Gas Exchange

Aquatic animals & Amphibians

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All animal tissues require oxygen for respiration and produce carbon dioxide as a waste product. For that reason, all animals must obtain oxygen from their environment and release carbon dioxide.

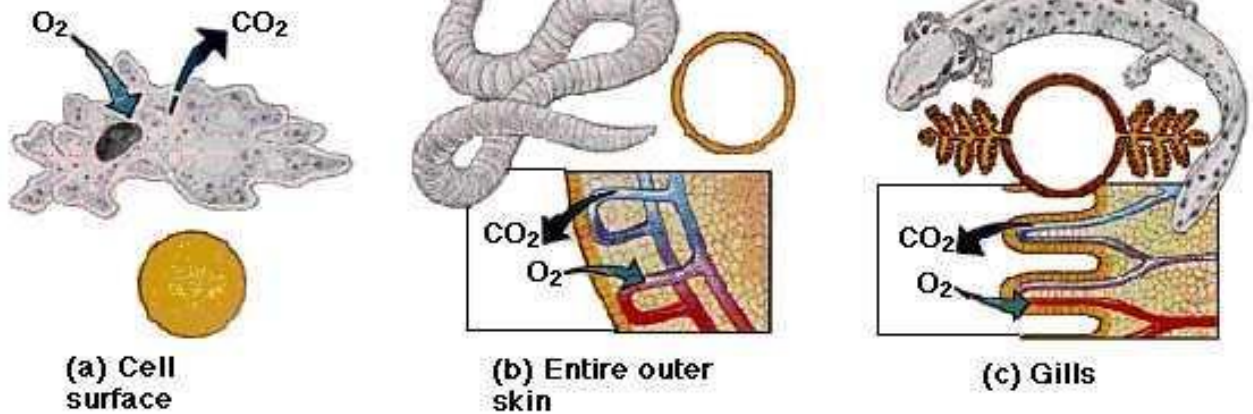
Humans can drown because our lungs cant extract the oxygen we need from water. Most fishes have the opposite problem, out of water, their gills don’t work

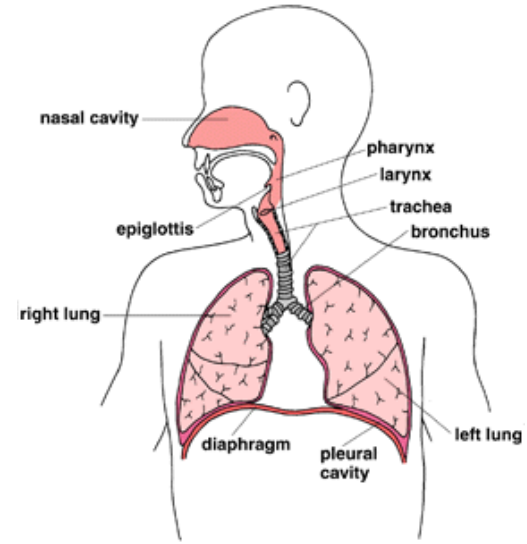
How are these different respiratory systems adapted to their different function?

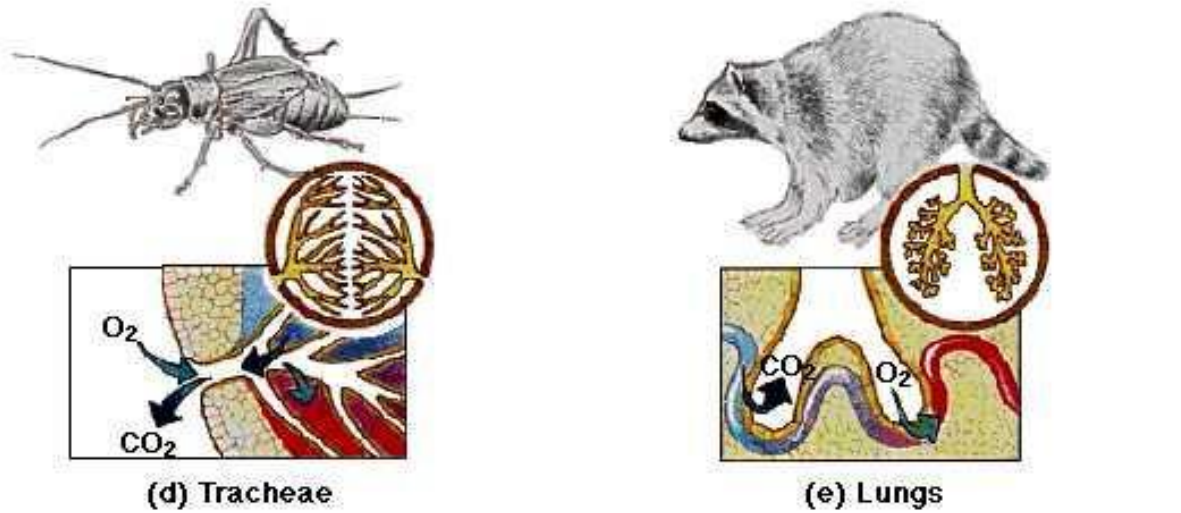
Gas Exchange

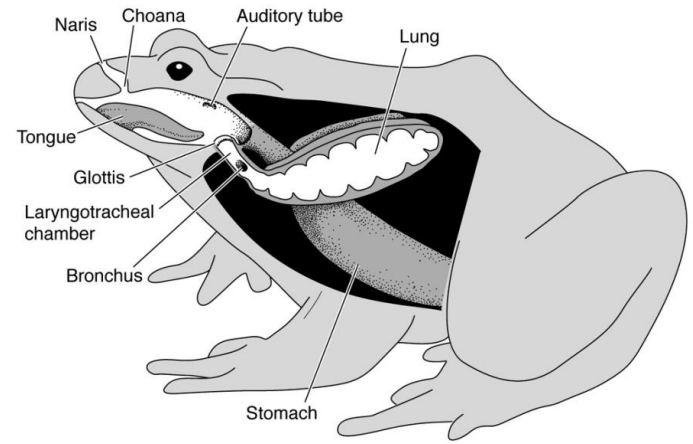
- ***Gas exchange*** is the uptake of oxygen from the environment and the discharge of carbon dioxide to the environment
- Can take place in air or water but ***diffusion*** is the only mechanism
- Gases are dissolved in water, so respiratory surfaces must be moist
- Respiratory surfaces are usually thin and have large areas as well as adaptations to facilitate the exchange
- Different organisms have different adaptations, based on their size, body covering and habitat. May use gills, skin/body surfaces, lungs or a combination

Gas Exchange









Gas Exchange Surfaces

Gases move by ***diffusion***

Diffusion is greater when :

- The ***surface area*** is ***large***
- The ***distance travelled*** is ***small***
- The ***concentration gradient*** is ***high***

Gas exchange also requires a ***moist surface***

- O2 and CO2 must be dissolved in water to diffuse across a membrane

Water as a Gas Exchange Medium

Oxygen is easier to obtain from air than from water :

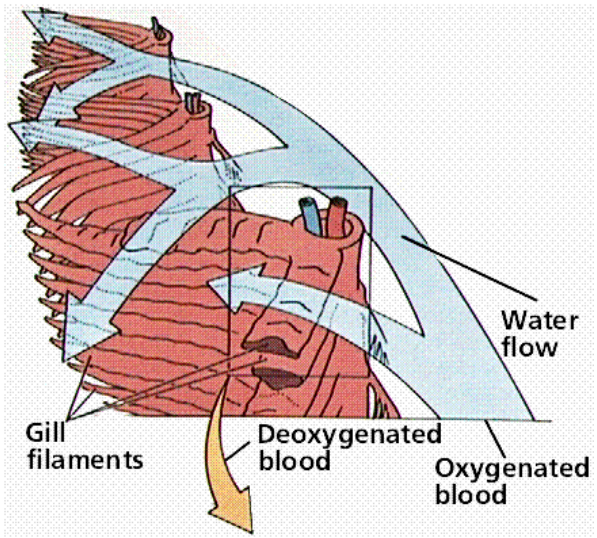
- O_2 content (volume) of air is higher than that of water
- O_2 diffuses much faster through air
- Less O_2 in warm water vs. cold water, less at high altitudes vs. sea level (both air and water)
- Water is thicker and denser than air – requires more energy to move across gas exchange surfaces

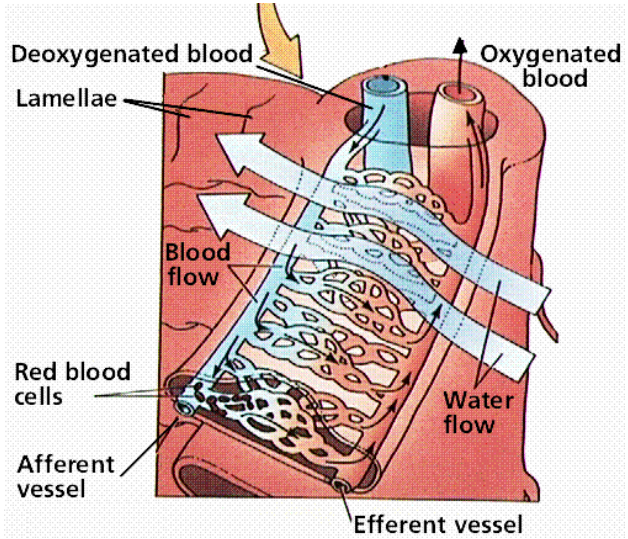
The gas exchange system must be very efficient to get enough oxygen for respiration

Getting Oxygen From Water: Fish Gills

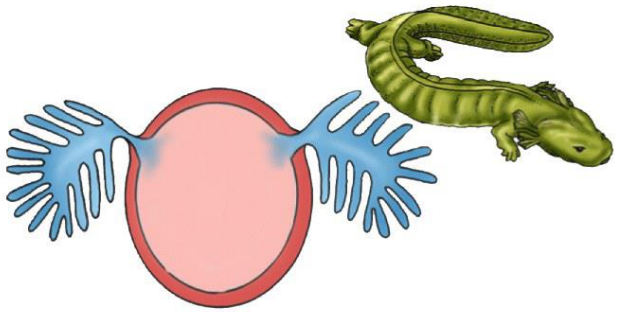
- Gills are outfoldings of the body surface, suspended in water
- Evaginations of the respiratory surface
  - Large surface area
  - Thin cuticle
- Used primarily for respiration in water
  - External exposure helps increase circulation of medium across respiratory surface
  - Water supports weight of the gills without need for sctructural support
- Gills may be internal or external

Getting Oxygen From Water : Fish Gills

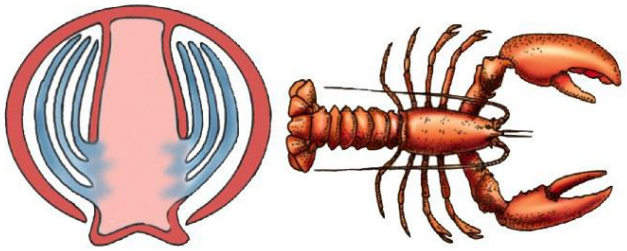




(A) External gills

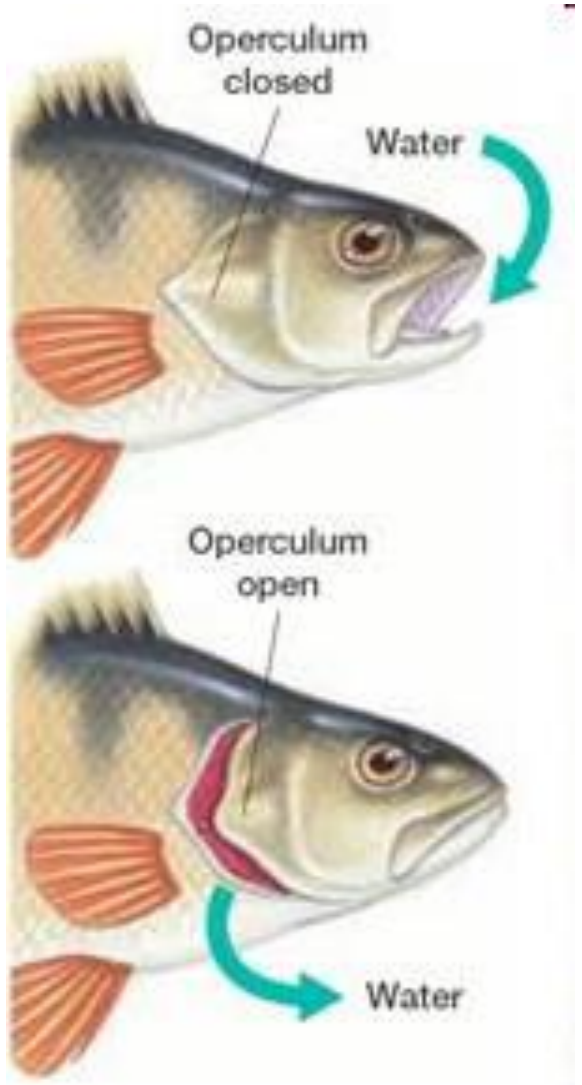


(B) Internal gills



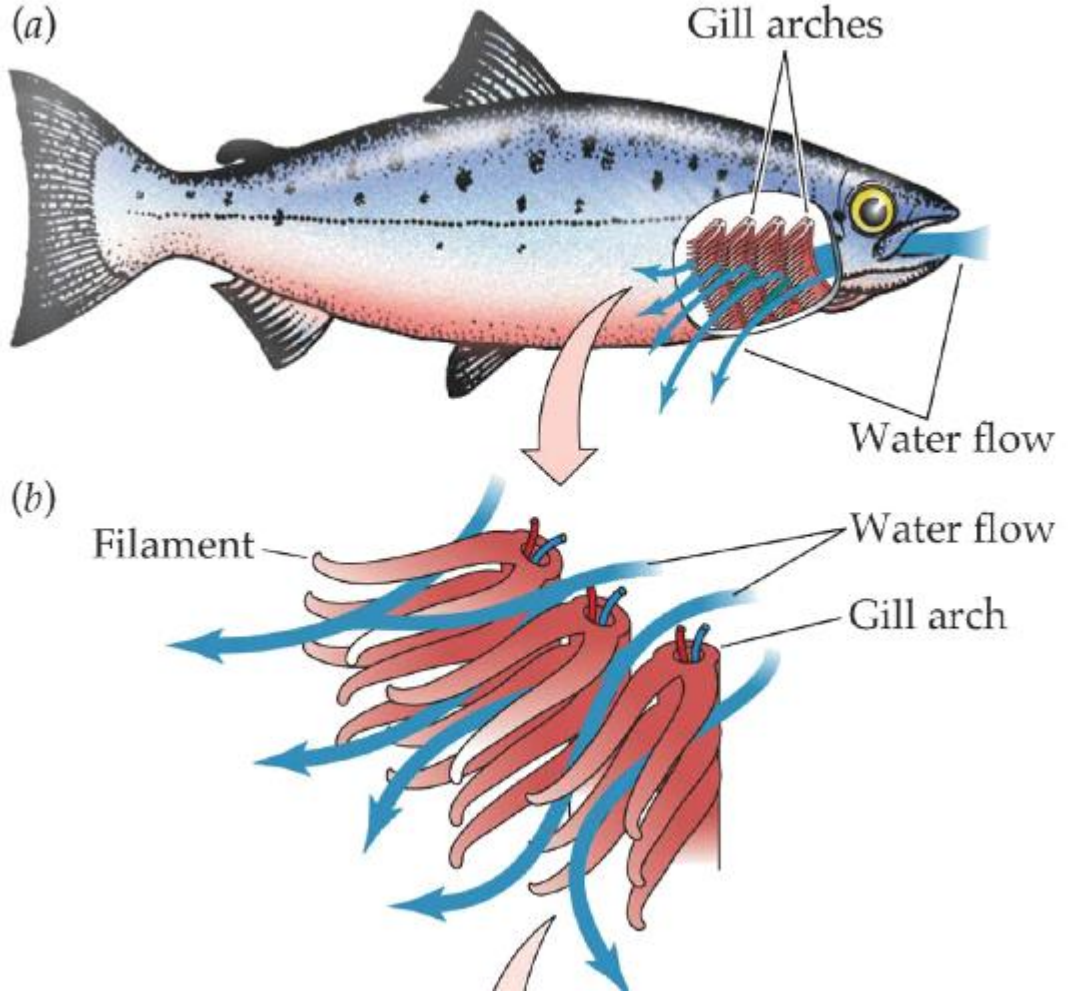
Getting Oxygen From Water : Fish Gills

- Gills covered by an **operculum** (flap)
- Fish **ventilates** gills by alternately opening and closing mouth and operculum
  - Water flows into mouth
  - Over the gills
  - Out under the operculum
- Water difficult to ventilate
  - Gills near surface of body



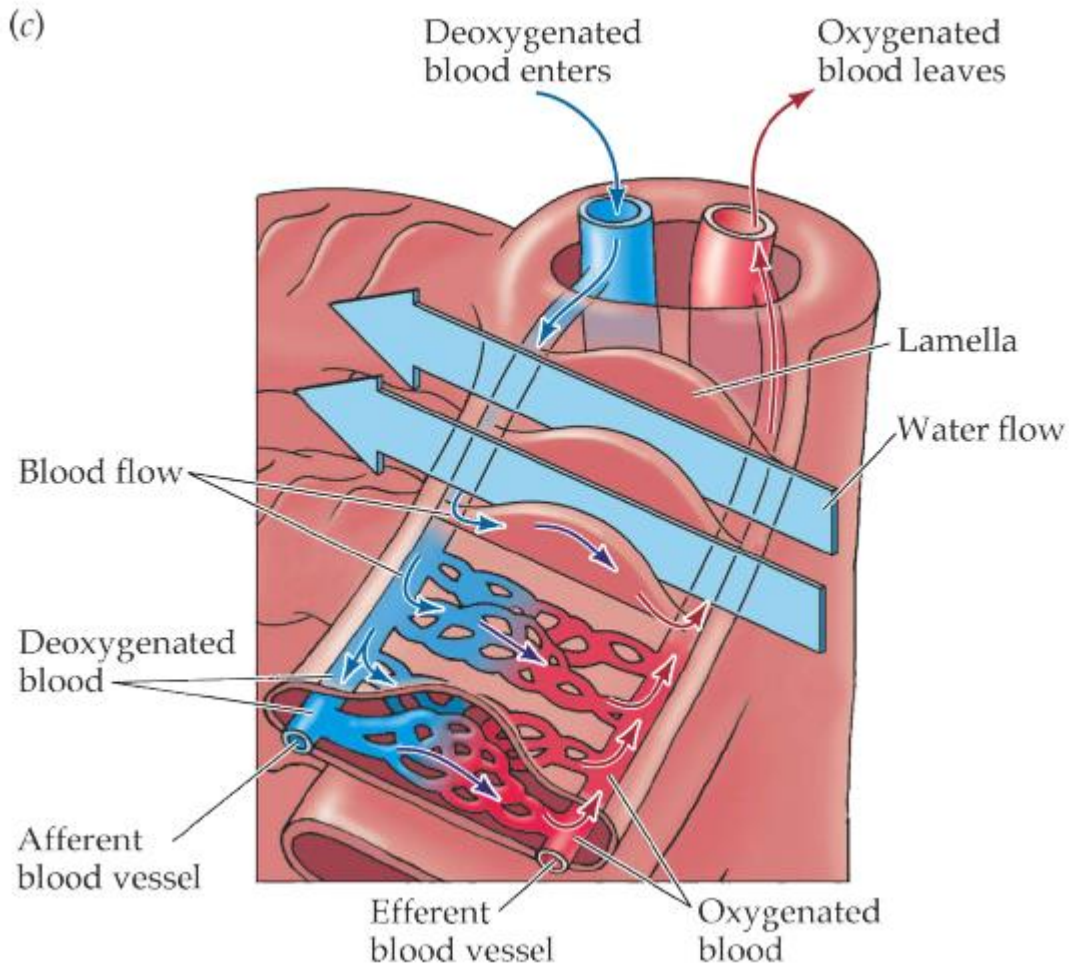
Getting Oxygen From Water : Fish Gills

- Each gill made by four bony **gill arches**
- Gill arches lined with hundreds of **gill filament** that are very **thin** and **flat**



Getting Oxygen From Water : Fish Gills

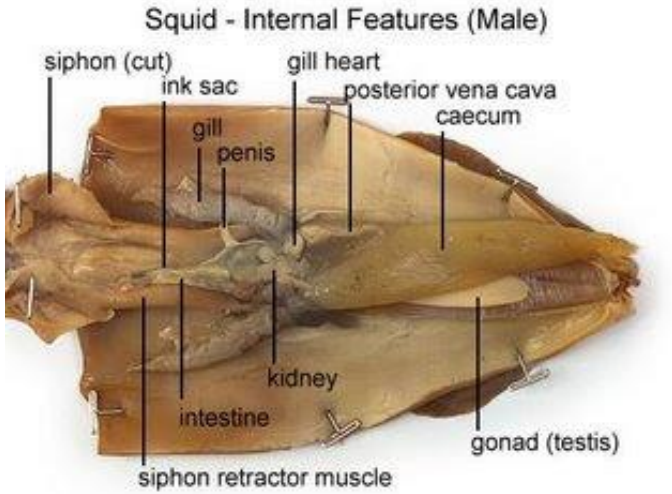
- Gill filaments are have folds called **lamellae** that contain a network of **capillaries**
- Blood flows through the blood capillaries in the **opposite direction** to the flow of water

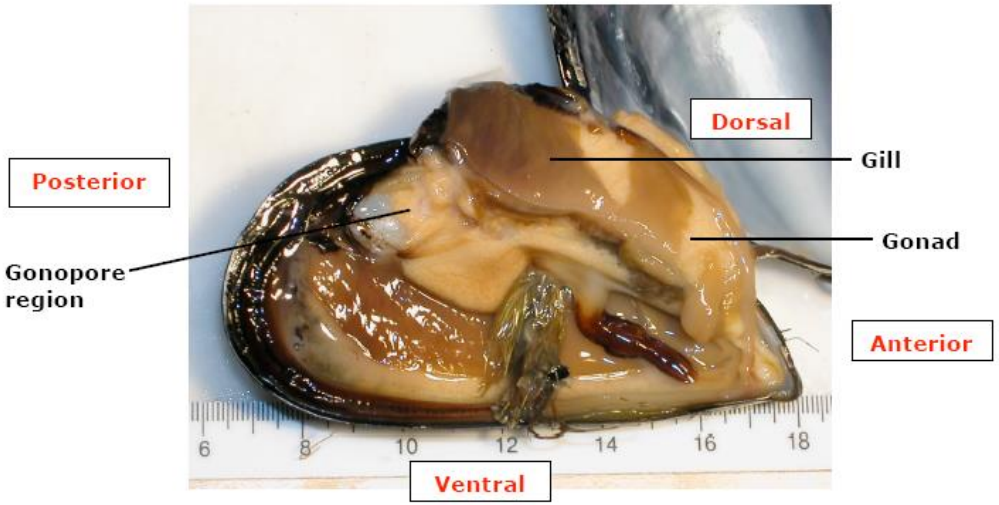


Getting Oxygen From Water : Gill Ventilation

Gills are ventilated by moving gills through water, or by moving water over gills. Its necessary for supplying oxygen.

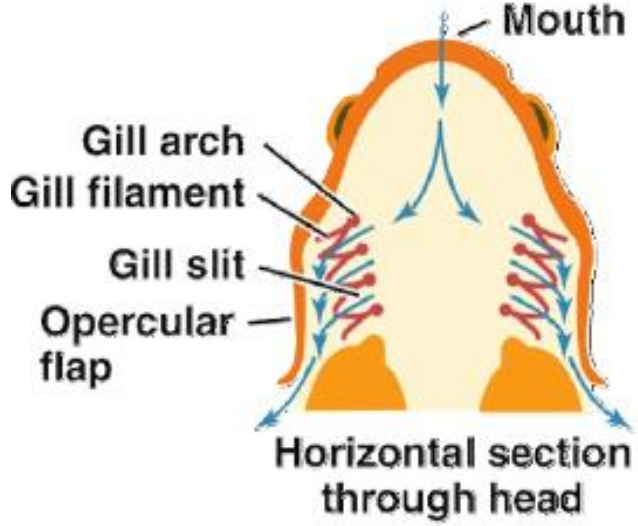
- Crayfish and lobster move water over gills with appendages
- Mussels and clams move water by cilia
- Squid/octopus pull in and eject water through their gills

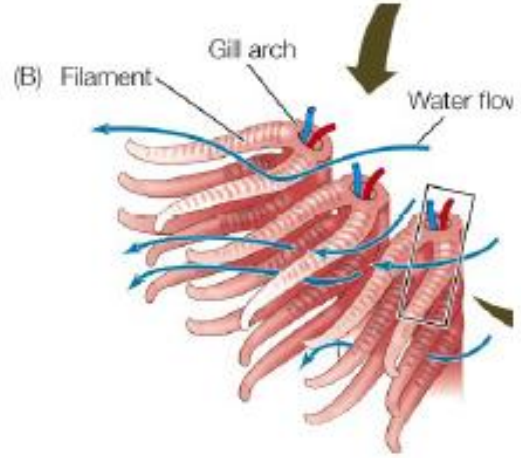




Getting Oxygen From Water : Gill Ventilation

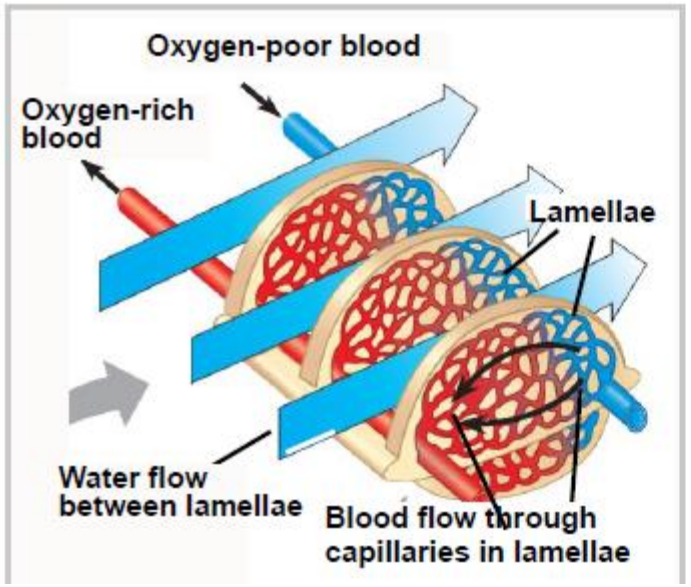
- Fish move water over gills as they swim
- Water flow is *unidirectional* enters mouth, passes through pharynx, flows over gills and exits body
- Gill filaments are covered with gill lamellae = lots surface area and minimal path length for gas exchange

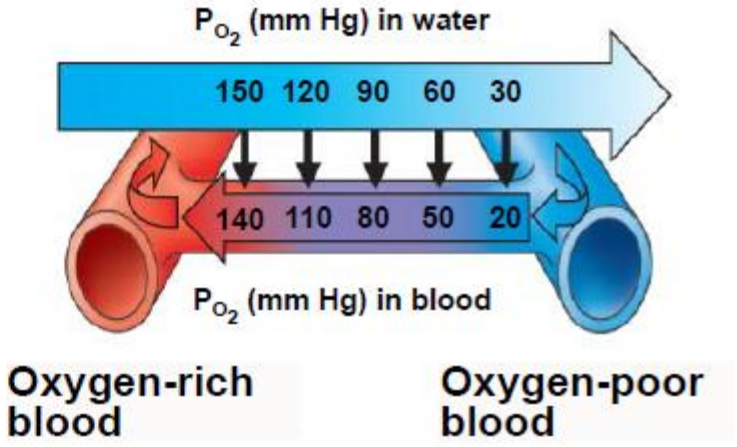




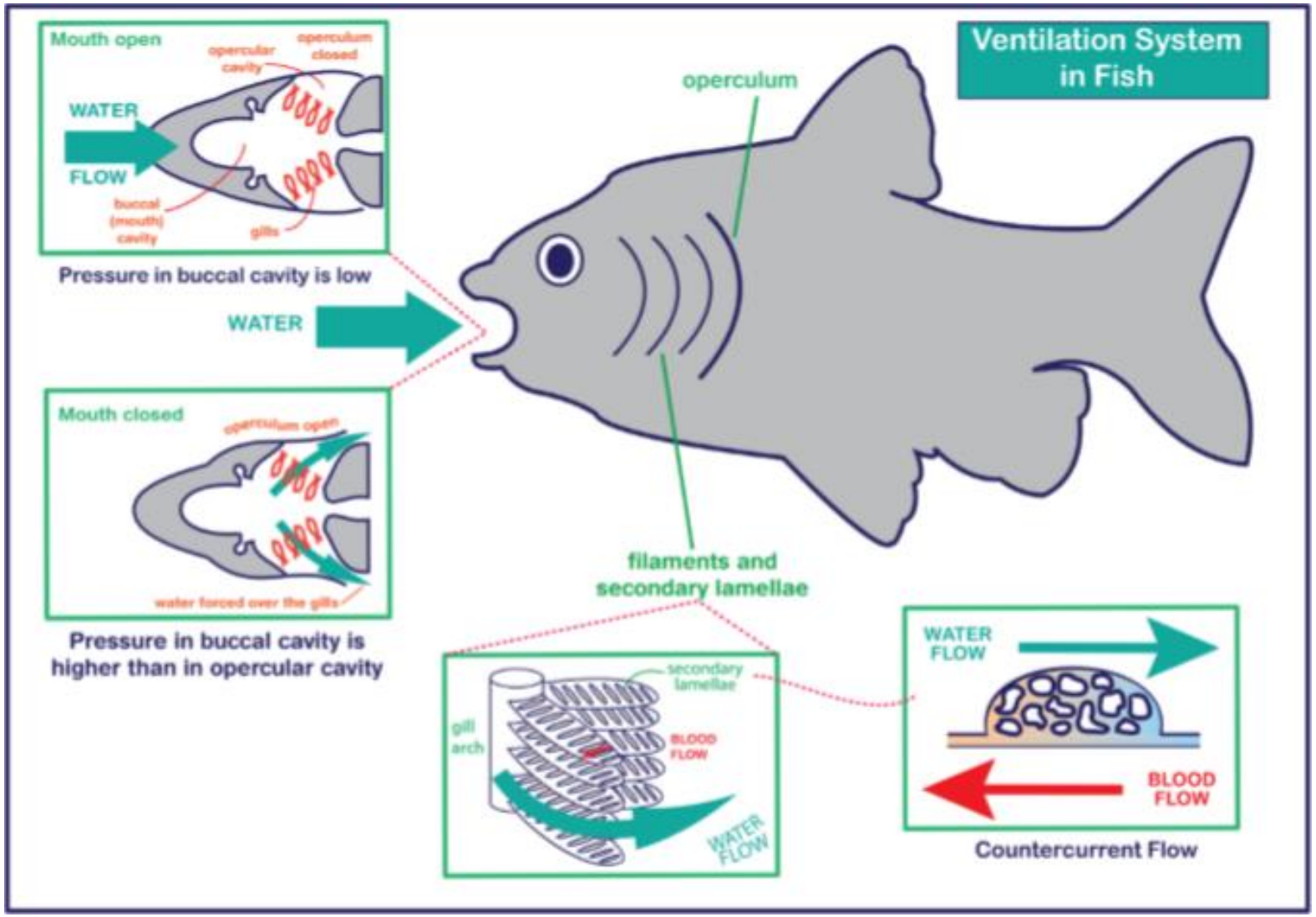
Getting Oxygen From Water : Gill Ventilation

Fish use highly efficient **countercurrent exchange** - over 80% of oxygen in water passing over gills is extracted





Getting Oxygen From Water : Gill Ventilation



Enhacing The Efficiency Of Fish Gills

- Gills have a **very large surface area** : four arches with flat filaments with lamellae
- Gills are **thin-walled** and in close contact with water : short distance for diffusion
- Gills have a **very high blood supply** to bring CO_2 and carry away O_2– dark red colour
- Gills are **moist**
- Countercureent flow : **opposite direction** – maintains a **favourable concentration gradient** for diffusion of both gasses

Gas Exchange : Amphibians

Amphibians exchange gases across four surfaces.

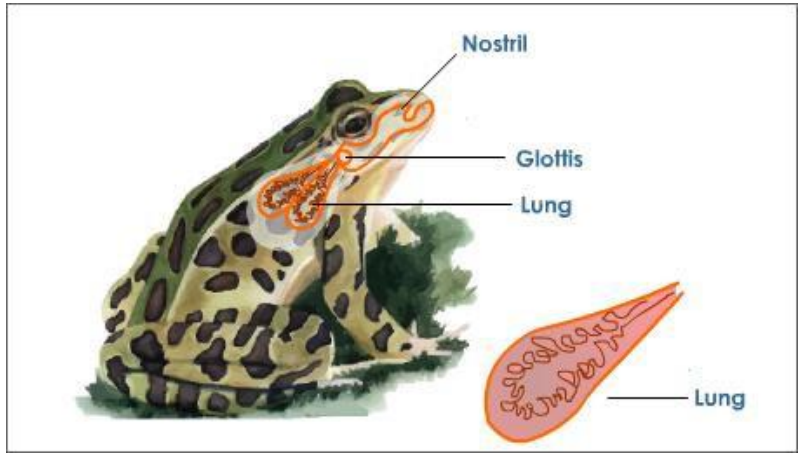
1. Gills
2. Lungs
3. Skin/cutaneous respiration
4. Buccopharyngeal respiration

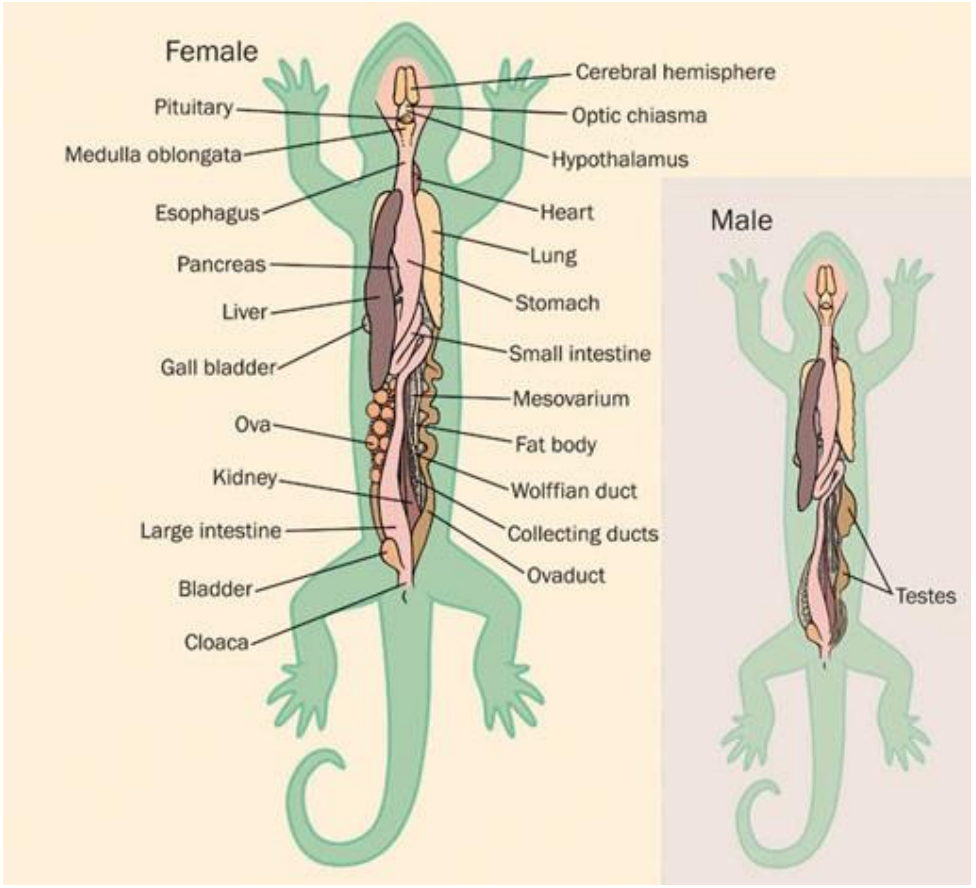
Amphibians : Gills

The gill arches may be inside or outside the animal's head

Amphibians : Lungs

Not all amphibians have them (frog). Salamanders and caecilians have simple lungs

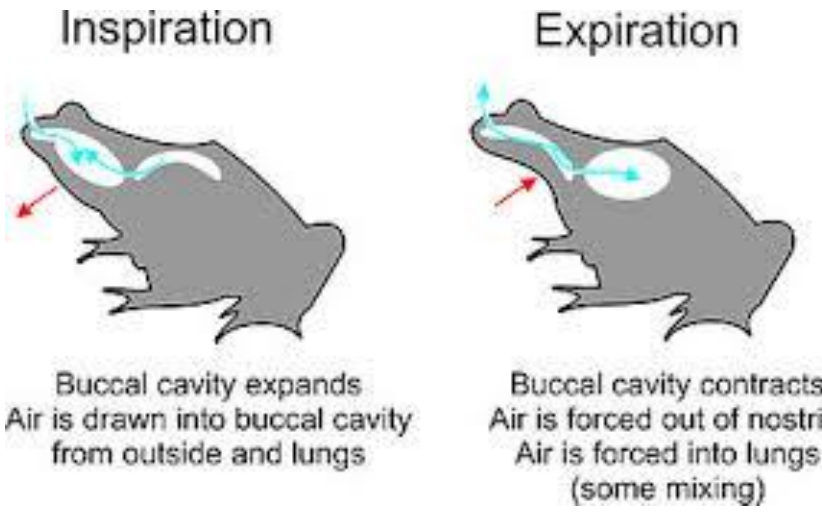


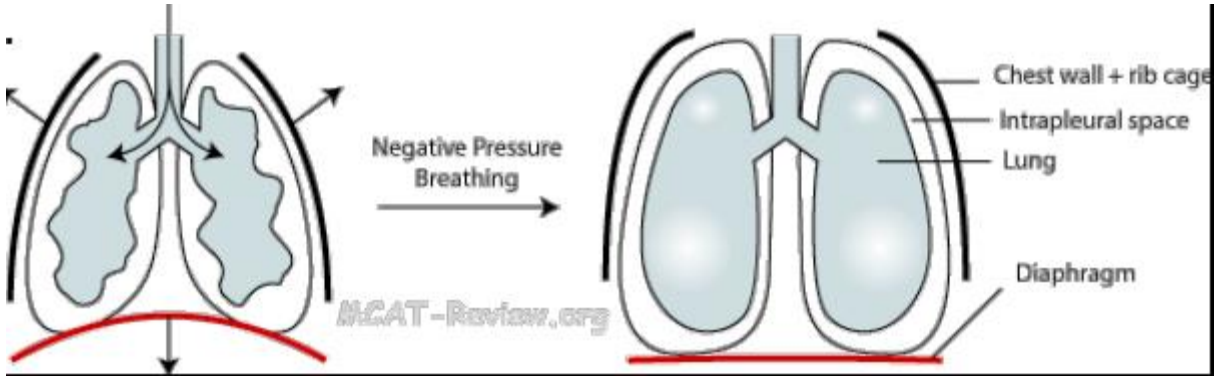


Amphibians : Lungs

Most terrestrial vertebrates (and some others) use **tidal** ventilation in lungs. Lungs must be in contact with the circulatory system to transport oxygen to body.
Ventilation of the lungs can occur by :

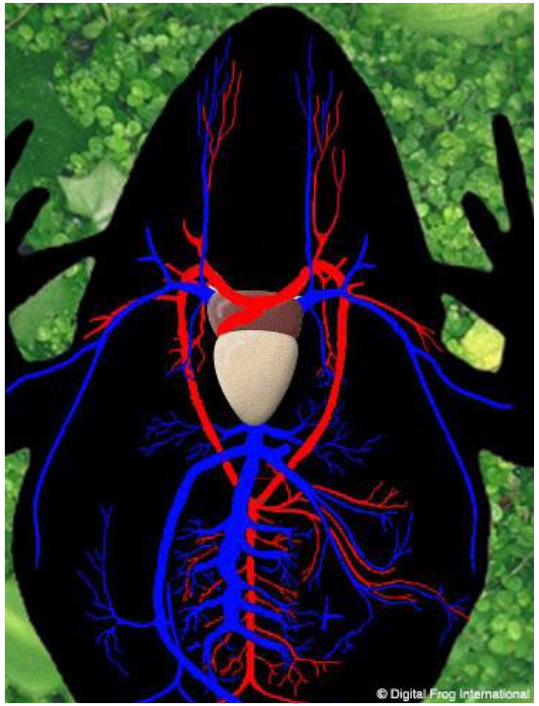
- **Positive pressure** (air gulping)
- **Negative pressure** (expanding the lungs)

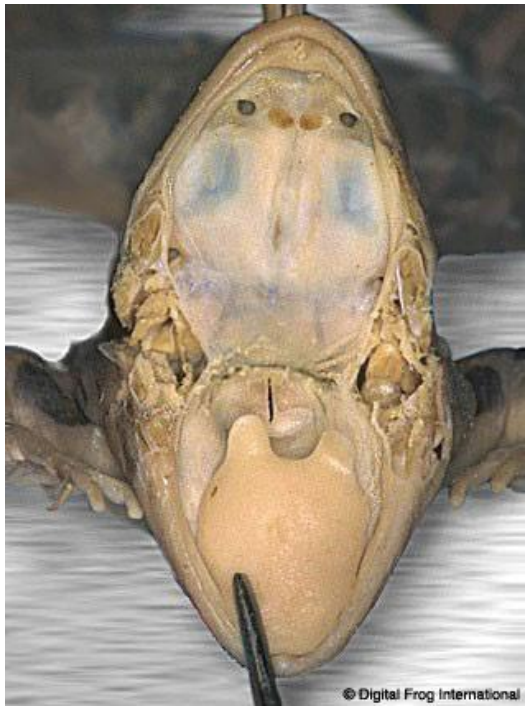




Amphibians : Buccopharyngeal Respiration

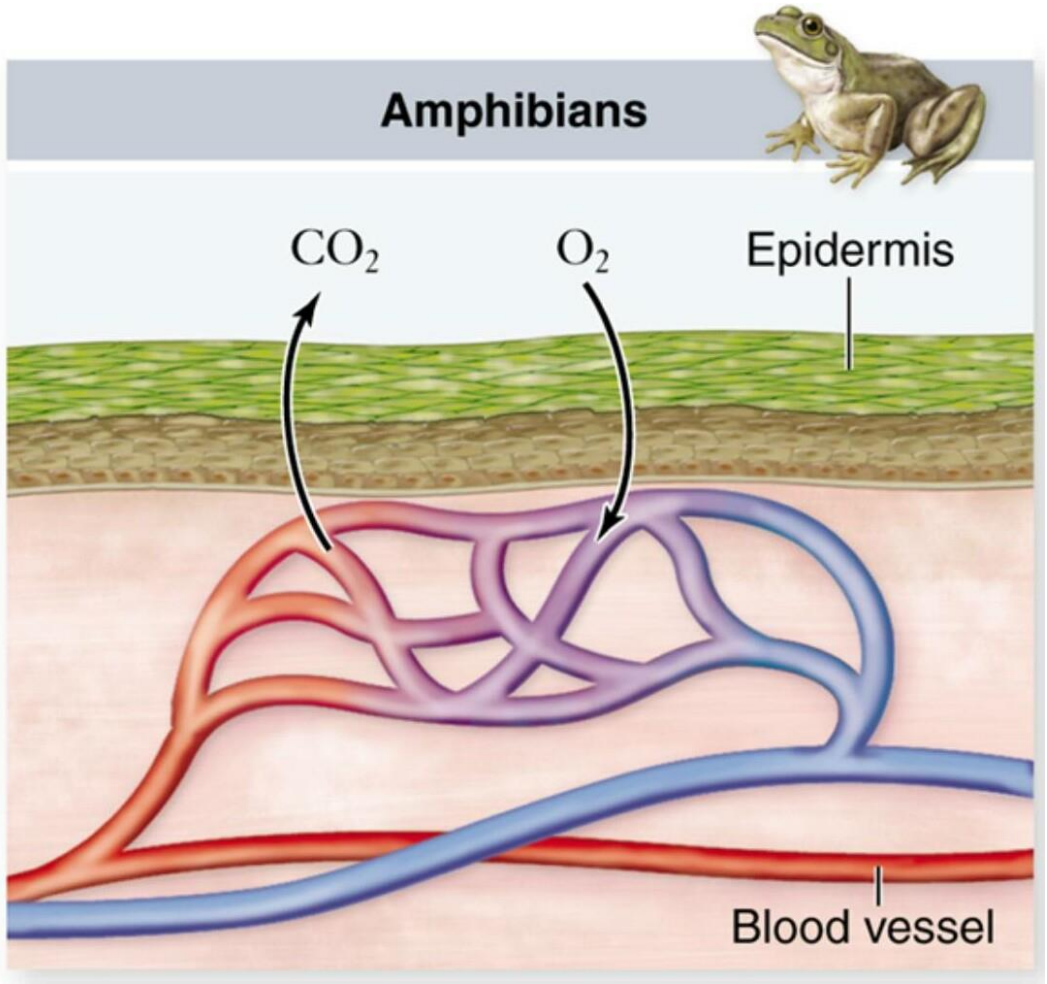
Through the lining of the mouth and throat. The throat of all amphibians has many blood vessels. Gases can difuse into or out of those blood vessels with relative efficiency





Amphibians : Cutaneous Respiration

The exchange of gases across the surface of the skin. In order for this to take place, the skin must remain moist



Thank You