Phylum Chordata

- Possess a dorsal, tubular nerve cord
- Notochord
- Pharyngeal gill slits
- Postanal tail
Other Characteristics of Phylum Chordata

- Bilateral symmetry
- Deuterostome, triploblastic, coelomate
- Segmented muscles
- Ventral heart, with dorsal and ventral blood vessels; closed circulatory system
- A cartilaginous or bony endoskeleton
- Complete digestive tract

Phylum Chordata

- ~45,000 species
  - No tentacles
  - Notochord
  - Postanal tail
- Subphylum Urochordata
  - Tunic
  - Loss of coelom
  - Pharyngeal basket
- Subphyla Cephalochordata & Vertebrata
  - Segmented muscles
  - Neural tube
  - Circulatory system with dorsal and ventral aortae
  - Buccal apparatus (Cephalochordata only)
  - Endoskeleton + cranium (Vertebrata only)

Subphylum Urochordata

- Sea-squirts or tunicates
- Notochord, nerve cord, and postanal tail present only in free-swimming larva
- Adults mostly sessile and enclosed in a tunic that contains cellulose that attach to a variety of solid substrates…mostly rocks.
- Large pharynx
- Monoecious and external fertilization
Subphylum Cephalochordata

- Called lancelets: ~45 species
- Body laterally compressed and fish or tadpole-like
- All four chordate characteristics persist throughout life
- Small; up to 5cm long
- Weak swimmers
- Spend most of their time in a filter feeding position
- Bury themselves in sand
- Dioecious with external fertilization
Sub-phylum Vertebrata

- Notochord, nerve cord, postanal tail, and pharyngeal slits present at least in embryonic stages; vertebrae surround nerve cord and serve as primary axial support
- Quadroblastic - 4th germ layer called neural crest

Living Endoskeleton

- Major departure from invertebrate form
- Grows with body
- Jointed scaffolding for muscles
- Skull and ribcage enclose and protect vulnerable organs/protection
- Cartilage was probably the first endoskeletal material; it is superior to bone for fast growth
- The more primitive vertebrates still have a cartilaginous endoskeleton
- Most vertebrates further protected by non-living structures: scales, hair, feathers

Gnathostomes - hinged jaw
Tetrapods - four legs
Amniotes - produce eggs with amnion (membrane which encloses embryo in fluid-filled sac; provides protection against egg desiccation; adaptation for life on land
- modern reptiles
- birds
- mammals
Traditional Taxonomy

- **Myxini** - jawless, cartilaginous hagfishes
- **Cephalaspidomorphi** - jawless, cartilaginous lampreys
- **Chondrichthyes** - cartilaginous fishes (sharks, rays, skates, ratfishes)
- **Osteichthyes** - bony fishes
- **Amphibia** - frogs, salamanders (ectothermic, no scales)
- **Reptilia** - snakes, lizards (ectothermic, scales)
- **Aves** - birds (endothermic, feathers, scales on legs)
- **Mammals** - mammals (endothermic, hair, mammary glands)

Fishes

- Two groups (superclasses)
  - **Agnatha** - jawless fishes (~80sp.)
    - Class Myxini - hagfishes
    - Class Cephalaspidomorphi - lampreys
  - **Gnathostomata** - jawed fishes (~24,000 sp.)
    - Class Chondrichthyes - cartilaginous (~850 sp.)
    - Class Osteichthyes - bony (>23,000 sp.)
Agnathans

- Lack jaws
- Lack paired appendages
- Cartilaginous skeleton
- Most primitive “living” group of vertebrates
- **Class Myxini** - mouth with 4 pairs of tentacles
- **Class Cephalaspidomorphi** - sucking mouth with teeth and rasping tongue; 7 pairs of pharyngeal slits; marine and freshwater

Class Myxini: hagfish with external anatomy

Class Myxini: Hagfishes

- Enter a dead or dying animal through an orifice or by digging through the body wall of its prey by rasping away bits of flesh using its tongue which has hard plate-like spikes
- Nearly blind but have an acute sense of smell and touch
- To obtain leverage while feeding - ties itself into a knot
Class Cephalaspidomorphi: lamprey

Predators/ectoparasites of other fish
Migrate to a freshwater stream to bury eggs in gravel
Larval lamprey is a filter feeder
Sea lampreys are found in the American Great Lakes and have been problematic as they kill or harm many economically important fish

External Structure and Life History of a Sea Lamprey

Gnathostomata

- Hinged jaws
- Paired appendages (fins)
- **Class Chondrichthyes** - heterocercal tail (different lobes); cartilaginous skeleton; lack opercula, swim bladder, lungs; sharks, rays, skates
- **Class Osteichthyes** - homocercal tail (approximately equal and lower lobes); bony skeleton, operculum covers single gill opening, possess lungs or swim bladders
Sharks
- Graceful, streamlined bodies
- Ventral mouth with paired nostrils, anterior to mouth
- Lidless lateral eyes
- Tough, leathery skin w/placoid scales (reduce water turbulence)
- Fins: pair of pectoral and pelvic; 1-2 median dorsal fins, 1 median caudal fin

Sharks
- Track prey using an orderly sequence of sensitive senses
- Long distances: olfactory (nostrils) 1 part per 10 billion; vibrations (lateral line)
- **Lateral Line** - consists of a canal-like system of specialized receptor organs called *neuromasts* (detect vibration/water current)
- Short distances: use receptors in head called *Ampullae of Lorenzini* - sense bioelectric fields

- Rays are closely related to sharks, but they have adopted a very different lifestyle.
  - Most rays are flattened bottom dwellers that crush mollusks and crustaceans in their jaws.
  - The enlarged pectoral fins of rays are used like wings to propel the animal through the water.
  - The tail of many rays is whiplike and may bear venomous barbs for defense against threats.
Class Osteichthyes

- ~23,000 species (58% marine, 42% freshwater)
- 70% of earth’s surface is covered by oceans and only 1% of the earth’s water is freshwater
- Possess gill covering (operculum) - increases the efficiency of drawing water across the gill surfaces, streamlines body
- Possess lung or swim bladder - extension of gut important for flotation
- Two groups: lobe-finned (Sarcopterygii) and ray-finned (Actinopterygii)

• **Lobe-finned** (Sarcopterygian) fishes have muscular pectoral and pelvic fins supported by extensions of the bony skeleton.
  - Many lobe-fins were large, bottom dwellers that may have used their paired, muscular fins to “walk” along the bottom.
  - Thought to be extinct until 1938, the remains of a coelacanth were found off coast of Africa
  - 1998 a new species discovered off coast of Indonesia

Neutral Buoyancy & The Swim Bladder

- All fish are slightly heavier than water
- **Sharks**: must continually move forward at a slightly upward angle to keep from sinking; possess squaline (fatty hydrocarbon) in liver - acts to keep shark a little buoyant
- **Bony Fish**: possess swim bladder (gas filled sac, nitrogen+oxygen), can control the depth at which they swim by adjusting gas volume (via blood) in the swim bladder
  Sound production is also possible in some fishes
Bony fishes breathe by drawing water over four or five pairs of gills located in chambers covered by a protective flap, the **operculum**.

- Water is drawn into the mouth, through the pharynx, and out between the gills by movements of the operculum and muscles surrounding the gill chambers.
The structure and function of fish gills

Countercurrent exchange

Osmoregulation

- Fish blood has a high salt concentration relative to freshwater and a low salt concentration relative to marine water
- Scaled, mucous-covered body is mostly impermeable, but the gills allow water and salt to be gained or lost by diffusion
- **Freshwater fish**: hyperosmotic regulators (tend to gain water and lose salt)
- **Marine fish**: hypoosmotic regulators (tend to lose water and gain salt)
- Anadromous fishes such as salmon
Osmoregulation in a saltwater fish

- Gain of water and salt ions from food and by drinking seawater
- Osmotic water loss through gills and other parts of body surface
- Excretion of salt ions from gills
- Excretion of salt ions and small amounts of water in scanty urine from kidneys

(a) Osmoregulation in a saltwater fish

Osmoregulation in a freshwater fish

- Uptake of water and some ions in food
- Osmotic water gain through gills and other parts of body surface
- Uptake of salt ions by gills
- Excretion of large amounts of water in dilute urine from kidneys

(b) Osmoregulation in a freshwater fish

Nitrogenous wastes

- Proteins
- Nucleic acids
- Amino acids
- Nitrogenous bases
- Amino group
- Most squamate reptiles, including many lizards
- Birds, reptiles, many mammals, birds, and seeds

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Reproduction and Growth

- Dioecious/external fertilization/external development (some sharks give live birth)
- Fish continue to grow throughout life
- Exhibit a wide variety of reproductive strategies (premating behaviors, egg guarding)
- Schools: increase chance of fertilization of eggs

Anglerfish

- Males 1/20 size of female
- Attaches to her with his mouth
- Overtime their bodies fuse
- Soon their circulatory systems become comingled; male derives nutrition from female
- Like a "sperm-bearing lobe" on female body

Fish Facts

- Most fish swim at a speed of ~10 body lengths per second
- 15lbs. Eaten per year U.S (tuna, shrimp, cod - mainly fish sticks) 1/2 of this is consumed in restaurants, (53lbs in Japan)
- Stinging fish: stonefish (kill a human in a couple of hours), Japanese puffer fish (delicacy) remove ovary, liver, stomach, eyes, kidney
- Biting fish: moray eels, barracuda, pirhana, shark (21-24C)
- Most fish live in <200ft of water around shorelines
Fish Facts (conservation)

- Orange Roughy
  Live to over 100 years old
  Do not reproduce until 50 years old
- Sharks
  Shark-fin soup delicacy
  Expensive aphrodisiac