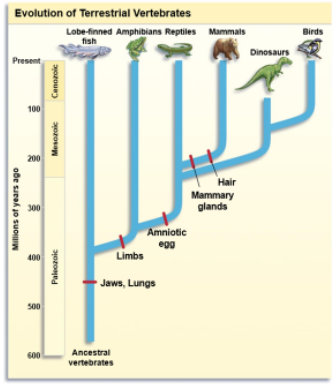


Fishes

- More fish species than all other vertebrate groups combined
- _____ fish
  - Hagfish
- Cartilaginous fish
  - Sharks, skates and rays
- Bony fishes
  - Ray finned fish
    - Teleosts
  - Lobe finned fish
    - Lungfish

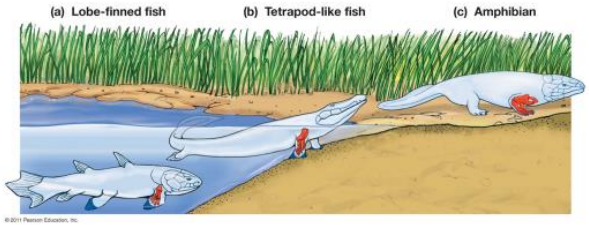
Adaptations to Terrestrial Environments

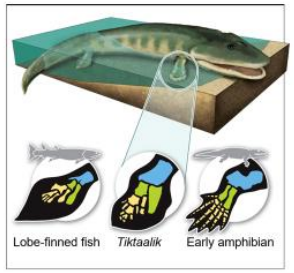
- **Jaws**: Allowed organism to grasp food
  - Diversification of _____
- **Lungs**: Allowed organisms to breath air outside of water
- **Limbs**: Allowed organisms to move around and search for food on land
- _____ **egg**: Allowed for organisms to reproduce away from water



Vertebrates Move onto Land

Early Tetrapods → Amphibians → Reptiles → Dinosaurs → Birds
↘ Mammals





Amphibians

Frogs and Salamanders

- Approximately 6,150 species
- Most go through metamorphosis ("two lives")
  - Aquatic, gill breathing larvae
  - Terrestrial, lung breathing adults
- Thin, highly vascularized skin
- _____ heart
- Ectothermic

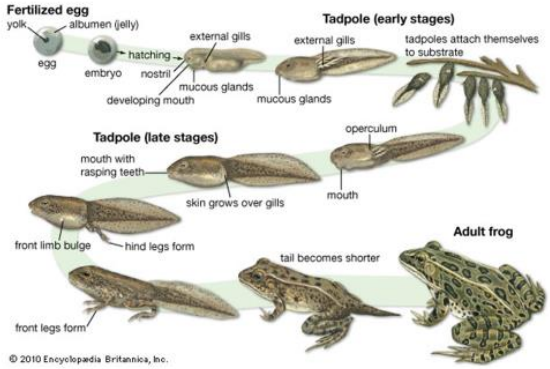
Amphibian Metamorphosis

Egg development:

- 6-21 days

Metamorphosis:

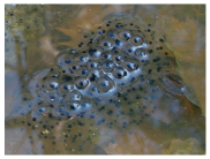
- **0-7 days:** tadpole feeds on yolk then attaches to substrate, breathes through external gills
- **7–28 days**: tadpole swims freely feeding on aquatic vegetation, breathes through internal gills
- **4-6 weeks**: lungs develop, skin grows over operculum
- **6-9 weeks**: legs develop from buds
- **10-12 weeks**: froglet with small tail
- **12-16 weeks**: adult frog



Amphibians as Ecological Indicators

Indicator species: a species whose presence, absence of abundance can be used to assess the biological _____ of a particular ecosystem

- 1/3 of amphibian species are at risk of extinction



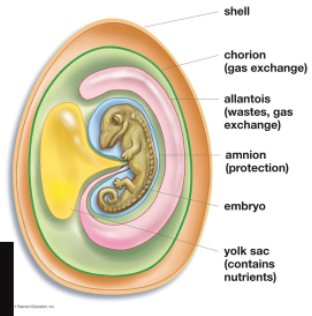
Characteristics that make amphibians good indicators

- Aquatic and terrestrial habitats
  - Metamorphosis
  - Breathe with gills and lungs
- Thin skin
  - Cutaneous respiration
  - Susceptible to environmental contaminants (chemicals)
- Jelly-like eggs lack shell
- Integral part of the food chain
  - Herbivorous tadpoles and carnivorous frogs and toads

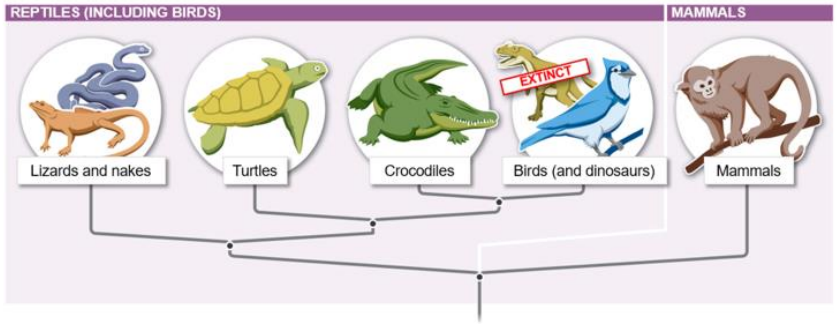
Amniotic Egg

Amniotic egg: Egg with hard outer casing (shell) and inner supportive membranes that provide padding to the developing embryo

- Reptiles and a couple mammals have leathery eggs
- Birds have hard shells
- "Egg" evolved to for placenta in mammals



Phylogeny of Amniotic Vertebrates



Reptiles

Snakes, lizards, tortoises, crocodiles and birds

- Ectothermic
  - Except birds (endothermic)
- Three-chambered hearts
  - Except crocodiles and birds (4 chambers)
- _____ and scutes
- Lungs
  - No embryonic stage with gills

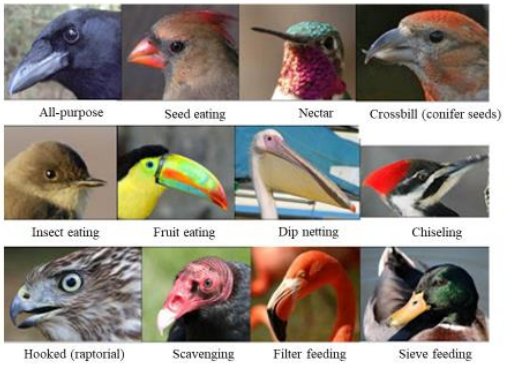
Birds

Ostrich, penguins, kiwi, sparrows, eagles, and albatross

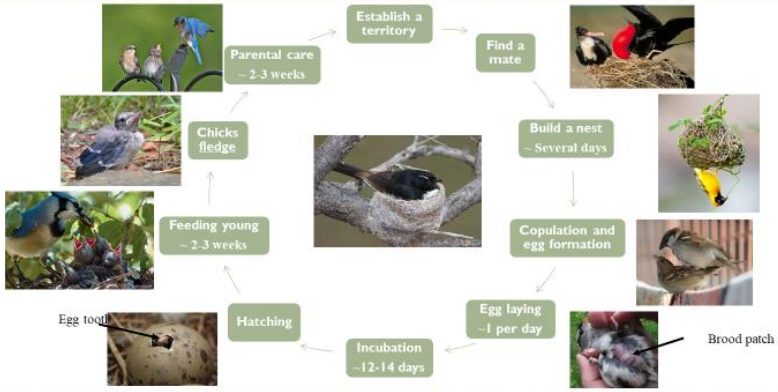
- _____
- Four-chambered heart
- Feathers
- Wings
- Bill with no teeth
- Strong, lightweight skeleton

Bird Bill Types

- Bills size and shape evolved to exploit different resources (diets)
- Upper and lower mandible covered in keratinized layer of epidermis



Nesting Cycle



Bird Development

- **Altricial**: young are immobile, lack down and have closed eyes after hatching
  - Essential parental care
  - Fast growth

- _____: young are mobile, have downy feathers, and open eyes after hatching
  - Minimal parental care (self-feeding)

Types of Nests

Scrapes: small depression in the ground
- Shorebirds, gulls, terns, vultures

Burrow nests: burrows or holes dug into the ground
- Burrowing owls, kingfishers, bank swallows

Cavity nest: nest constructed in a chamber, typically in a tree trunk
- Woodpeckers, bluebirds, parrots, some ducks

Cup nest: cup-shaped nest constructed using grasses, twigs, spider silk, saliva, mud
- Most passerines (song birds), hummingbirds

Platform nest: large nests built on large trees or structures
- Hawks, eagles, osprey

Pendant nest: elongated sac woven from grasses and plant material and suspended from a branch
- Bushtits, orioles, weavers

Mammals

Monkeys, giraffes, rats, tigers, whales, elk, and humans

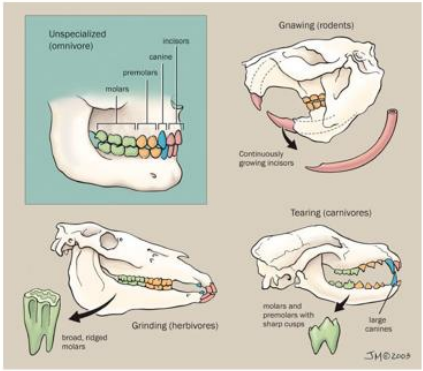
- Endothermic
- Four-chambered heart
- Hair at some point of their development
- Mammary glands produce milk
- Three inner ear bones
- Differentiated teeth

Mammal Dentition

- Differentiation of teeth led to success in mammals
- Size and arrangement of teeth associated with diet

Four distinct tooth types

- Incisors: cutting
- _____: tearing
- Premolars: grinding
- Molars: crushing, grinding



Timing of Activity

Diurnal: animals active during daylight
- Many mammal species
- Squirrels, ungulates, primates

_____: animals active during twilight hours (dawn and dusk)
- Predator avoidance
- Skunks, rabbits, mice, deer, bear, bobcats, coyotes

Nocturnal: animals active at night
- Reduce competition, escape heat, avoid predators
- Highly developed senses
  - Large eyes (more rods, tapetum lucidum)
  - Large ears (greater hearing range)
- Bush babies, bats, wolves, cats, raccoons, opossums, cougar

Mammals

- _____: egg laying mammals
  - Echidna and platypus

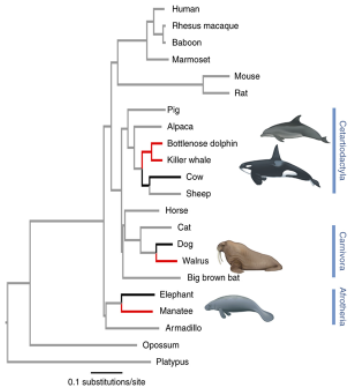
- **Marsupials**: most of their young's development occurs within a pouch
  - Kangaroo and opossum

- **Placentals**: young develop within a placenta inside of mother

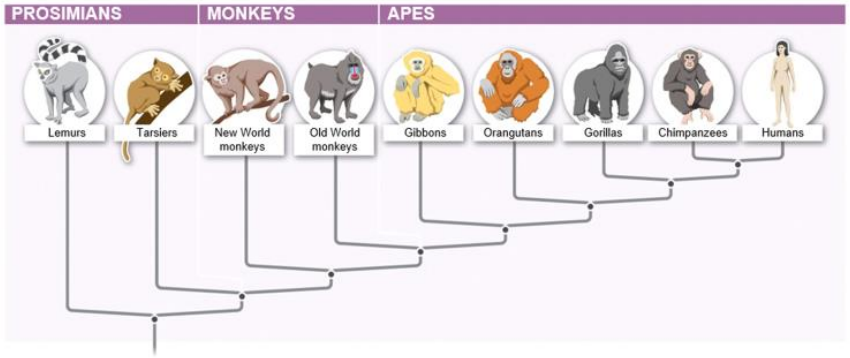
Return to Water

Three mammal clades returned to water
- Cetartiodactyla
- Carnivora
- Afrotheria

Characteristics that support terrestrial origin
- Lungs and a need to breathe air from the surface
- Limb bones homologous with land mammals
- Vertical movement of spine
- Vestigial pelvic bones in cetaceans



Primates



Primates

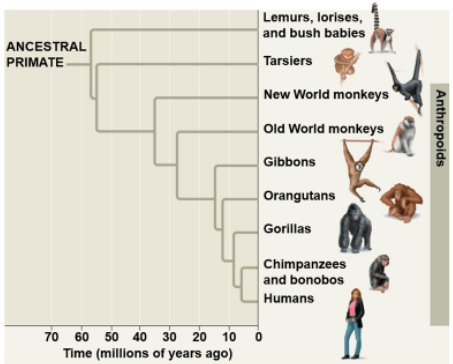
Lemurs, lorises, monkeys, apes, humans

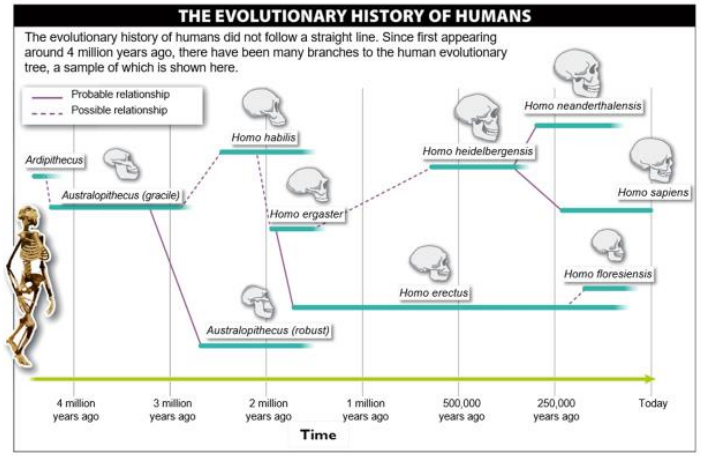
- _____ instead of claws
- Clavicle
- Two lower limb bones
- _____ thumb
- Reduced snout
- Reduced olfactory region of brain and increased cerebrum
- _____
  - Depth perception

Humans and Apes

Homo sapiens characteristics

- Bipedal
- _____
  - Language
  - Symbolic thought
  - Artistic expression
  - Use complex tools
- Reduced jaw bones and jaw muscles
- Differ from chimpanzees in 19 regulatory genes





Check Your Understanding

True or False: In Protostomes, the mouth develops before the anus

True or False: All animals have a complete digestive tract with a separate mouth and anus

True or False: All mammals give live birth

Check Your Understanding

Which of the following have radial symmetry?

a. Porifera
b. Molluscs
c. Echinodermata
d. Cnidarians
e. More than one of the above has radial symmetry

Check Your Understanding

Which of the following are **not** one of the adaptations that allowed vertebrates to colonize terrestrial habitats?

a. Amniotic egg
b. Lungs
c. Placenta
d. Limbs
e. Jaws

Check Your Understanding

Which of the following does not have an alimentary canal?

a. Platyhelminthes
b. Nematodes
c. Molluscs
d. Chordates
e. All of the above have an alimentary canal

Check Your Understanding

Which of the following animal phyla undergo protostome development, have two life stages, exhibit radial symmetry, and have specialized stinging cells?

a. Annelids
b. Porifera
c. Chordata
d. Cnidaria
e. Molluscs