

# 33-3 Form and Function in Chordates





**The digestive systems of vertebrates have organs that are well adapted for different feeding habits.**

Carnivores → short digestive tracts with fast-acting, meat-digesting enzymes.

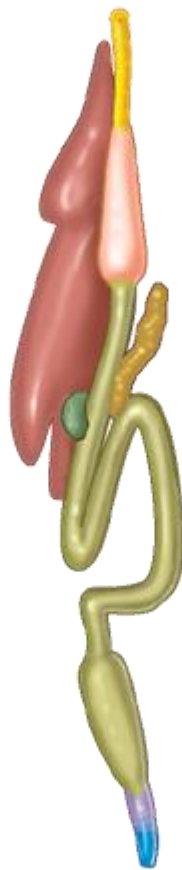
Herbivores → long intestines. Some have bacteria that help digest the tough cellulose fibers.

# Vertebrate Digestive Systems

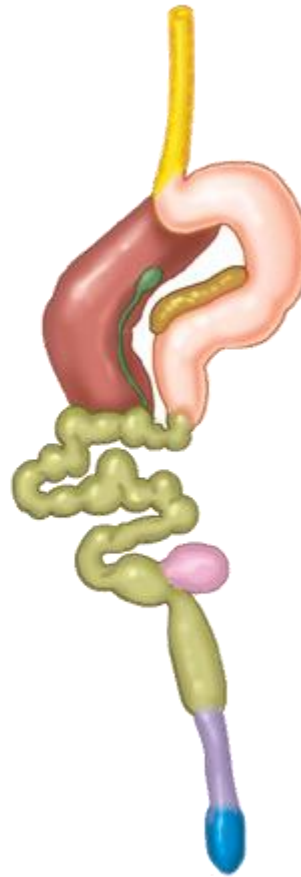
**Shark**



**Salamander**



**Lizard**



Esophagus

Stomach

Intestine

Liver

Gallbladder

Pancreas

Cloaca

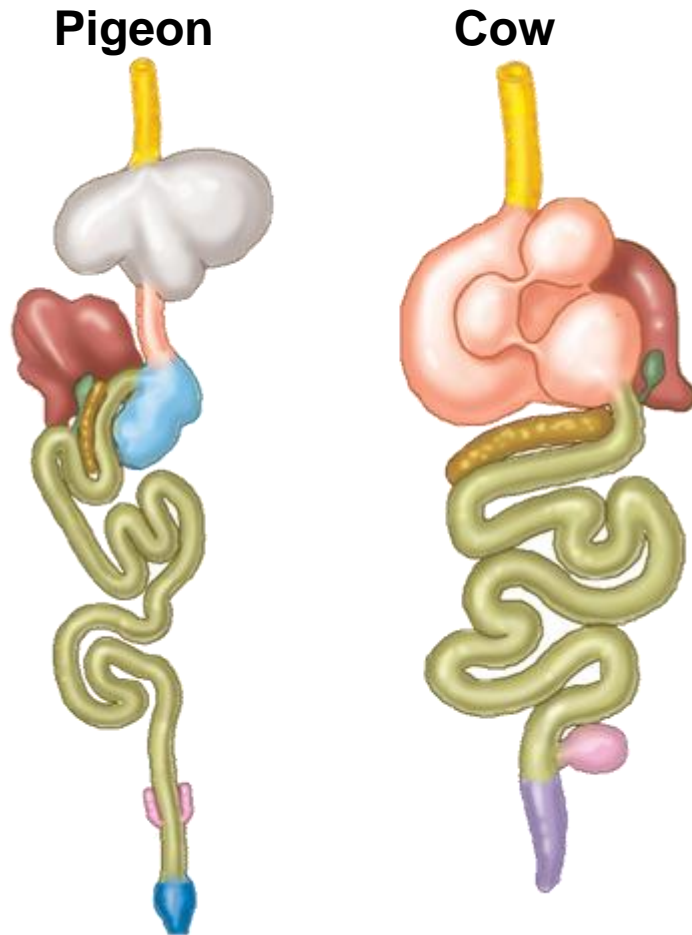
Crop

Gizzard

Ceca

Rectum

# Vertebrate Digestive Systems



- Esophagus
- Stomach
- Intestine
- Liver
- Gallbladder
- Pancreas
- Cloaca
- Crop
- Gizzard
- Ceca
- Rectum

# Respiration



**Aquatic chordates → gills for respiration.**

**Land vertebrates → use lungs.**

Some chordates have respiratory structures in addition to gills and lungs.

Bony fishes have simple air sacs.

Lancelets respire by diffusion of oxygen across their body.

Many adult amphibians use moist skin and the lining of their mouths and pharynxes to respire by diffusion.

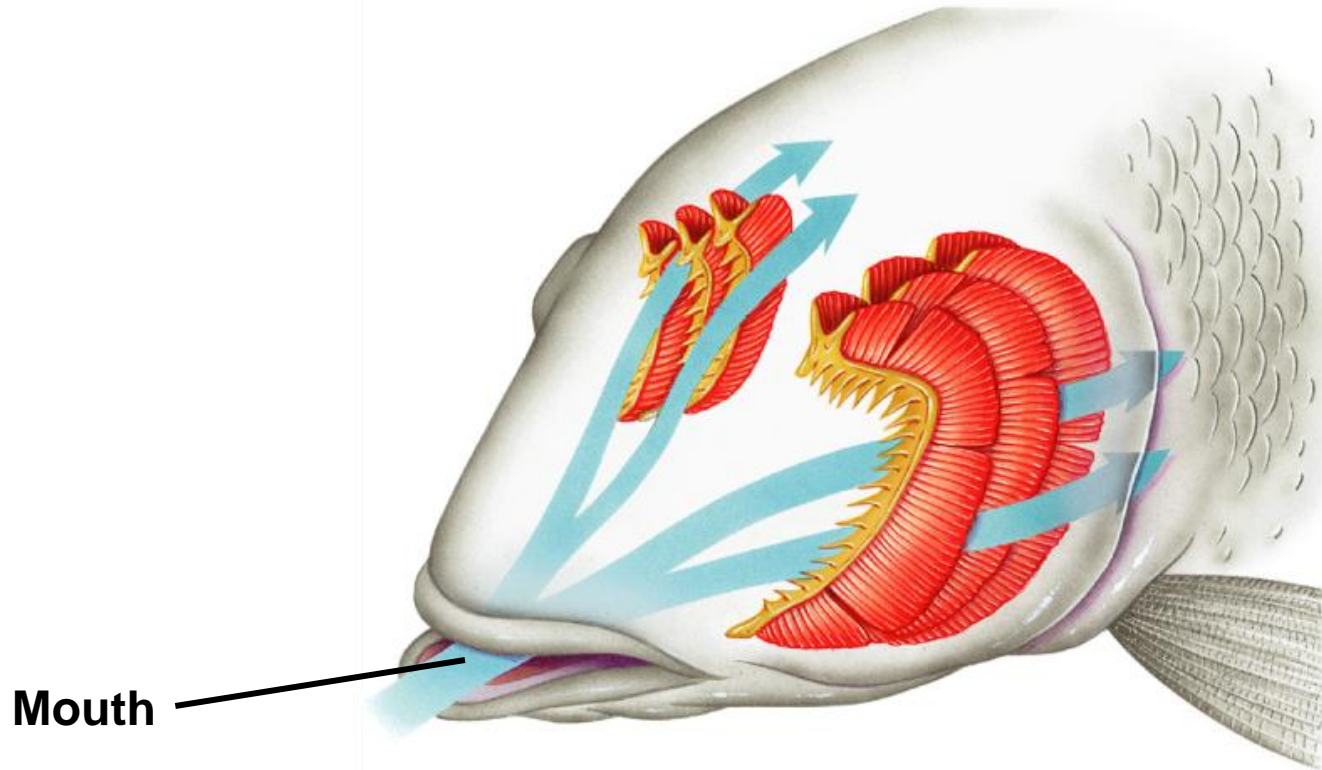
## Gills

Oxygen diffuses into blood in tiny blood vessels called capillaries.

At the same time, carbon dioxide diffuses from blood into the water.

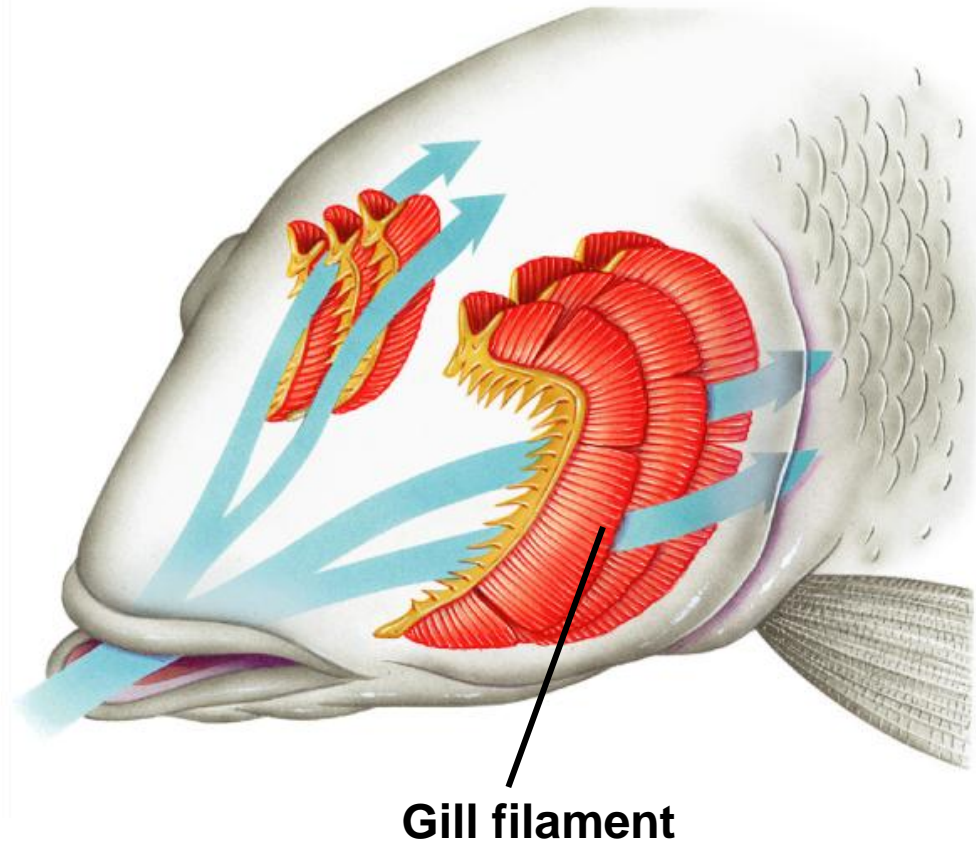


## 33-3 Form and Function in Chordates → Respiration

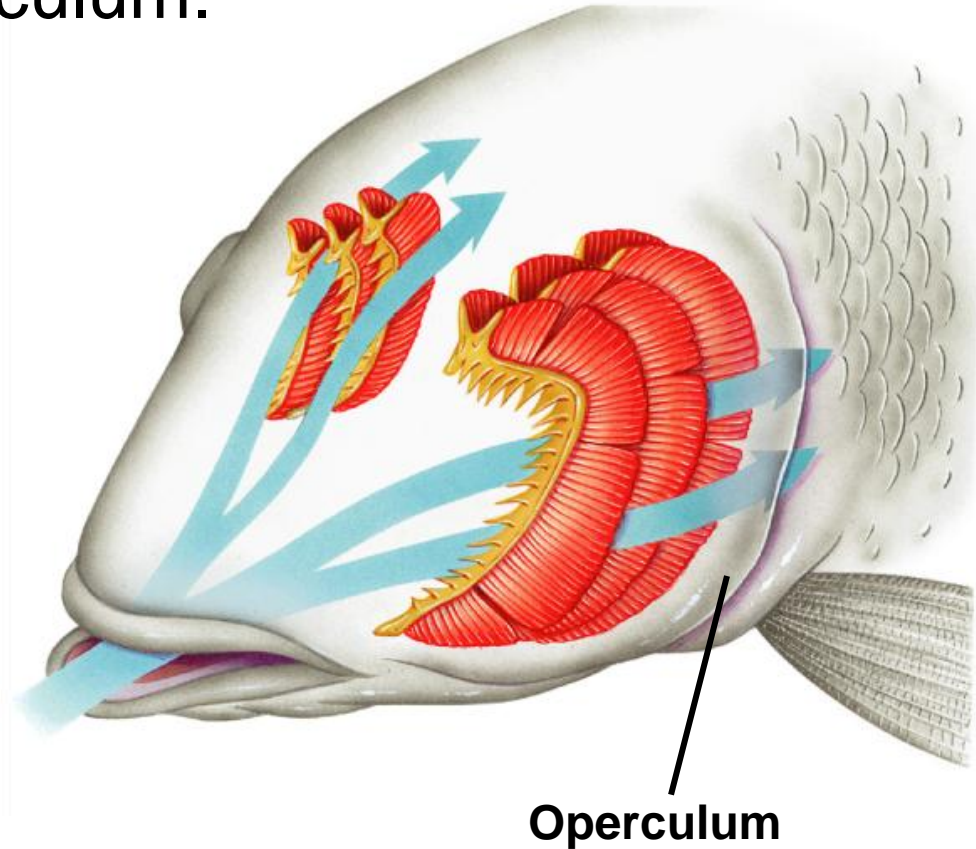




## 33-3 Form and Function in Chordates → Respiration



**Operculum:** Water and carbon dioxide are pumped out through the operculum.



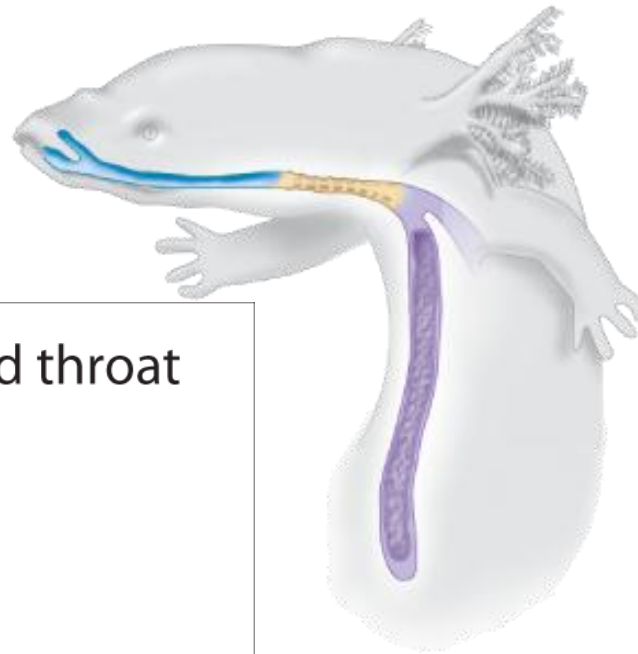
## Lungs

The basic process of breathing is the same among land vertebrates.

Inhaling brings oxygen-rich air from outside the body through the trachea and into the lungs. Oxygen diffuses into the blood inside the lung capillaries.

Carbon dioxide diffuses out of the capillaries into the air within the lungs. Oxygen-poor air is then exhaled.

# Vertebrate Respiration



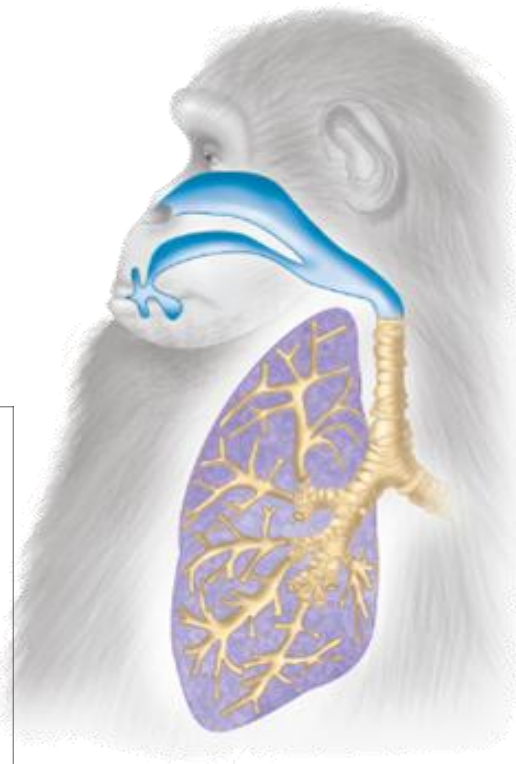
- Nostrils, mouth, and throat
- Trachea
- Lung
- Air sac

**Salamander**

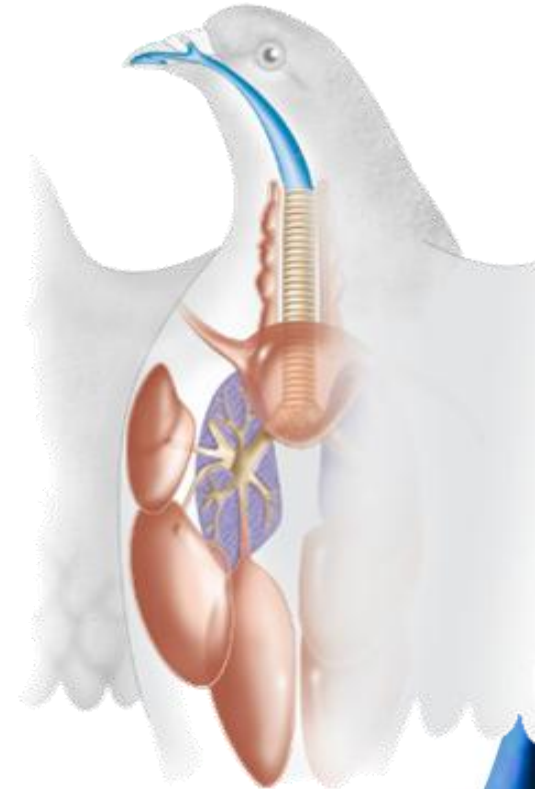
**Lizard**

# Vertebrate Respiration

- Nostrils, mouth, and throat
- Trachea
- Lung
- Air sac



**Primate**



**Bird**

The surface area of lungs increases as you move from the amphibians to mammals.

The amphibian lung is little more than a sac with ridges.

Reptilian lungs are divided into a series of large and small chambers that increase the surface area for gas exchange.



In mammals, their entire lung is filled with structures called **alveoli**.

→ provide an enormous surface area for gas exchange.

→ enables mammals to take in the large amounts of oxygen required by their endothermic metabolism.



In birds, air flows in only one direction. A system of tubes, plus air sacs, enables one-way air flow.

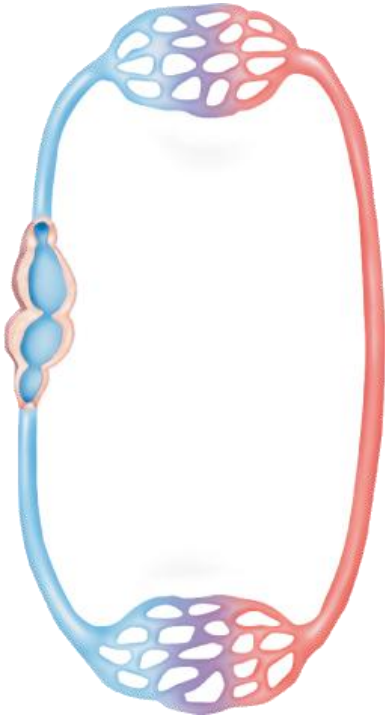
Gas exchange surfaces are constantly in contact with fresh air that contains a lot of oxygen.

This enables birds to fly at high altitudes, where there is less oxygen in the atmosphere than at lower altitudes.

# Circulation

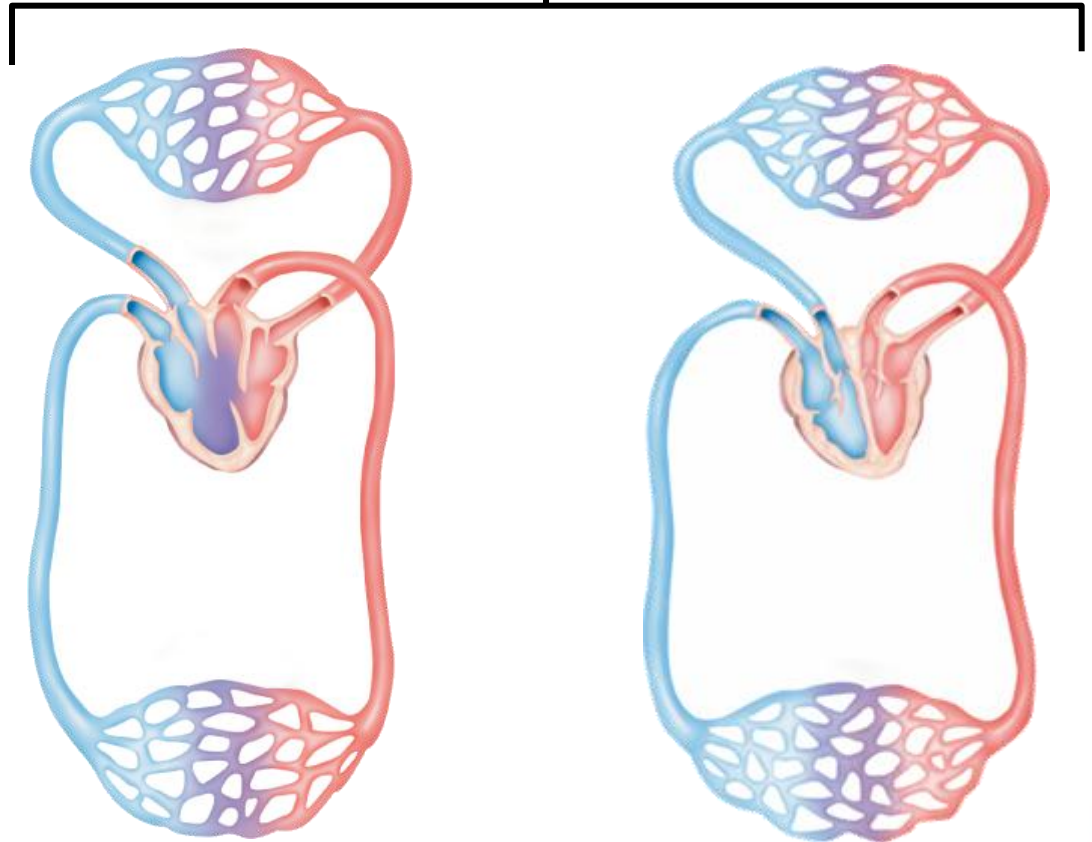
Circulatory systems maintain homeostasis by transporting materials throughout animals' bodies.

Single-loop circulatory system



Fishes

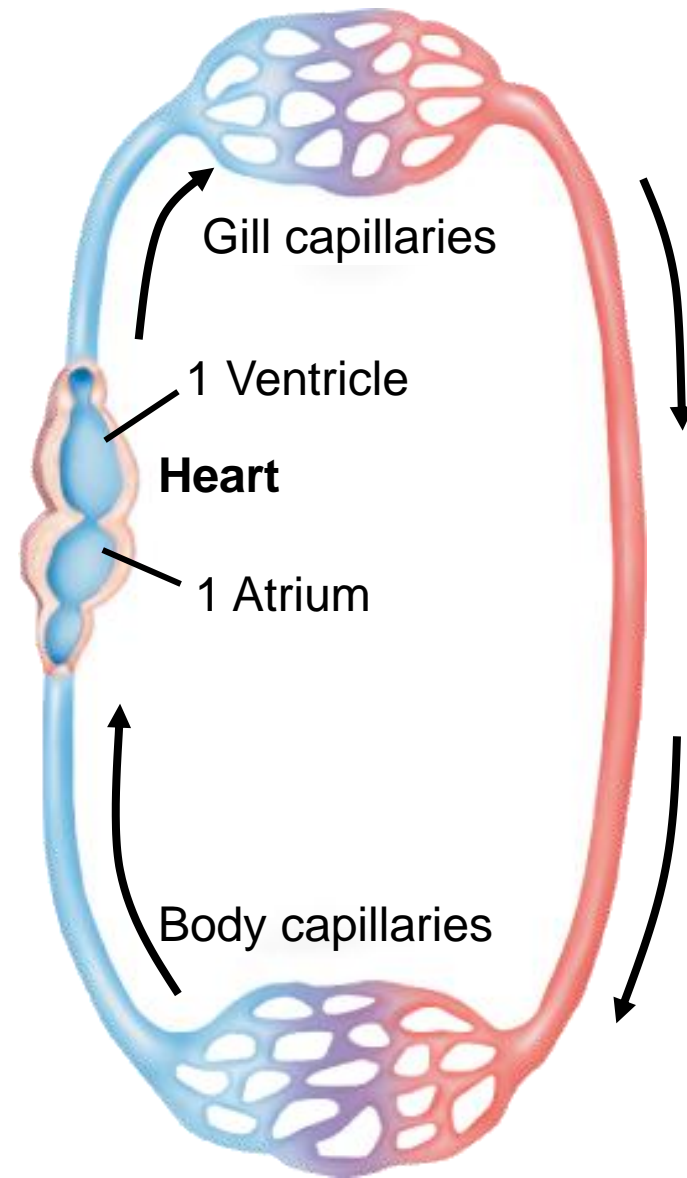
Double-loop circulatory system



Most reptiles

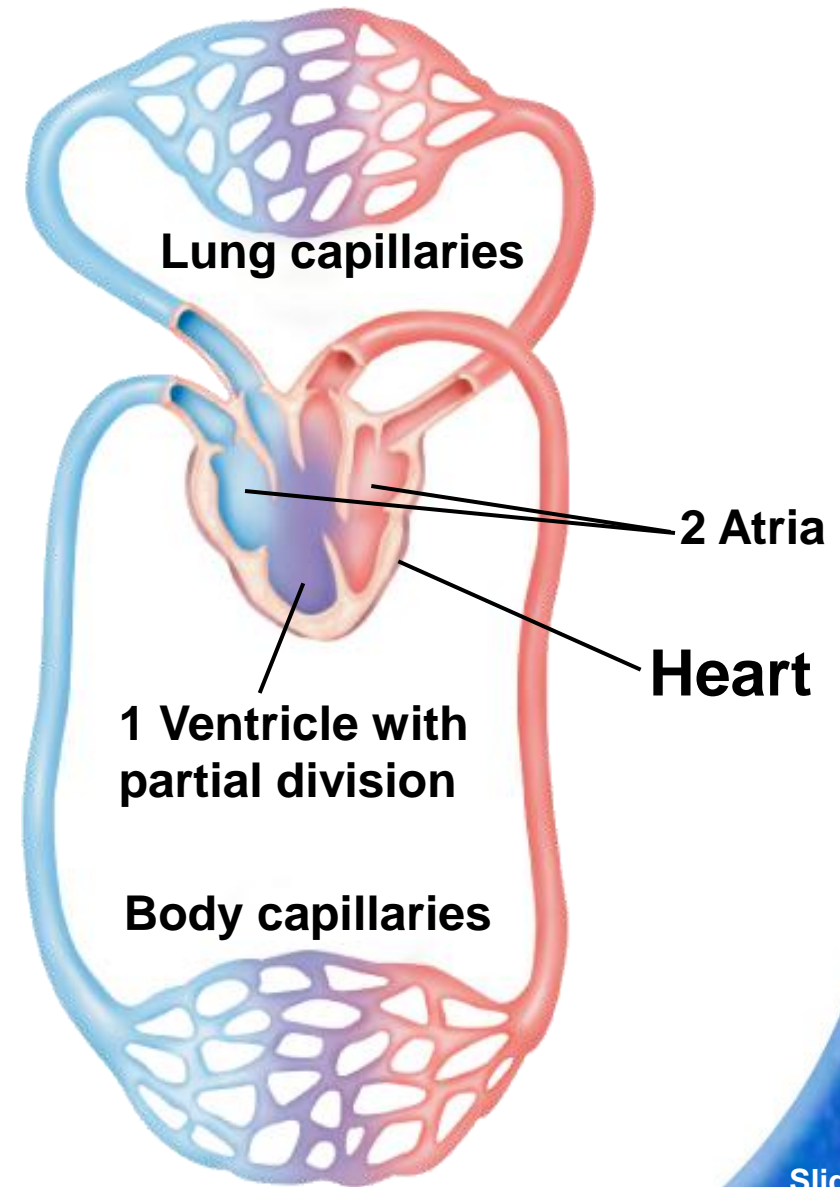
Crocodylians, birds, and mammals

Chordates that use gills for respiration have a single-loop circulatory system.



**FISHES**

Vertebrates with lungs have a double-loop circulatory system.

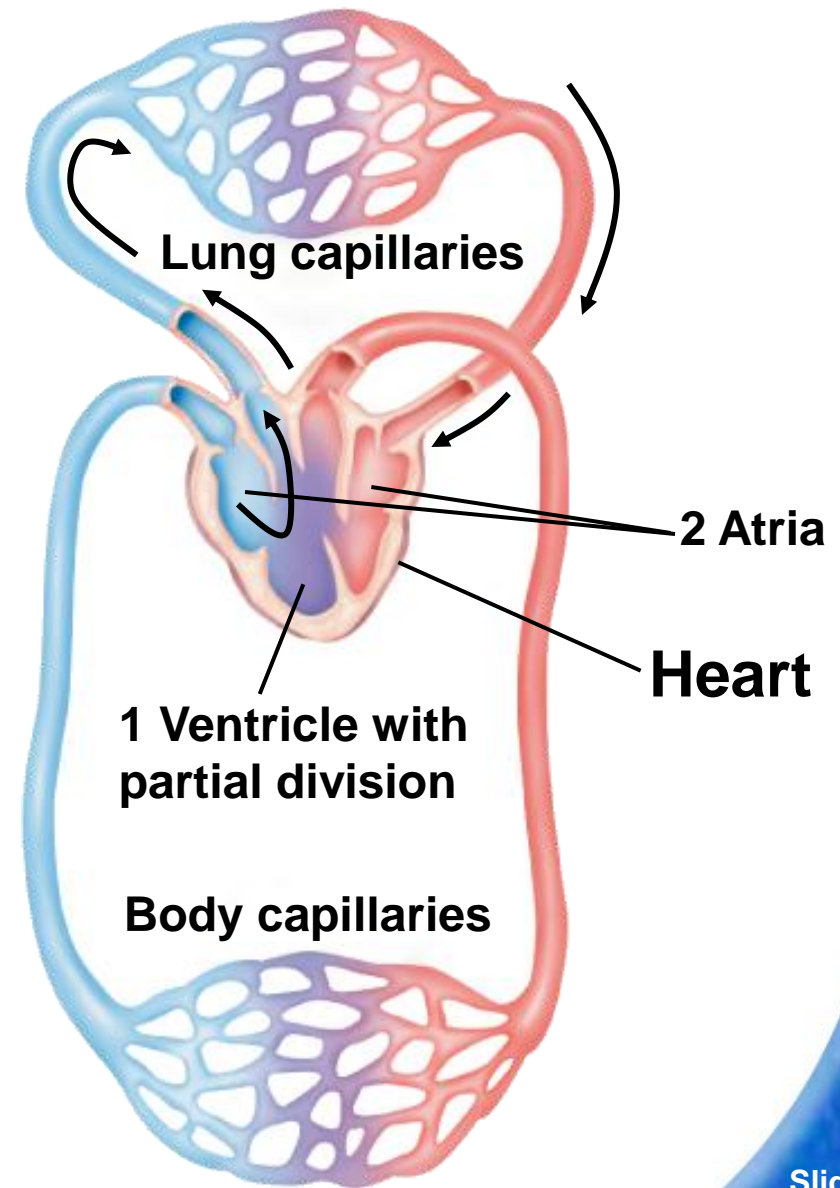


**Most reptiles**

The first loop carries blood between the heart and lungs.

Oxygen-poor blood from the heart is pumped to the lungs.

Oxygen-rich blood from the lungs returns to the heart.



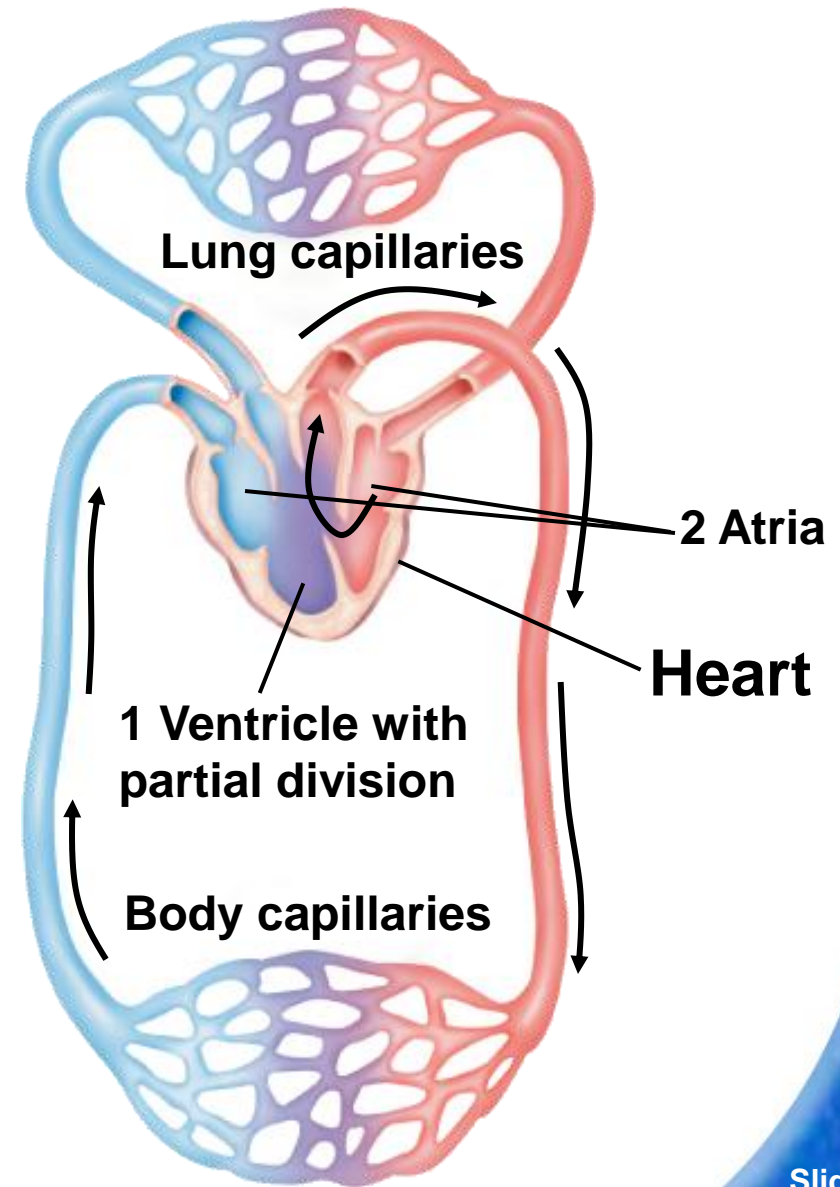
**Most reptiles**



The second loop carries blood between the heart and the body.

Oxygen-rich blood from the heart is pumped to the body.

Oxygen-poor blood from the body returns to the heart.



**Most reptiles**



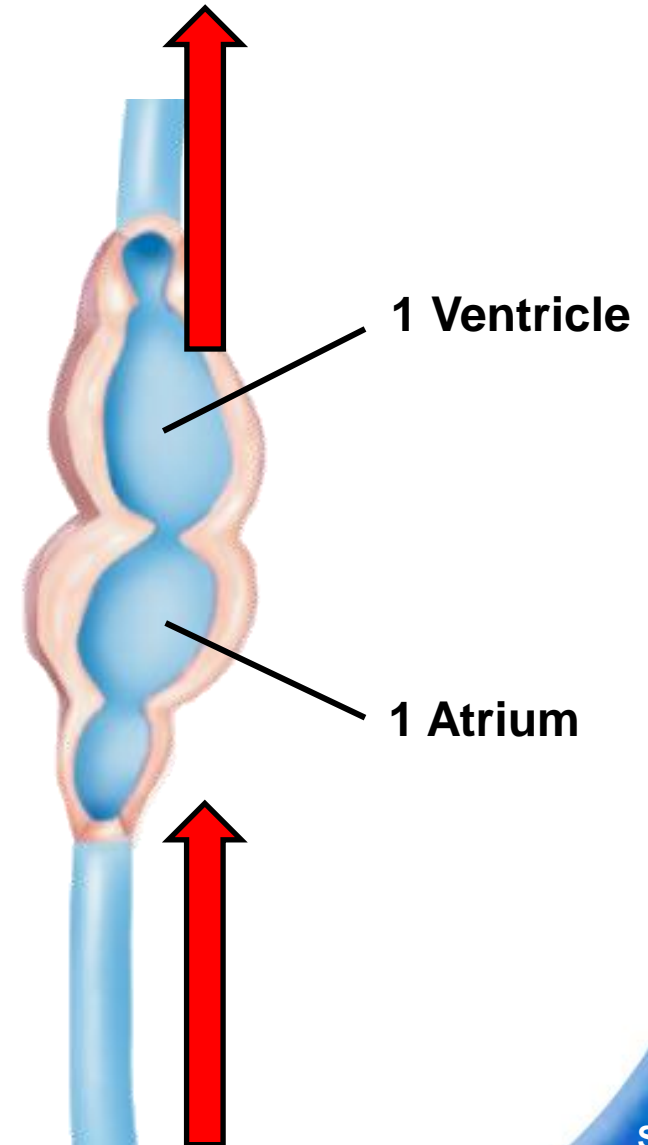
## Heart Chambers



**During the course of chordate evolution, the heart developed chambers and partitions that help separate oxygen-rich and oxygen-poor blood traveling in the circulatory system.**

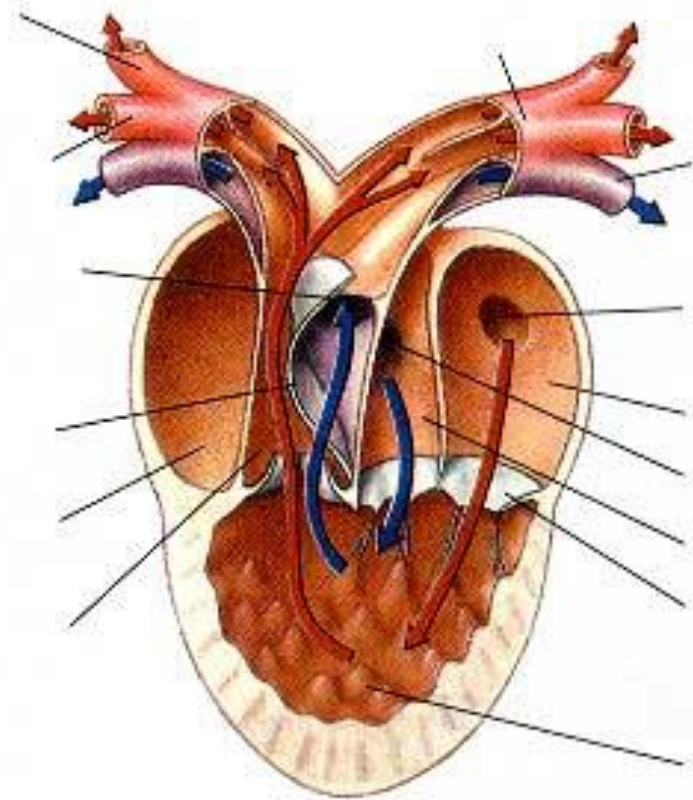
In vertebrates with gills, such as fishes, the heart consists of two chambers:

- an atrium
- a ventricle



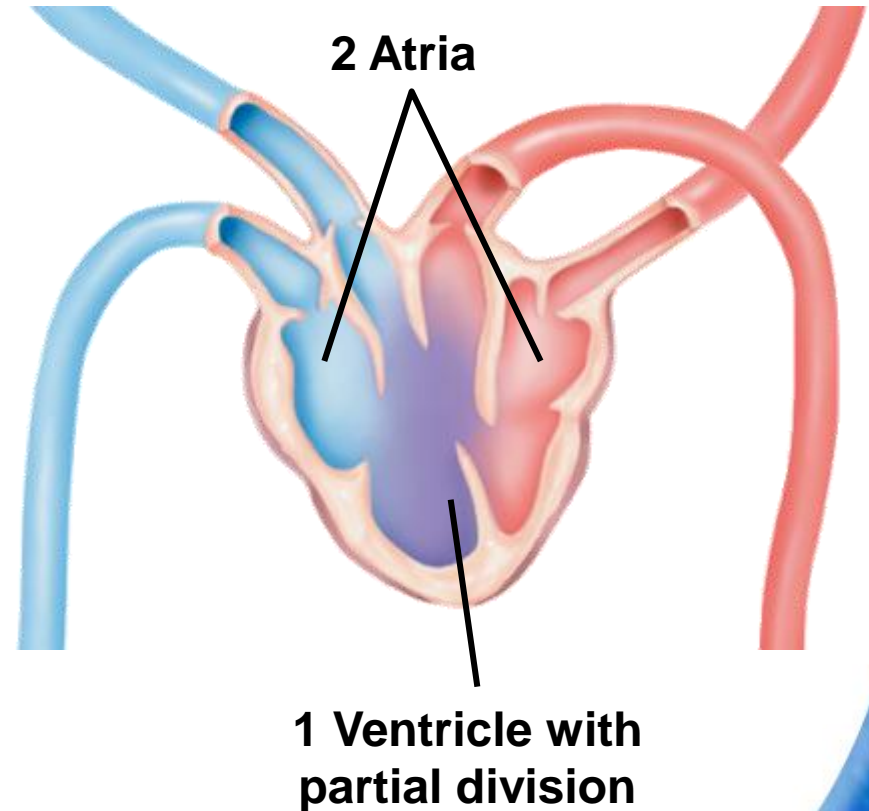
Most amphibians have three-chambered hearts.

- The left atrium receives oxygen-rich blood from the lungs.
- The right atrium receives oxygen-poor blood from the body.
- Both atria empty into the ventricle, which directs blood flow.



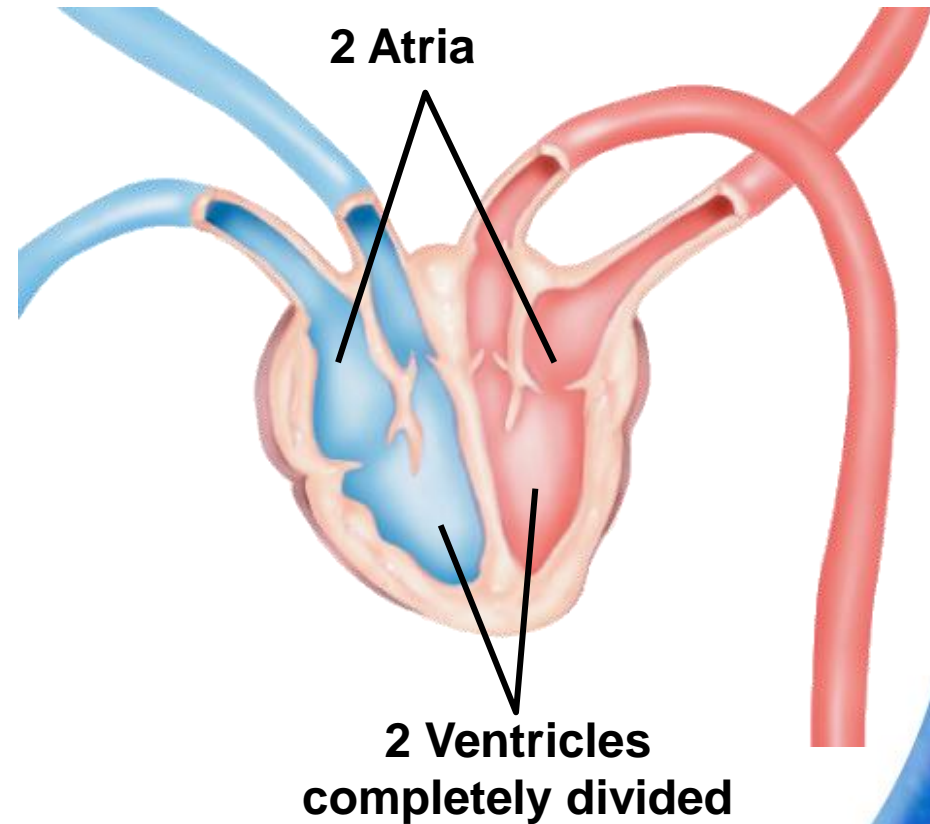
Most reptiles have a three-chambered heart.

Unlike amphibians, most reptiles have a partial partition in their ventricle that reduces the mixing of oxygen-rich and oxygen-poor blood.

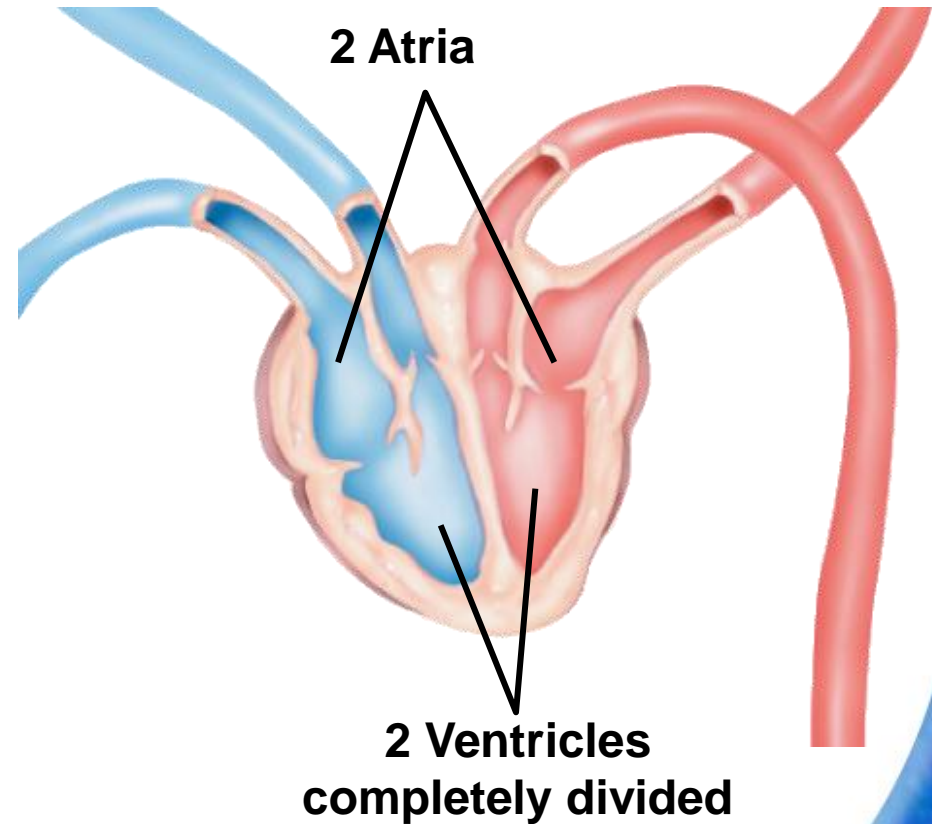


Birds, mammals, and crocodilians have four-chambered hearts sometimes called a double pump.

One pump moves blood through the lung loop and the other moves blood through the body loop.



The two loops are separated. Therefore, oxygen-rich and oxygen-poor blood do not mix.



# Excretion

Excretory systems eliminate nitrogenous wastes.

In nonvertebrate chordates and fishes, gills and gill slits play an important role in excretion.

Most vertebrates rely on kidneys—excretory organs composed of small filtering tubes that remove wastes from the blood.



Nitrogenous wastes are first produced in the form of ammonia.

Ammonia is highly toxic. Therefore, it must quickly be eliminated from the body or changed into a less poisonous form.

In vertebrates, excretion is carried out mostly by the kidneys.

Aquatic amphibians and most fishes also excrete ammonia from gills into the water through diffusion.

Mammals, land amphibians, and cartilaginous fishes change ammonia into urea before it is excreted.

In reptiles and birds, ammonia is changed into uric acid.

# Response



**Nonvertebrate chordates have a relatively simple nervous system with a mass of nerve cells that form a brain.**

**Vertebrates have a more complex brain with distinct regions, each with a different function.**

Nonvertebrate chordates do not have specialized sensory organs.

Vertebrates display a high degree of cephalization, or concentration of sense organs and nerve cells at the front of the body.

The head contains a well-developed brain, which is situated on the anterior end of the spinal cord.

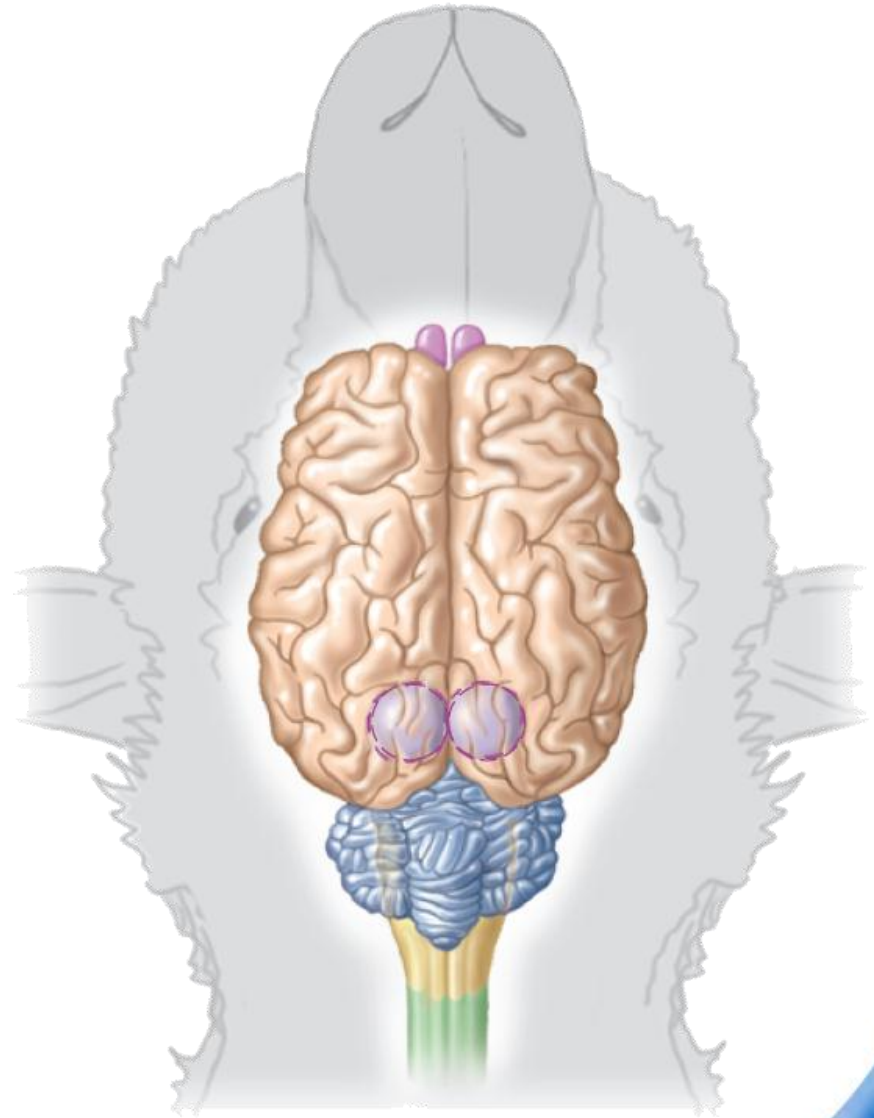
The vertebrate brain is divided into several parts:

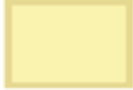




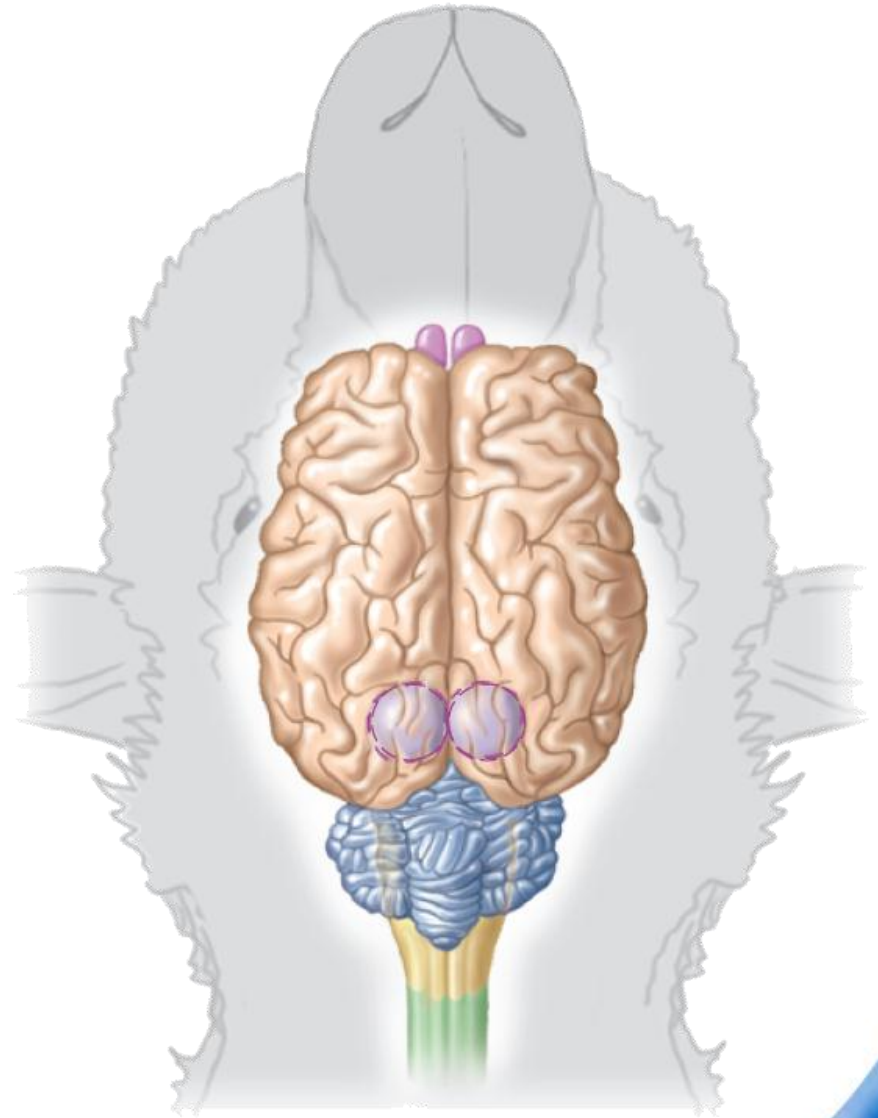
cerebrum, or “thinking and learning” region



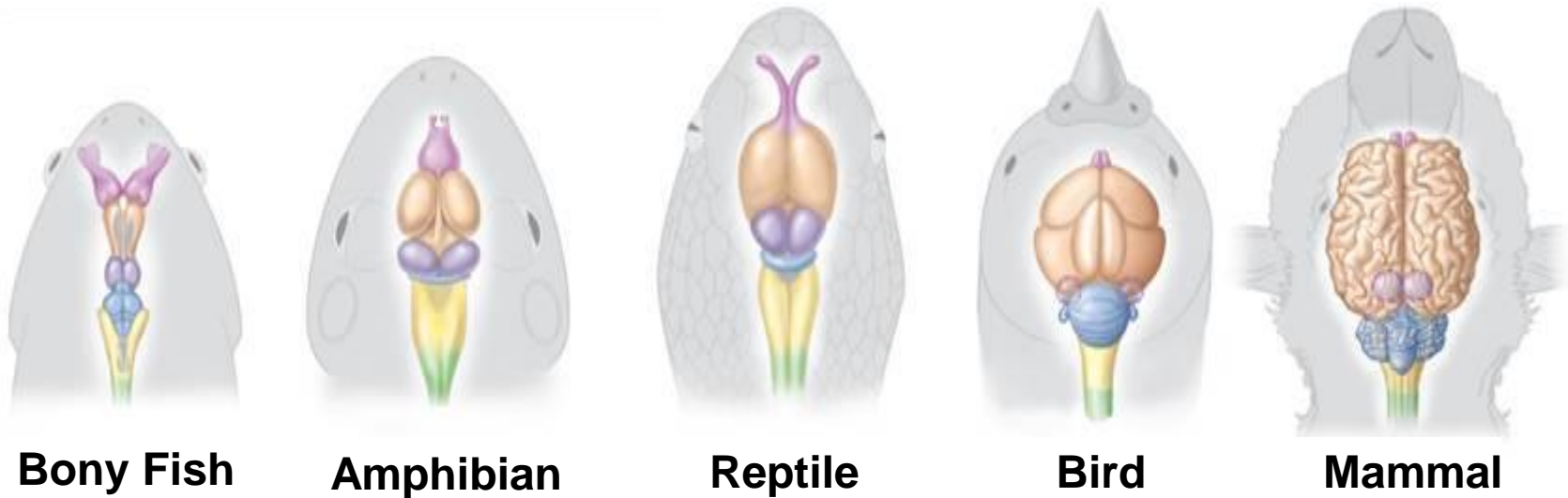
cerebellum, which coordinates movement and balance



-  medulla oblongata, which controls many internal organs
-  optic lobes, which are involved in vision
-  olfactory bulbs, which are involved in smell



The size and complexity of the cerebrum and cerebellum increase from fishes to mammals.

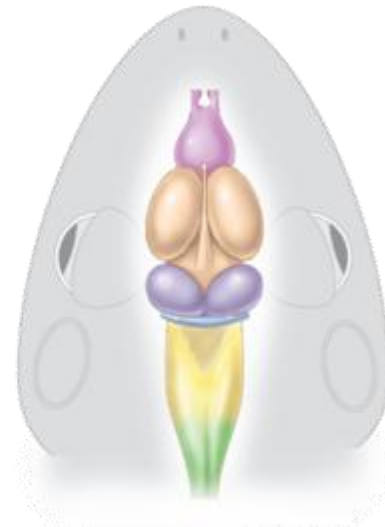




# Vertebrate Brains



**Bony Fish**



**Amphibian**

 **Olfactory bulb**

 **Cerebrum**

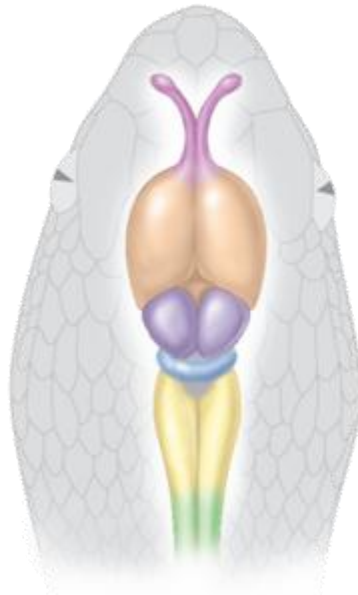
 **Optic lobe**

 **Cerebellum**

 **Medulla oblongata**

 **Spinal cord**

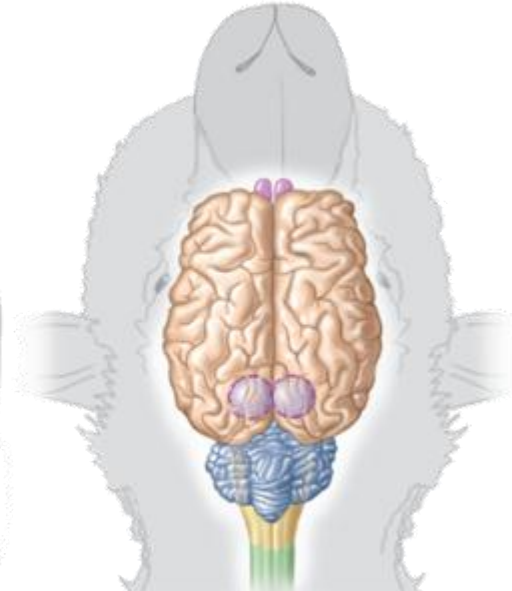
# Vertebrate Brains



Reptile



Bird



Mammal



Olfactory bulb



Cerebellum



Cerebrum



Medulla oblongata



Optic lobe



Spinal cord

## Movement

Unlike most chordates, nonvertebrate chordates lack bones.

Nonvertebrate chordates, however, do have muscles.

Lancelets and larval tunicates swim with a fishlike movement of their muscular tails.

Most vertebrates have an internal skeleton of bone or cartilage.

The skeleton includes a backbone of individual bones called vertebrae.

Ligaments connect vertebrae and allow the backbone to bend.

Most vertebrates have fin or limb girdles that support fins or limbs.

In many fishes and snakes, the main body muscles are arranged in blocks on either side of the backbone. These muscles generate forward thrust.

In many amphibians and reptiles, limbs stick out sideways from the body in a position resembling a push-up.

Most mammals stand with their legs straight under them, a position that supports body weight efficiently.

# Reproduction

Almost all chordates reproduce sexually.

Vertebrate evolution shows a general trend from external to internal fertilization.

Eggs of nonvertebrate chordates—and many fishes and amphibians—are fertilized externally.

Eggs of reptiles, birds, and mammals are fertilized internally.



After fertilization, the development of chordates can be:

- Oviparous—eggs develop outside the mother's body.
- Ovoviviparous—eggs develop within the mother's body, but are born alive.
- Viviparous—developing embryos obtain nutrients directly from the mother's body and are born alive.

Some vertebrates, such as most amphibians, produce many offspring but give them little care. This reproductive strategy favors populations that disperse and grow rapidly.

Mammals and birds produce few young but care for them. This reproductive strategy aids survival in crowded, competitive environments.

## 33-3 Section QUIZ

Continue to:

**Section QUIZ**

- or -

Click to Launch:



## 33-3 Section QUIZ

**1** In mammals, the lungs branch extensively, and their entire volume is filled with thousands of bubblelike structures called

a. trachea.

b. gills.

**A** c. alveoli.

d. air sacs.

## 33-3 Section QUIZ

**2** In vertebrates, excretion is carried out mostly by the

a. pancreas.

**A** b. kidneys.

c. liver.

d. intestine.

## 33-3 Section QUIZ

**3** As you move from fish to mammal, there is an increase in the size of the cerebrum and

a. spinal cord.

**A** b. cerebellum.

c. medulla.

d. ganglia.



## 33-3 Section QUIZ

**4** Which of the following groups of organisms is arranged in order of 2-chambered, 3-chambered, and 4-chambered heart?

a. whale, salamander, fish

**A** b. fish, adult frog, elephant

c. adult frog, fish, human

d. bat, fish, adult frog

## 33-3 Section QUIZ

**5** Which of the following vertebrate groups provides most care to its young?

- a. fishes
- b. amphibians
- c. reptiles

**A** d. mammals

**END OF SECTION**