Aquatic vertebrates that are characterized by:

- Paired fins
  - Used for movement

- Scales
  - Used for protection

- Gills
  - Used for exchanging gases
EVOLUTION OF FISHES

• Fishes were the first vertebrates to evolve.

• The evolution of jaws and the evolution of paired fins were important developments during the rise of fishes.
THE FIRST FISHES

- Jawless creatures whose bodies were armored with bony plates.
- Lived in the oceans during the late Cambrian Period, about 510 mya.
- Fishes kept this armored, jawless body plan for 100 million years.
• Ordovician and Silurian Periods: 505-410 mya, fishes underwent a major adaptive radiation

• Devonian Period: “Age of Fishes”

• Some were jawless with little armor

• Ancestors of modern hagfishes and lampreys

• Others were armored and ultimately became extinct about 360 mya
Other ancient fishes kept their bony armor and possessed a feeding adaptation that would revolutionize vertebrate evolution: JAWS

- Jawless fishes
  - Limited to eating small particles of food that they filter out of the water or suck up like a vacuum cleaner

- Jaws can hold teeth and muscles
  - Much wider variety of food
  - Defend themselves by biting
THE ARRIVAL OF PAIRED FINS

- More control of body movement
- Fin tails and powerful muscles gave greater thrust when swimming
- Enabled fishes to move in new and varied patterns
- This enabled fishes to use their jaws in complex ways
Although the early jawed fishes soon disappeared, they left behind two major groups that continued to evolve and still survive today:

- Ancestors of modern sharks and rays: skeletons made of resilient cartilage
- Group that evolved skeletons made of true bone
Adaptations to aquatic life include:

- Various modes of feeding
- Specialized structures for exchange
- Paired fins for locomotion
• Herbivores, carnivores, parasites, filter feeders, detritus feeders

• A single fish may exhibit several modes of feeding (carp: eat what is available) while others are very specialized (barracuda: carnivore)

• **Pyloric ceca**: finger-like pouches found in many species of fish that secrete digestive enzymes to help digest food
Most fishes exchange gases using gills located on either side of the pharynx.

The gills are made up of feathery filaments.

Lampreys and sharks have several gill openings on the side of the body.

A number of fishes, such as the lungfish, have an adaptation that allows them to survive in oxygen-poor water or in areas where bodies of water often dry up.
RESPIRATION

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).
• Closed circulatory systems with a heart that pumps blood around the body in a single loop

• Heart consists of 4 parts:
  – **Sinus venosus**: thin-walled sac that collects blood from the fish’s veins
  – **Atrium**: a large muscular chamber that serves as a one-way compartment for blood
  – **Ventricle**: thick-walled muscular chamber; portion of the heart
  – **Bulbus arteriosus**: connects to a large blood vessel called the aorta, which moves blood to the fish’s gills
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.
EXCRETION

• Most fishes rid themselves of nitrogenous wastes in the form of ammonia

• Gills, kidneys
  
  – Saltwater fishes
    • Lose water by osmosis: kidneys return as much water to the body as possible

  – Freshwater fishes
    • Gain water by osmosis: kidneys pump out plenty of dilute urine
Well-developed nervous systems organized around a brain

- **Cerebrum**: area of the brain responsible for all voluntary activities of the body

- **Cerebellum**: region of the brain that coordinates body movements

- **Medulla oblongata**: area of the brain that controls the functioning of many internal organs
Lateral line system: sensitive receptor system that enables fish to detect gentle currents and vibrations in the water (the 6th sense)
**MOVEMENT**

- Most move by alternately contracting paired sets of muscles on either side of the backbone.

- Because their body tissues are more dense than the water they swim in, sinking is an issue for fishes.

- **Swim bladder**: gas-filled organ found in many bony fishes that adjusts their buoyancy.
• **Oviparous**: term used to refer to animals whose eggs hatch outside the mother’s body

• **Ovoviviparous**: term used to refer to animals whose young are born alive after developing in eggs inside the mother’s body

• **Viviparous**: term used to refer to animals that bear live young that are nourished directly by the mother’s body as they develop
Over 24,000 living species that are extremely diverse

- Jawless fishes
- Cartilaginous fishes
- Bony fishes
JAWLESS FISHES

• Have no true teeth or jaws

• Skeletons are made of fibers and cartilage

• Lack vertebrae; keep notochords as adults

• Two main classes:
  – Lamprey
  – Hagfishes
• Class Chondrichthyes
• Sharks, rays, skates,
• Also: sawfishes and chimaeras
• Cartilage, not bone
• Curved tails

• Torpedo-shaped bodies

• Pointed snouts

• Mouth underneath

• Enormous number of teeth

• Always exceptions!
BONY FISHES

• Class Osteichthyes

• Skeletons made of hard, calcified bone

• Ray-finned fishes
  – Rays or spines that support the fins
  – Only 7 living species of bony fish are not finned

• Lobe-finned fishes
• **Anadromous**: fishes that spend most of their lives in the ocean but migrate to fresh water to breed
  
  – Examples: lampreys, sturgeons, and salmon

• **Catadromous**: fishes that spend most of their lives in fresh water but migrate to the ocean to breed
  
  – Example: European eel, American eel
Fish

- Common characteristics:
  - Aquatic vertebrates
  - Paired fins
  - Scales
  - Gills
  - Ectothermic
  - Fertilization usually external

- Examples:
  - Jawless fish: lampreys & hagfishes
  - Cartilaginous fish: sharks, rays, etc.
  - Bony fish
    - Ray-finned fish (most fish)
    - Lobe finned fish: lungfish, coelacanth, & several others