Chapter 30
Fishes and Amphibians
30.1 The Fish Body

- **Key Characteristics of Modern Fishes**
  - **Gills**
    - Obtain oxygen from the oxygen gas dissolved in the water around them
    - Pump a great deal of water through their mouths and over their gills
  - **Single-loop blood circulation**
    - From the heart to the capillaries in the gills
    - From gills, to the rest of the body
      - Then returns to heart
      - Lungfishes = exception (double loop)
  - **Vertebral column (backbone)**
    - Internal skeleton made of either cartilage or bone with a vertebral column surrounding the spinal cord
    - Brain is fully encased within a protective covering called the skull
Gills

- What looks like eating is actually breathing
- Gills = major respiratory organ of fish
- Made of rows of gill filaments
  - Fingerlike projections through which gases enter and leave the blood
  - Hang like curtains between mouth and cheeks
  - At rear of cheek is opening called gill slit
    - When fish “swallows” water is forced over the gills and out through the gill slits
Respiration in Fishes

1. Oxygen-rich water enters the fish’s mouth and passes over the gills as it exits through the gill slits.

2. Each gill is composed of rows of gill filaments, which have thin membranes through which oxygen and carbon dioxide can diffuse.

3. Water passes over the filaments from front to back. Blood circulates through the filaments from back to front. When blood enters the filaments, its oxygen content is low (blue). When it exits the filaments, its oxygen content is high (red).
Circulation of Blood

- Tiny capillaries in fish’s gills create resistance to the flow of blood, so a stronger pump is needed to overcome resistance.
- Early heart of chordates has been replaced with a simple chamber-pump heart:
  - Sinus venosus.
    - This collection chamber acts to reduce the resistance of blood flow into the heart.
  - Atrium.
    - Blood from the sinus venosus fills this large chamber, which has thin, muscular walls.
  - Ventricle.
    - Contractions of the ventricle pump the blood toward the gills.
  - Conus arteriosus.
    - This chamber is a second pump that smoothes the pulsations and adds still more force.
- Fish heart represents one of the great evolutionary changes found in vertebrates – a heart that pumps fully oxygenated blood through a single circulatory loop to the body’s tissues.
Fish Heart Structure

1. Oxygen-poor blood from the body enters the sinus venosus. From there it moves into the atrium.

2. The atrium delivers blood to the ventricle.

3. Contractions of the ventricle pump the blood toward the gills.

4. The conus arteriosus smooths the pulsations of the bloodstream.
Kidneys

- Gills play huge role in maintaining salt and water balance, but so do the kidneys
- Vertebrate’s body is about 2/3 water, most will die if water level falls much lower
- Salt concentration sea water is 3x that of tissues of marine bony fish
  - These fish lose water to environment through osmosis
    - To make up for this, they drink sea water actively and pump excess ions out of their body
- Freshwater fish have opposite problem
  - Body contains more ions than surrounding water
    - Take in water via osmosis
Kidneys, cont.

Kidneys are organs made up of nephrons
- Tubelike organs made up of thousands of nephrons
- Regulate the body’s salt and water balance and remove metabolic wastes from the blood
- Excess water and bodily wastes leave the kidneys in the form of urine
  - Marine fishes excrete small amounts of urine and rid their bodies of ammonia largely through their gills
  - Freshwater fishes excrete large amounts of dilute urine
Reproduction

- **Sexes are separate in most fishes**
  - Generally, fertilization takes place externally
    - Process called *spawning* – male and females gametes are released next to each other
      - Yolk sac within each egg contains nutrients to help the embryo develop
        - Quickly runs out
        - Then fish must seek its own food
      - Most fish become food for another fish, which is why many species of fish release large numbers of eggs
      - Helps to ensure that some will survive to maturity

- **Eggs of sharks, skates, and rays are fertilized inside the female’s body**
  - Use organs called claspers to insert sperm into the female
  - In most species, eggs develop inside of the female and young are born alive
  - A few species of sharks lay eggs.
Skate vs. Ray
30.2 Today’s Fishes

- **Jawless Fishes – Lampreys and Hagfishes**
  - Class agnatha
  - Primitive fish have no jaws
  - Do not have paired fins
  - Have a skeleton made of cartilage (not bone)
    - Strong connective tissue – retain notochord in adulthood
  - Scale-less, eel-like bodies with multiple gill slits
Lamprey & Hagfishes

- **Lampreys**
  - Parasitic
  - Has suction-like structure around mouth – attaches itself to host
    - Gouges out wound using tongue, feeding on blood and bits of flesh

- **Hagfishes**
  - Scavengers of dead and dying animals on ocean bottom
  - called “vulture’s of the sea”
  - Can produce large quantities of slime from roughly 200 slime glands
Cartilaginous Fishes

- Class chondrichthyes
- Sharks, skates, and rays
- Have a skeleton made of cartilage
  - Made of calcium carbonate
    - Light, but strong
- Paired fins
- No swim bladder
Sharks

- Their skin has triangular-shaped scales
  - Scales and teeth are similar in structure (teeth are modified scales!!)
    - Teeth arranged in 6 to 10 rows
      - Teeth in front are pointed and sharp – used for biting and cutting
      - Behind are immature teeth that are growing
        - Can lose more than 20,000 in a lifetime

- Fertilization of eggs is internal

- Most are predators
  - Largest of sharks, whale sharks, eat plankton 😊
Bony Fishes

- Class osteichyes
- Most numerous of all fishes
- Have a skeleton made of bone and paired fins
- Have teeth that are fixed onto the upper jaw
- Have a swim bladder
  - an air filled sac that helps them with buoyancy
- Bony fish do not have to swim to breathe (to push water through the gills)
Structural Adaptations of Bony Fishes

- **Lateral line system (1)**
  - Sensory system that extends along each side of a bony fish’s body
  - Enables a fish to detect motionless objects by the movement of water deflected by that object
    - Helps a fish perceive its position in water
  - Occurs by nerve impulses from ciliated sensory cells
    - Much like we hear music with our inner ear
      - Both use sensory cells with cilia to detect vibrations
Structural Adaptations of Bony Fishes, cont.

- **Gill Cover (2)**
  - Operculum – hard plate that covers the gills on each side of the head
  - Movement of the opercula and other muscles permit a fish to draw water over the gills, which allows them to take in oxygen
  - Can move water over their gills while remaining stationary
    - Doesn’t have to swim to respire
      - Enables them to conserve energy
Swim Bladder (3)
- Keeps a fish from sinking
- Swim bladder is a special gas sac
  - By adjusting gas content of swim bladder, fish can regulate their buoyancy
    - As it fills, they rise and vice versa
- Early bony fish had swim bladder connected to throat
  - Gulped air to fill it
- Modern bony fish swim bladder does not have a direct passageway to mouth
  - Gas is exchanged between bloodstream and the swim bladder
Bony Fish Groups

**There are 2 groups of bony fishes**
- Ray-finned fishes
  - Yellow perch
- Lobe-finned fishes
  - coelacanth
Ray-Finned Bony Fishes

- Vast majority of living fishes
- Fins are supported by bony structures called rays
- Teleosts – most advanced of the ray-finned bony fishes
  - Highly mobile fins
  - Very thin scales
  - Completely symmetrical tails
  - Includes 95% of all living fish species
Lobe-Finned Bony Fishes

- Only 7 species survive today
- 1 species is coelacanth
- Other 6 are all lungfishes
- Have paired fins
  - Each fine consists of a long, fleshly, muscular love that is supported by central core of bones
  - Bones are connected by joints
    - like joints in the bones of your hand
  - Bony rays are only found at the tips of each lobed fin
- Scientists are still debating ancestry..
  - Used to believe ancestor was amphibian
    - Now they believe it is most likely a third type of lobe-finned fish now extinct
30.3 The Amphibian Body

- The first vertebrates on land
- Descendants of lobe-finned fishes
- Ancestors of all other land vertebrates
Characteristics of Amphibians

- *Most amphibians share 5 key characteristics:
  - Legs
  - Lungs
  - Cutaneous respiration
  - Double-loop circulation
  - Partially divided heart

- Characteristics allow them to thrive on land
  - Must still reproduce in wet area (eggs are not watertight)
Movement and Response

- **Skeleton**
  - Must have strong support of internal skeleton to live on land
  - Strong limbs **(1. LEGS)** support the body’s weight as well as allow movement
    - Lower limbs are fused into a single, thick bone
    - Hips are sturdy to absorb impact of landing
Sense Organs

- Well developed eyes and ears
  - Vision important for hunting and avoiding predators
    - Eyes covered by nictitating membrane
      - Transparent and moveable
  - Inner ear detects sound
    - Sounds transmitted to inner ear by tympanic membrane, or eardrum
      - Impulses from vibrations are sent to the brain
Respiration

- Larval amphibians have gills, most adults breathe with a pair of \textbf{2. LUNGS}
  - Lungless salamanders are the exception
- Air contains 20x as much oxygen as sea water
  - Gill cannot function when out of water
- Lung = internal, baglike respiratory organ that allows oxygen and carbon dioxide to be exchanged between the air and the bloodstream
- The greater the surface area, the greater the amount of oxygen that can be absorbed
Amphibian Lungs

Internal folds increase surface area.

Air flows to the lungs through a tubular passage from the head and then flows back out through the same passage.
Respiration (3. Cutaneous Respiration)

- Also obtain oxygen through their skin
- Gases and water pass directly through their skin
- Skin must remain moist for exchange of gases
  - Have mucous glands to keep them moist
Circulation

- More energy is needed to walk than swim
  - Land animals have higher metabolic rates
4. Partially Divided Heart

- Atrium – divided into left and right sides, but ventricle is not
  - mixture of oxygen-rich and oxygen-poor blood is delivered to the amphibian’s body tissues
- Septum – separates atrium into left and right halves
- Amphibians also obtain oxygen through their skin
  - Additional oxygen partly offsets the limitations of their circulatory system
Amphibian Heart Structure

1. Oxygen-poor blood from the body enters the right atrium.
2. The pulmonary veins carry oxygen-rich blood from the lungs to the left atrium.
3. A mixture of oxygen-rich and oxygen-poor blood enters the ventricle.
4. The ventricle pumps blood to the lungs and the body tissues.
5. Double-Loop Circulation

- Two large veins (pulmonary veins) return oxygen-rich blood from the lungs to the heart
  - Blood is then pumped to the tissues at a much higher pressure than fish heart
- Allows more oxygen to be delivered to muscles
- In fish, blood is pumped through the gills before reaching the body’s organs
  - Results in much of the force of the heartbeat being lost
Fish vs. Amphibian Heart Structure

Fish:
- Gill capillaries
- Body-organ capillaries
- Heart

Amphibian:
- Lung capillaries
- Pulmonary vein
- Heart
- Oxygen-rich blood
- Oxygen-poor blood
1. What is the function of the septum?
2. Why does mixing of oxygen-rich and oxygen-poor blood occur in amphibians?
• What is the function of the right atrium?
• What is the function of the left atrium?
• What is the function of the ventricle?
Sequence the circulation of blood in amphibians

- Blood goes to the lungs
- Oxygen-rich blood enters the ventricle
- Oxygen-poor blood enters the right atrium
- Blood goes to the body
- Oxygen-rich blood from the lungs enters the left atrium
- Oxygen-poor blood enters the ventricle
30.4 Groups of Amphibians

- Divided into three main groups
  - Salamanders
  - Caecilians
  - Frogs and toads
Salamanders

- **Order Caudata**
- **Characteristics:**
  - elongated bodies
  - long tails
  - smooth, moist skin.

- Most are unable to stay away from water for long
  - Some do by remaining inactive during the day

- Some have long tongues that extend to catch prey
Reproduction in Salamanders

- Salamanders lay their eggs in water or in moist places
  - Fertilization is usually external
  - Few have internal

- Female picks up a sperm packet deposited by male and places it in her body

- Unlike frog and toad larvae, salamander larvae do not undergo a dramatic metamorphosis.

- The young that hatch from eggs are carnivorous and resemble small versions of the adults, except that the young usually have gills
  - Some retain gills when they become adults
Caecilians

- Order Gymnophiona
- Are highly specialized group of tropical, burrowing amphibians with small, bony scales embedded in their skin
- Most burrow, but some are aquatic
- Most are blind
- All have teeth (for prey)
- Eat worms and other invertebrates

- Detects prey by using a tentacle on the side of its head
  - Senses chemicals
Reproduction in Caecilians

- The male deposits sperm directly into the female
  - Depending on the species, the female may bear live young or lay eggs that develop externally

- Caecilians are rarely seen, and scientists do not know a lot about their behavior.
Frogs and Toads

- **Order Anura** – frogs and toads that live in environments EVERYWHERE
- **Adults are carnivorous**
  - Some have sticky tongue
  - Skeleton adapted for jumping
  - Long, muscular legs for power
- **Toads** are similar to frogs, have shorter legs. Skin is not smooth, but bumpy
Reproduction in Frogs

- Depend on water to complete life cycle
  - Females releases eggs into water and a male’s sperm fertilize them externally
  - After a few days, the fertilized eggs hatching into swimming, fishlike larval forms called tadpoles
    - Breathe with gills and feed on algae
  - After growth period, body changes into that of adult frog
    - Rate of growth depends on availability of resources
- Process of dramatic physical change = metamorphosis
Life Cycle of A Frog

The life cycle of a frog involves large-scale changes in body form. First, a mass of eggs is laid in a wet or moist environment.

The young tadpole emerges from the egg with external gills, which are later replaced by internal gills. After feeding and growing, the tadpole begins to transform into an adult frog.

Dramatic changes occur in the tadpole. The tail and gills recede. Lungs and front and hind limbs grow. Feeding habits may also change. Herbivorous tadpoles change into carnivorous adults.

The adult frog has completely lost its tail and gills. Its lungs enable it to breathe air. The changes that transform a tadpole into an adult frog are called metamorphosis.
Review

1. What habitat requirement do all three groups of amphibians have in common?
2. How does a salamander carry out internal fertilization?
3. Why is being blind not a disadvantage to a caecilian?
4. Why do frogs need to live near water?
5. Which amphibians do not have 4 legs?