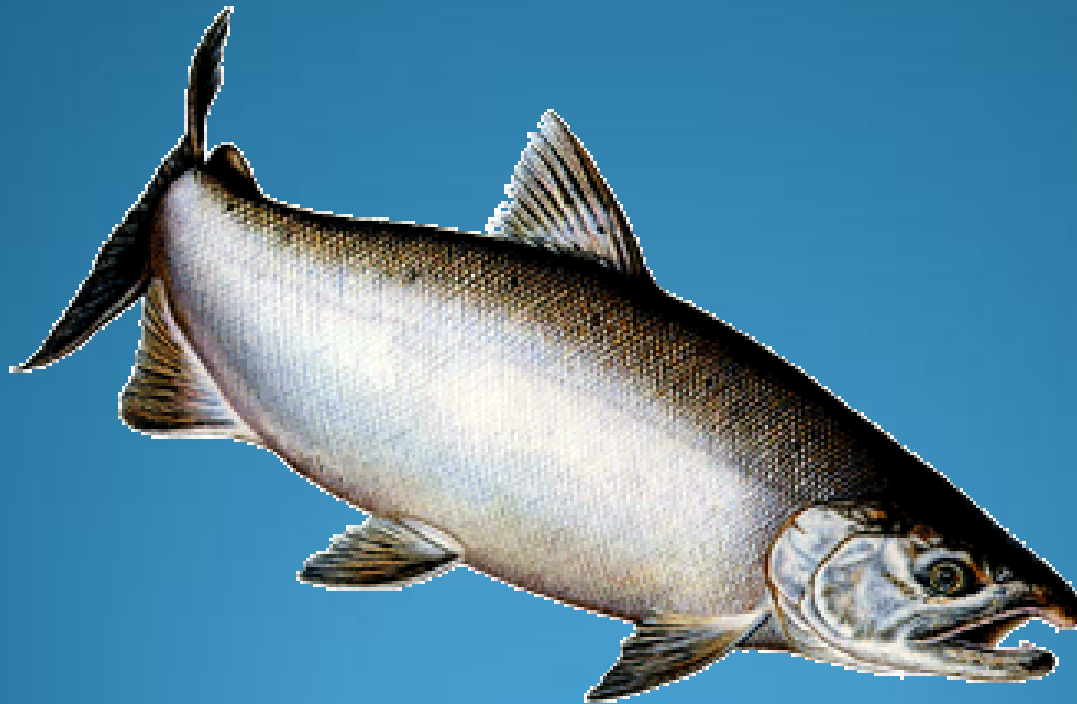
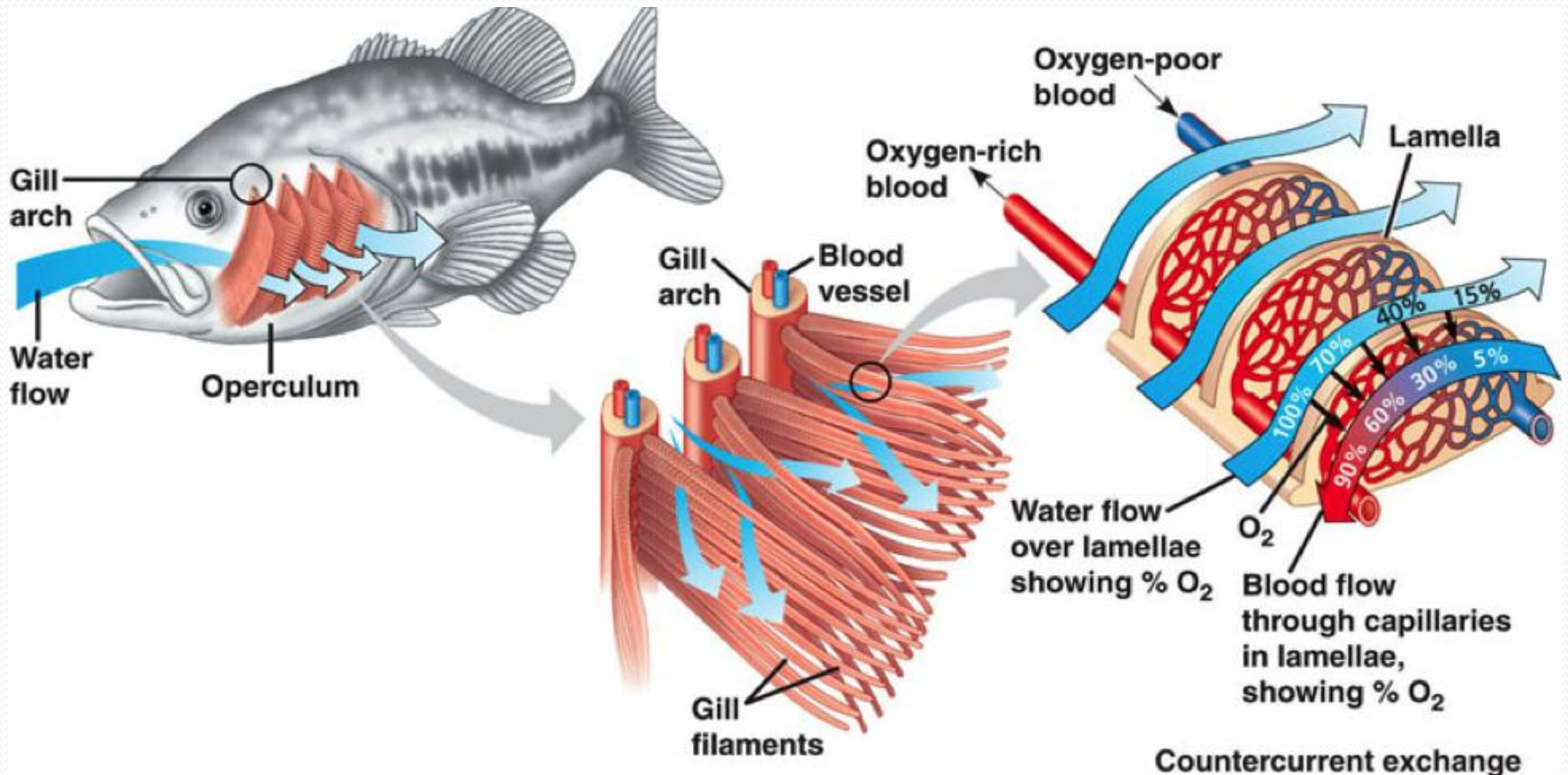


Gas Exchange in Fish

How do fish breath?



BONY FISH



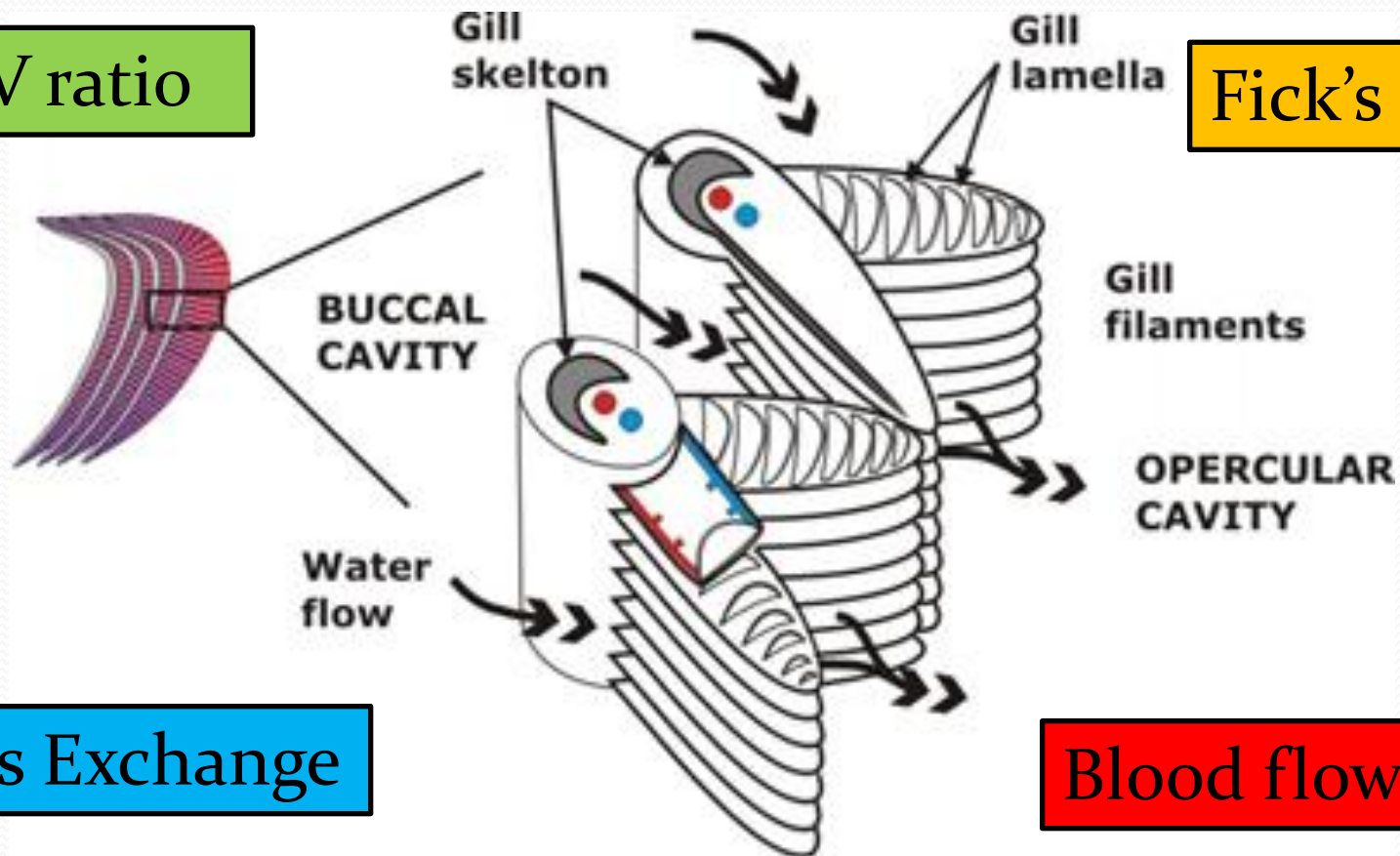
How is the structure of the gills related to its function?

Think:

Specialised exchange surface

SA/V ratio

Fick's Law

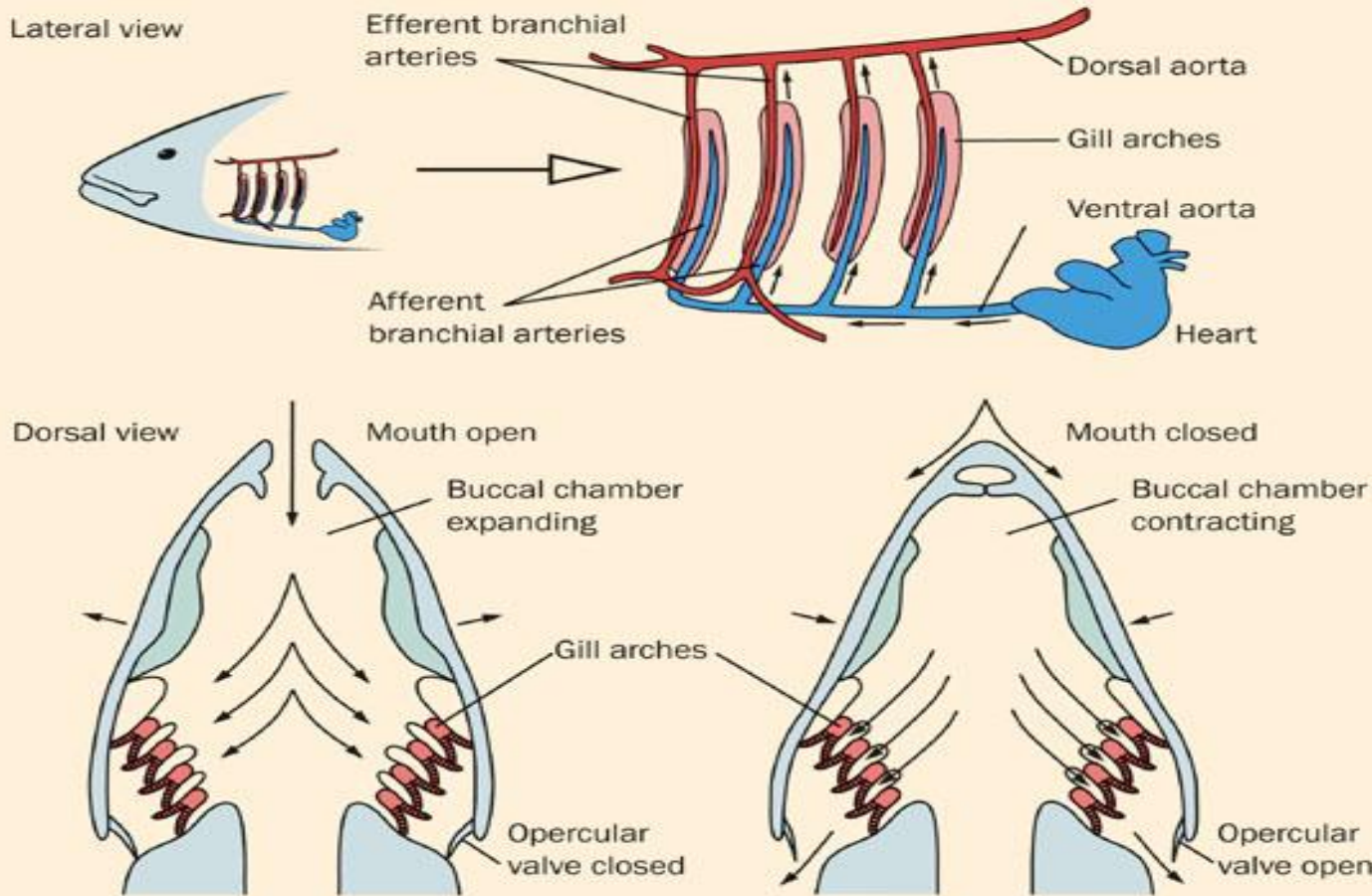


Gas Exchange

Blood flow

BONY FISH

<http://www.s-cool.co.uk/a-level/biology/gas-exchange/revise-it/gas-exchange-in-fish>



Blood flows between gill plates under pressure in opposite direction of blood in capillaries. As blood always meets water with higher O₂ content it removes 80% of O₂ from water.

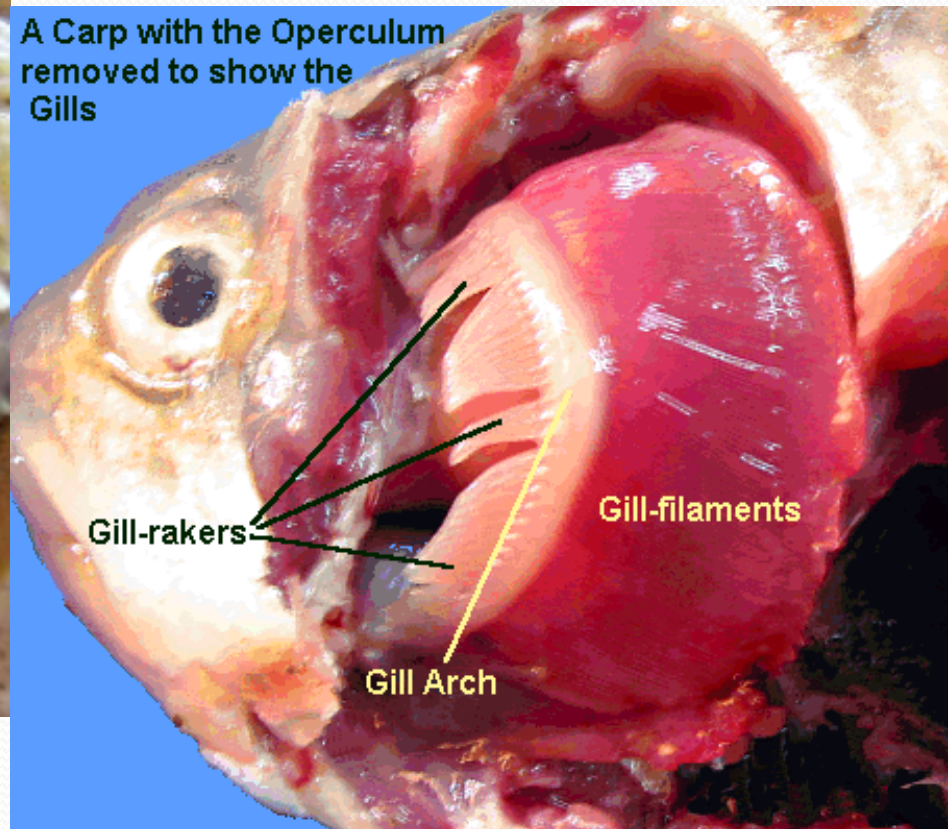
Water flows past the gills in the opposite direction to the blood (**countercurrent flow**) – so they can extract oxygen at **3xs the rate a human can**.

Fish head dissection

<http://www.youtube.com/watch?v=pNZQEmGpuk>

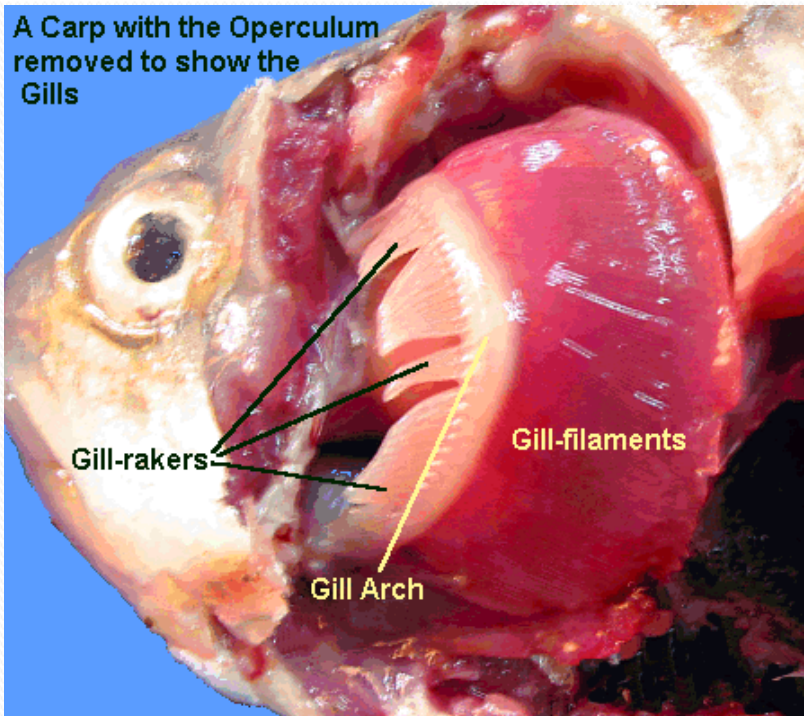


A Carp with the Operculum removed to show the Gills



How many filaments?

- You will have to work out how many filaments a fish has in your Unit Standard



How will you do it?

Step 1: count the number of filaments in a cm piece of gill arch

Step 2:

Aim

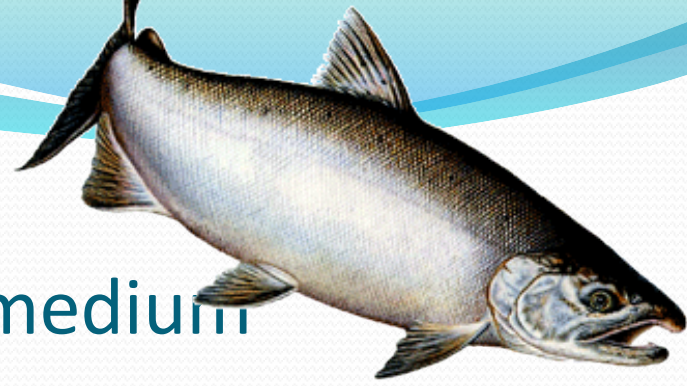
To understand the physiological adaptations of fish for gas exchange

In depth – Bony fish

General – Cartilaginous fish

A Fishy Issue

Problem of water as an exchange medium



Problems:-

- Water has ~20x less oxygen per cm³ than air
- Water is denser/more viscous (777 x's) than air

So fish need.....

- An efficient *surface* to obtain oxygen
- Mechanisms to maximise water movement over the surface

There are 2 different types of fish:

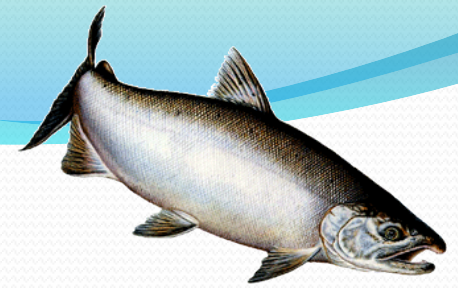
Do you know the differences?

Cartilaginous

Bony



COMPARISONS



CARTILAGINOUS

- Have a skeleton made up of cartilage.
- Most live in the sea.
- Blood travels through the gills in the **SAME** direction as the water :- **PARALLEL FLOW**

BONY

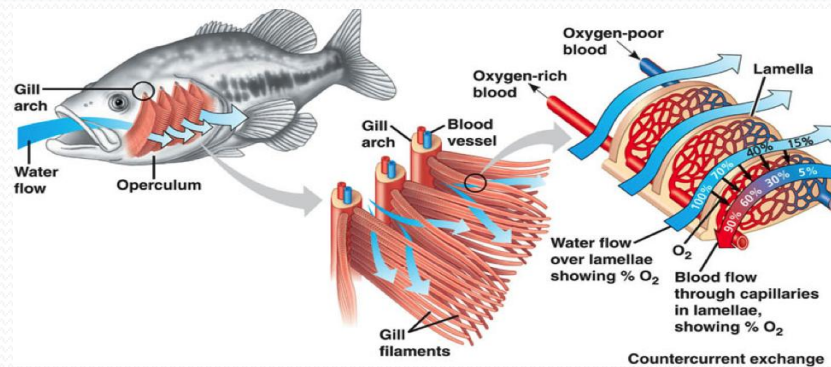
- Are by far the most numerous.
- Live in both fresh and salt water .
- Blood in the gill capillaries flows in the **OPPOSITE/ACROSS** direction to the water flowing over the ***gill plates*** in **COUNTER-CURRENT FLOW.**

BONY FISH

Animation of process

The ventilation mechanism for forcing water over the gill is:
Water flows in:

Structure	What is does
Mouth	
Operculum	
Buccal cavity floor	
Volume	
Pressure	

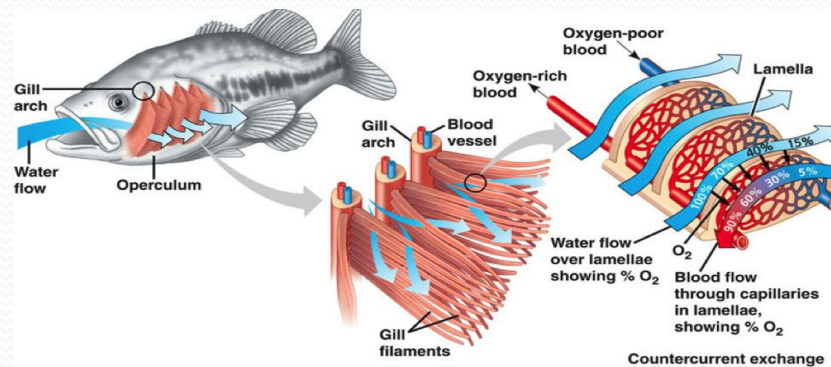


BONY FISH

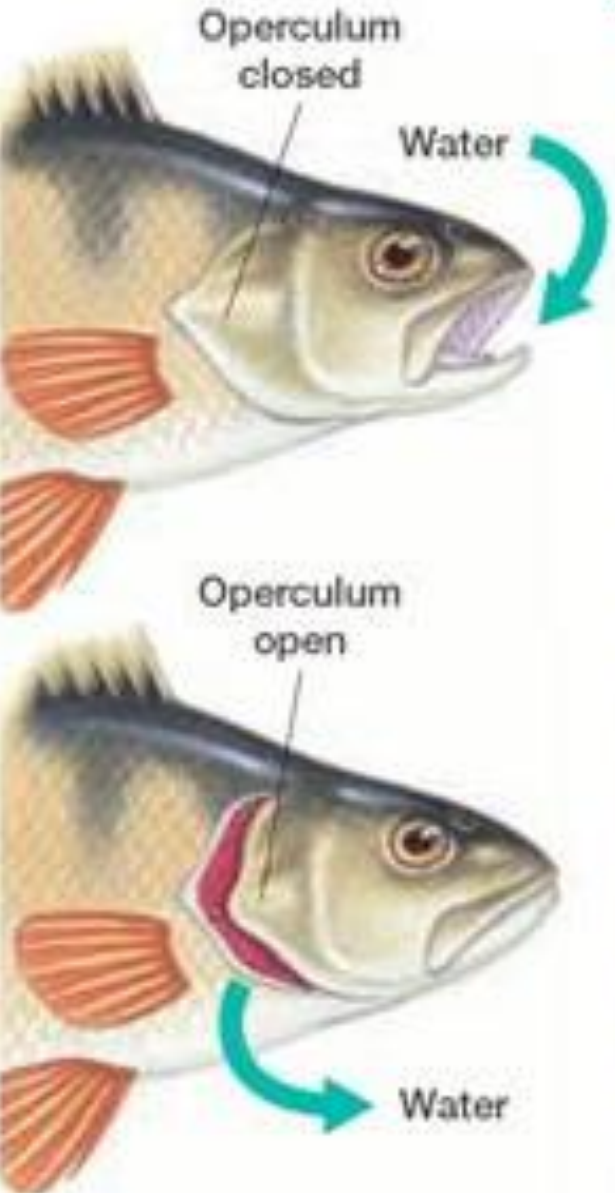
Animation of process

The ventilation mechanism for forcing water over the gill is:
Water flows in:

Structure	What it does
Mouth	Opens
Operculum	Closes
Buccal cavity floor	Lowered (making cavity larger)
Volume	increases
Pressure	decreases



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

Ventilation of Gills in Bony Fish



TO TAKE IN WATER

Pressure within the mouth decreases when:

The mouth opens and the floor of the mouth cavity is lowered increasing the size of the mouth

The **OPERCULUM** (gill cover) closes the opening at the back of the throat (pharynx)

Water rushes into the mouth



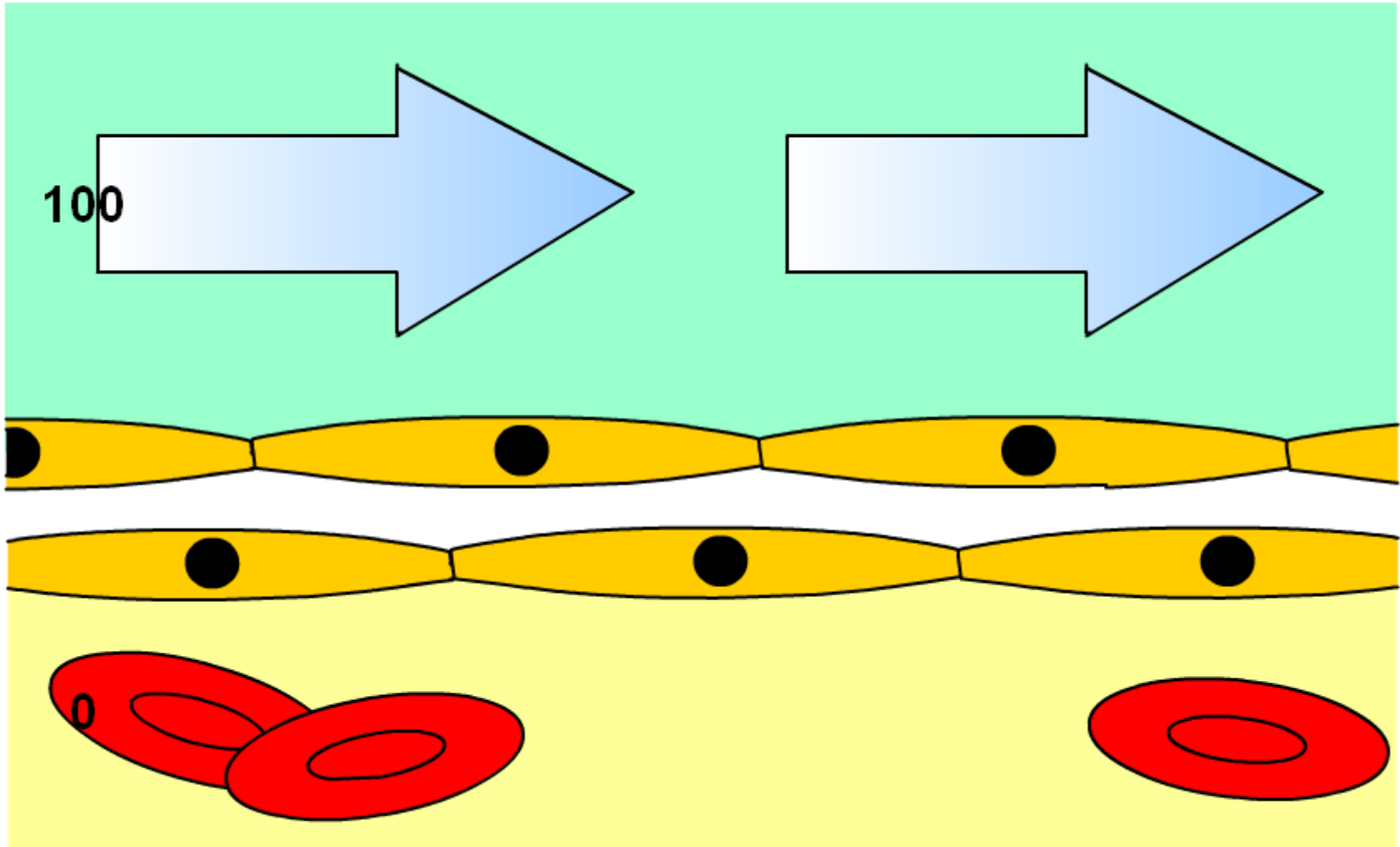
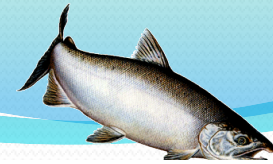
FOR WATER TO PASS OUT:-

Pressure within the mouth decreases when:-

The mouth closes and the floor of the mouth cavity is raised decreasing the size of the mouth

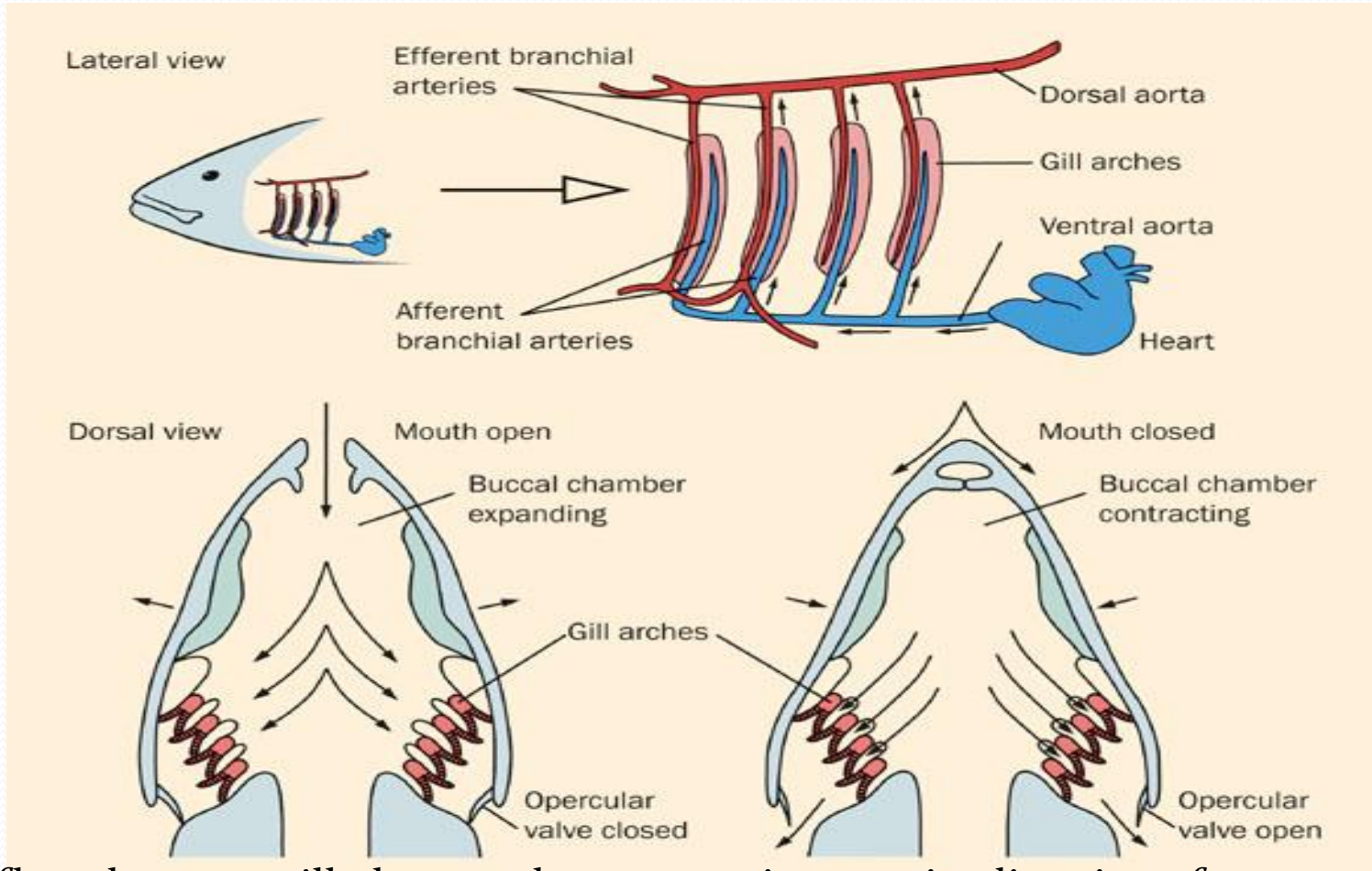
The **OPERCULUM** (gill cover) opens and due to the increase in pressure, the water flows out over the gills.

PARALLEL FLOW (Cartilaginous)



BONY FISH

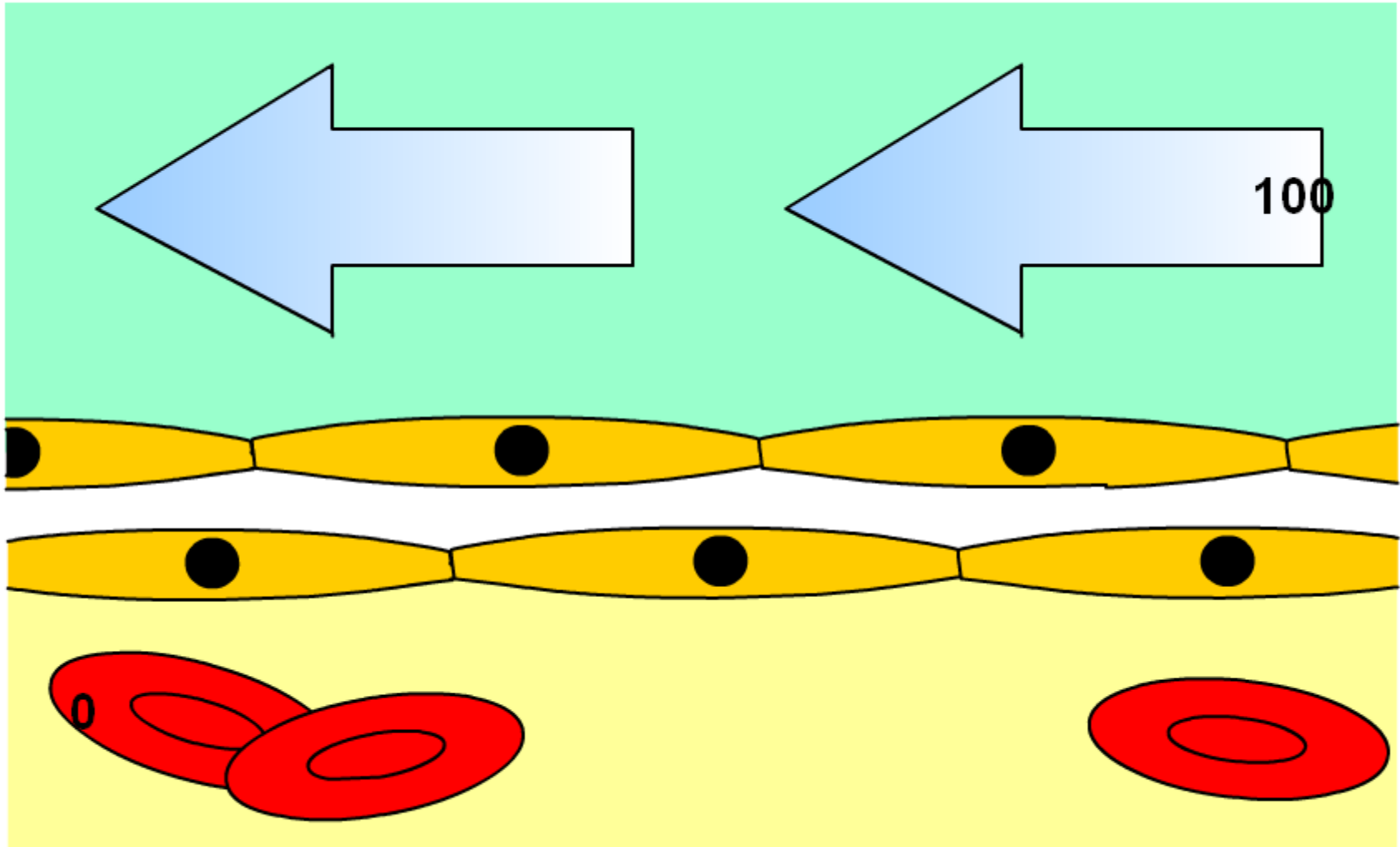
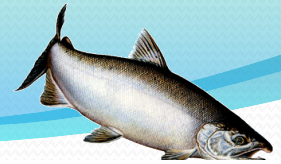
<http://www.s-cool.co.uk/a-level/biology/gas-exchange/revise-it/gas-exchange-in-fish>



Blood flows between gill plates under pressure in opposite direction of water (countercurrent flow). Blood always meets water with higher O₂ content it removes 80% of O₂ from water.

3xs the rate of humans

COUNTER-CURRENT FLOW (Bony)



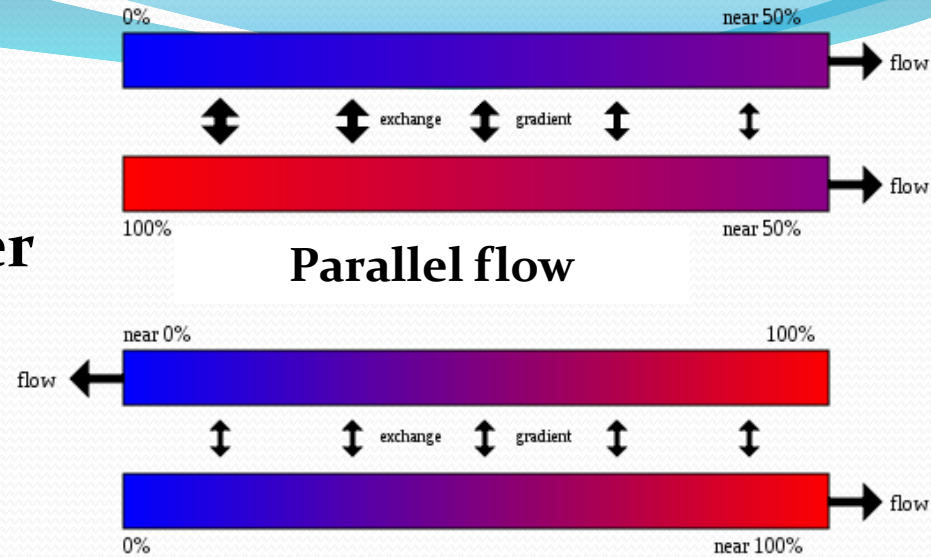
How it works!

We are going to represent water flow over the gill plate/lamellae

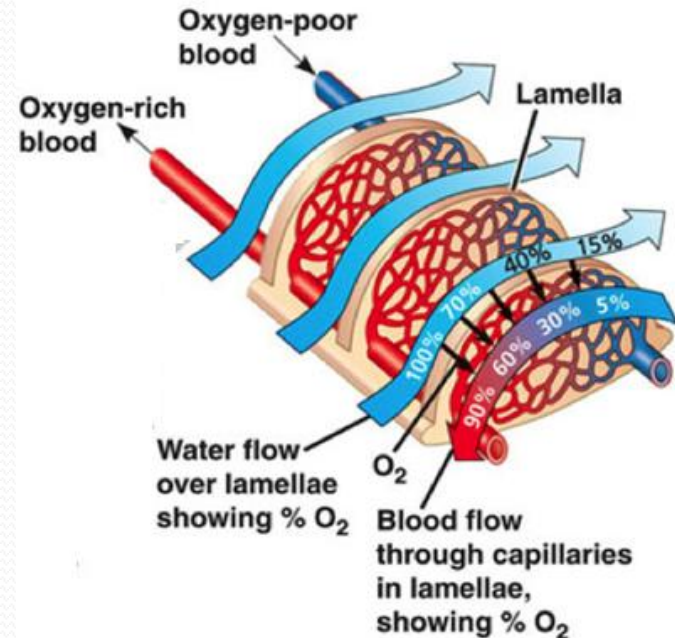
Volunteers –

You are water or red blood cells....

- 4 water molecules with slowly walks across lamellae
- At the end of the lamellae go back to the start and pick up more oxygen
- 4 RBCs in capillary take O₂ from water as it goes past you through lamellae
- At end of lamellae, go back to start and give up all oxygen

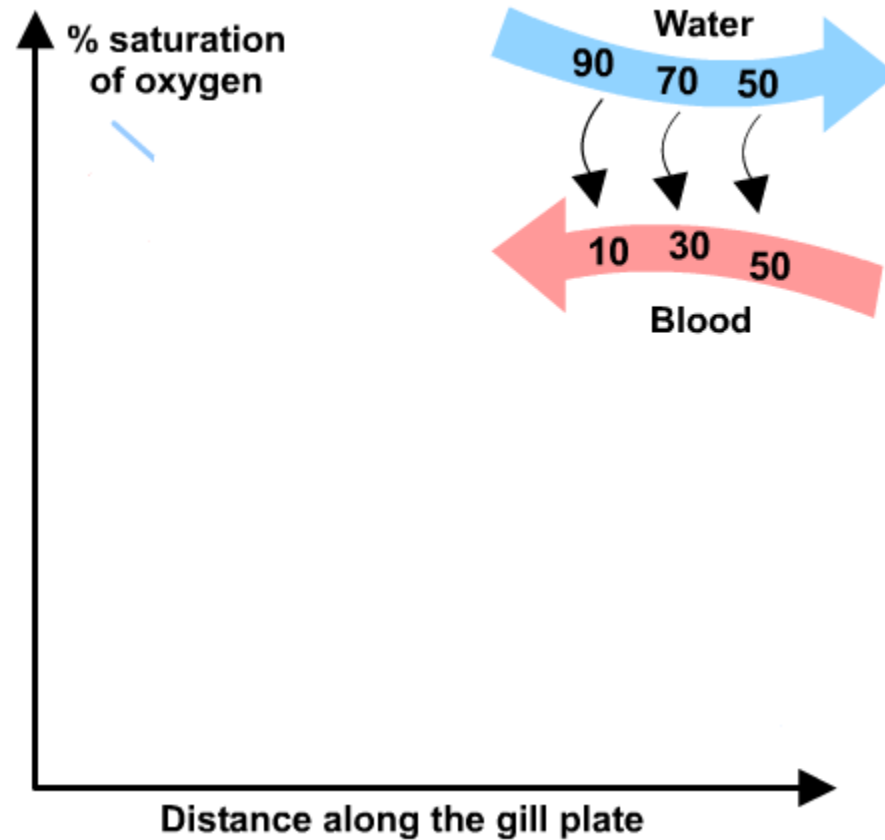
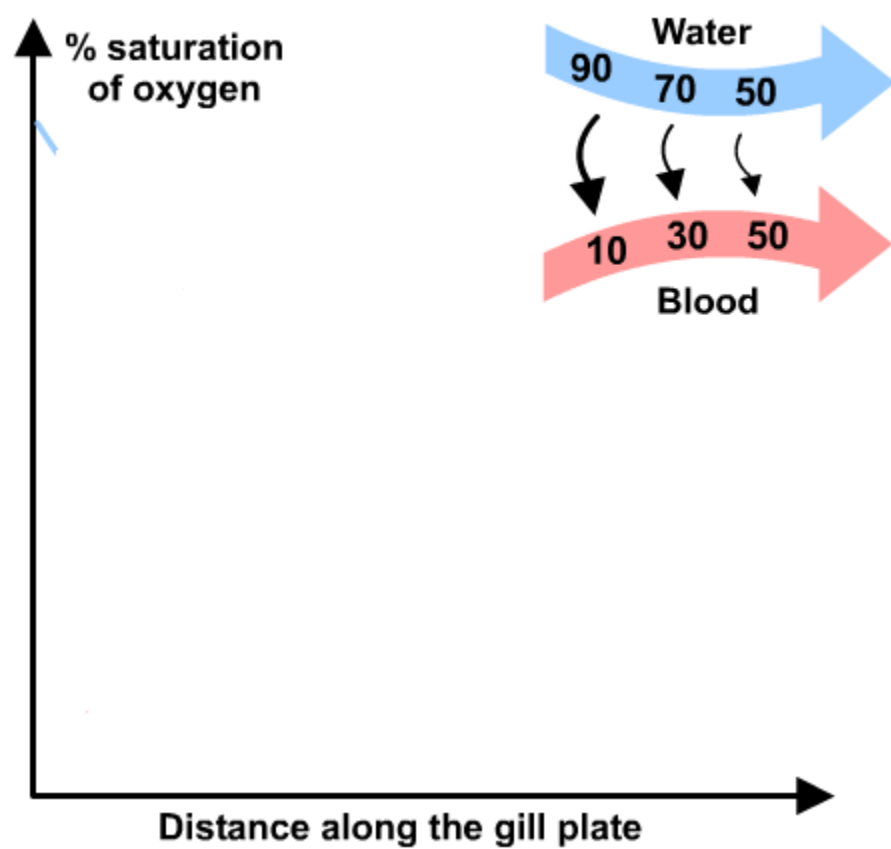


Countercurrent flow

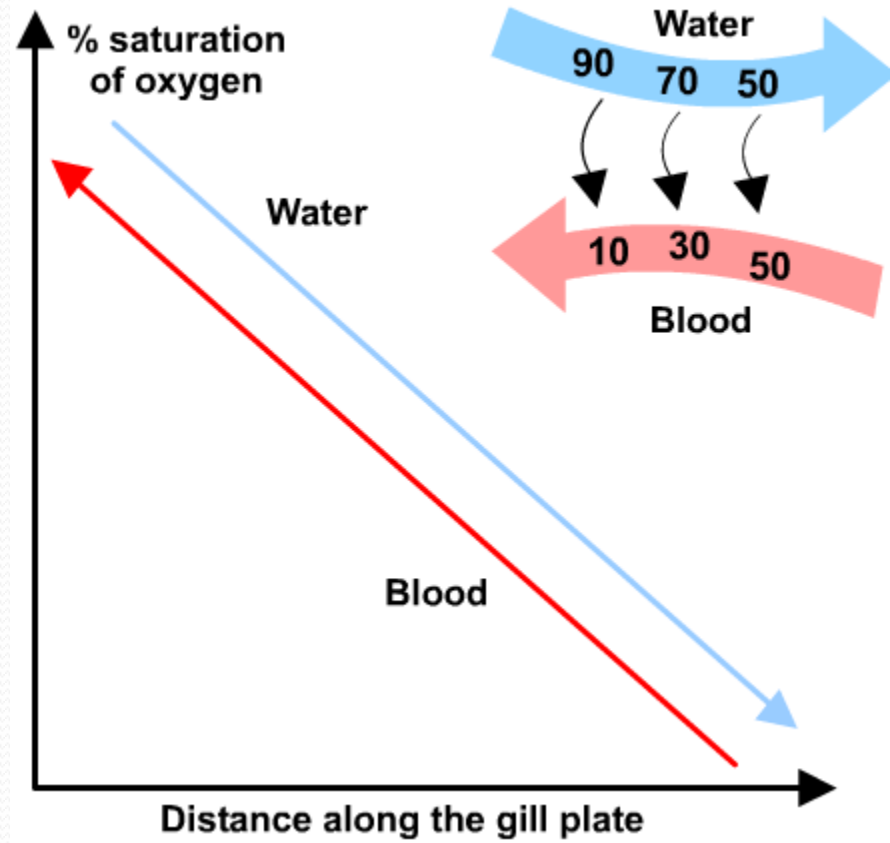
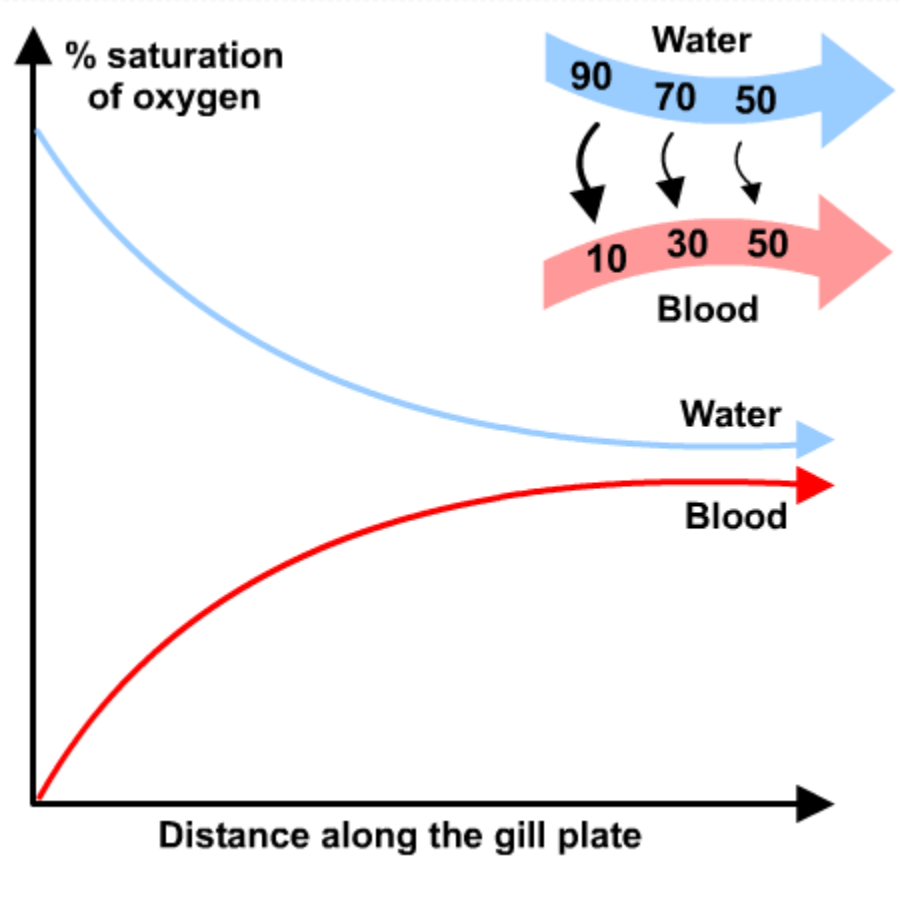


Countercurrent exchange

Draw two lines – a blue line starting from 100% oxygen saturation (on the left) and a red line started from 0% (on the right)



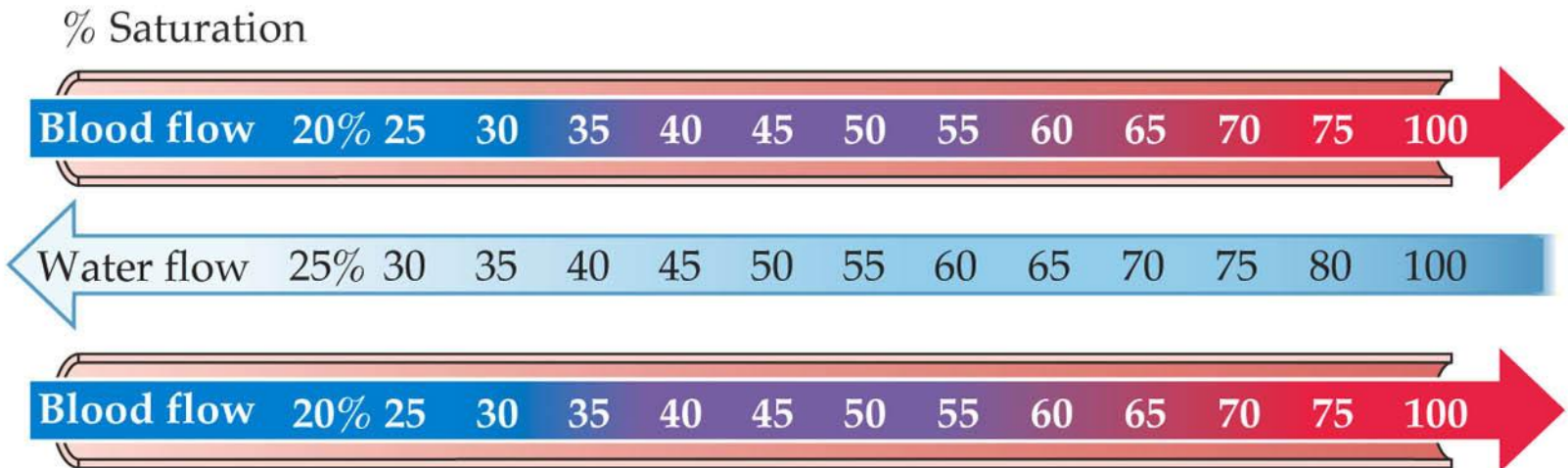
Which is which?



(a) **Concurrent flow**



(b) **Countercurrent flow**



COMPARISONS

CARTILAGINOUS

- Just behind head - **5 gill clefts** open at **gill slits**
- Water in the mouth is forced over the slits when floor of the mouth is raised.

BONY

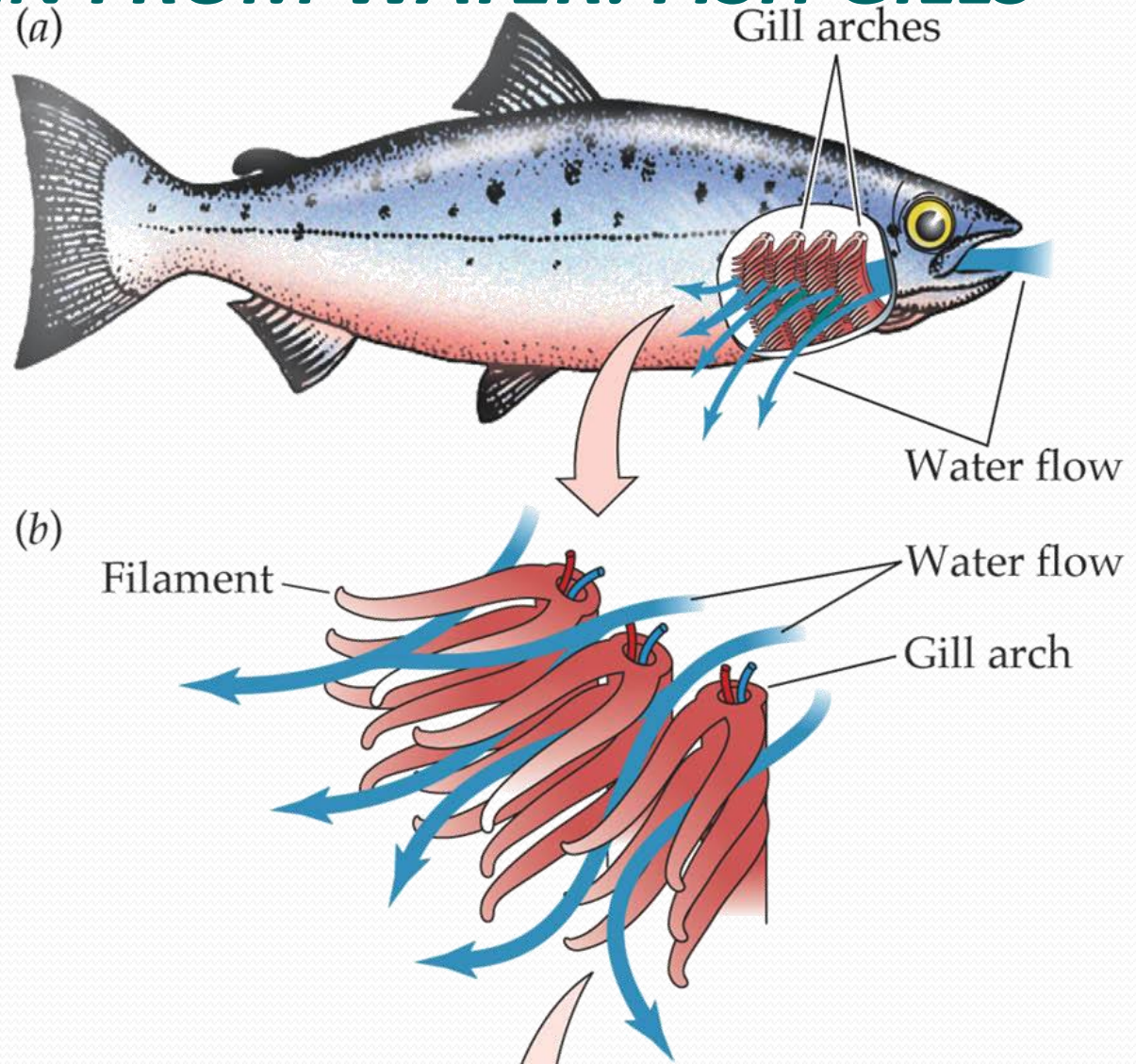
- **4 pairs** of gills and each gill is supported by a **gill arch**.
- Along each arch there are thin plates called **lamellae** + on these there are **gill plates** where gaseous exchange happens
- The gills are covered by a flap called the **OPERCULUM**

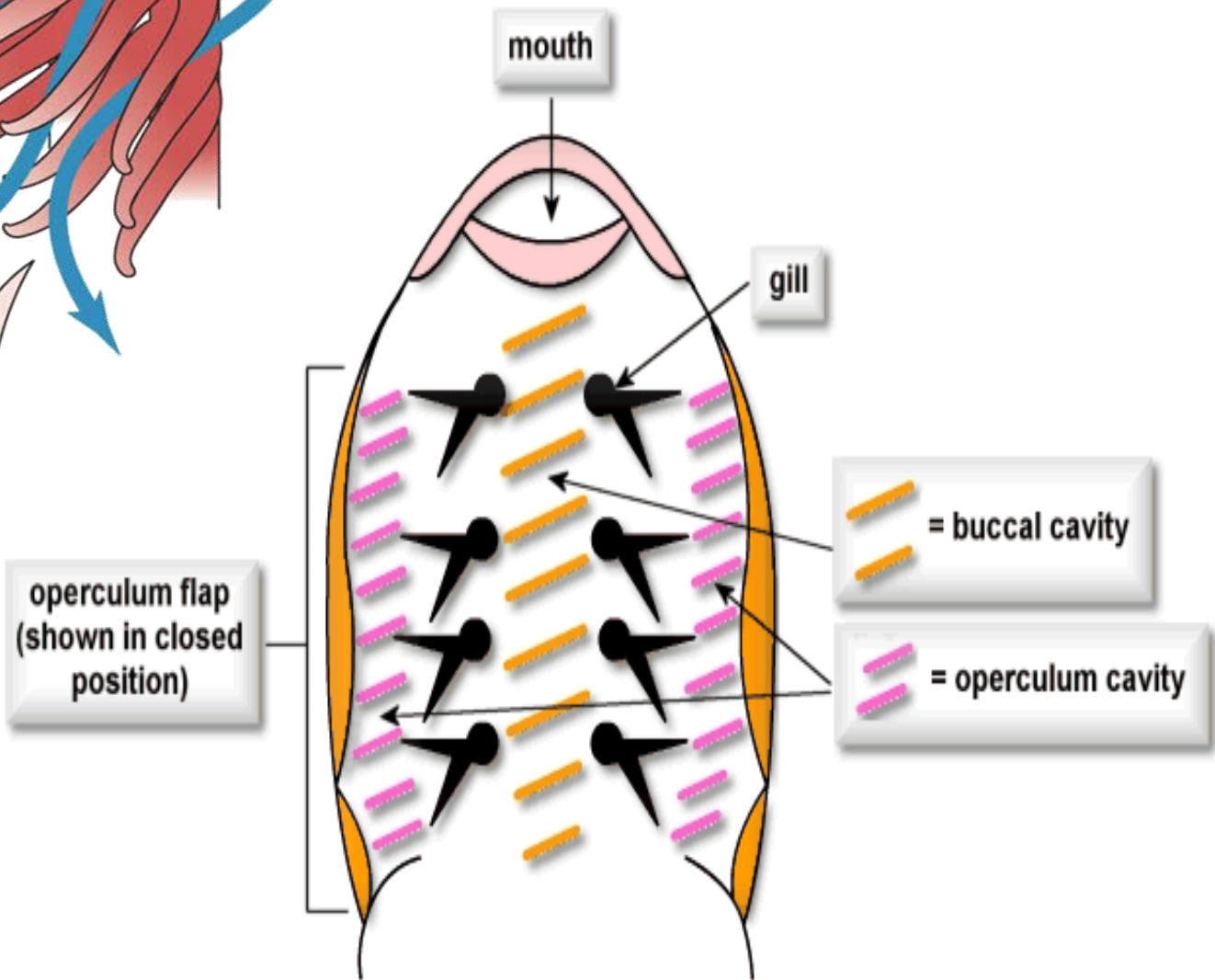
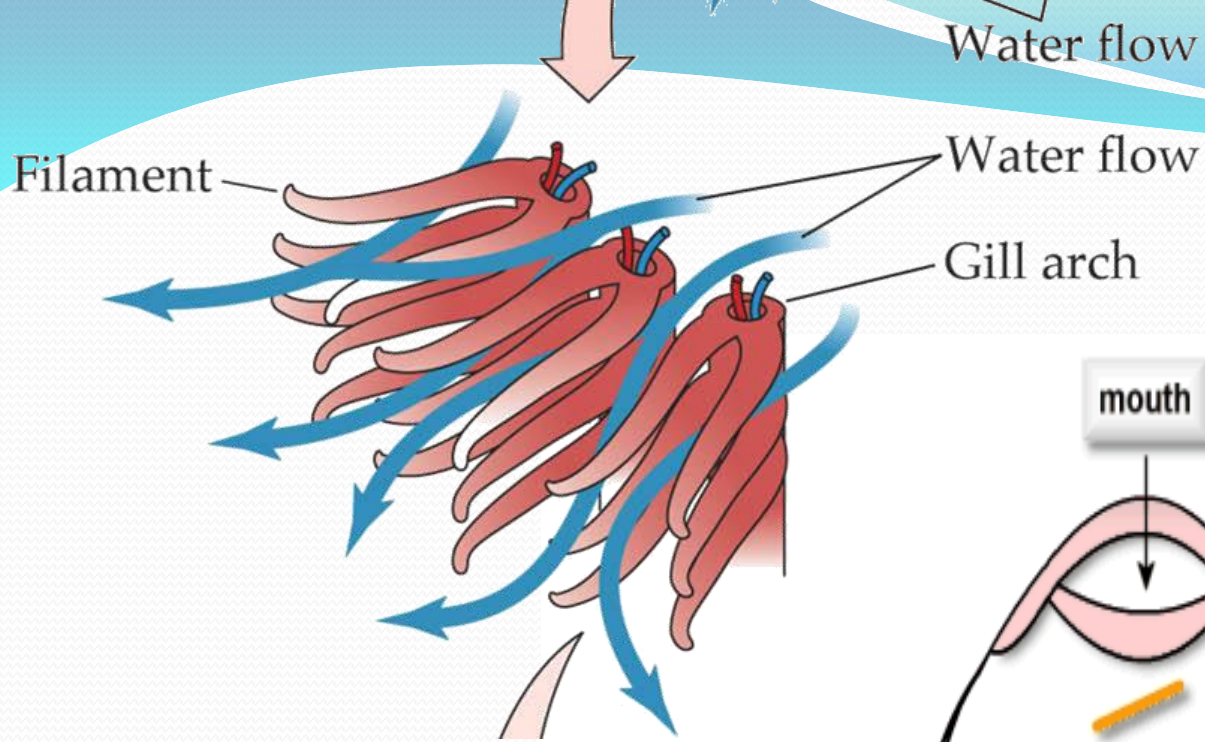


Additional Diagrams

GETTING OXYGEN FROM WATER: FISH GILLS

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

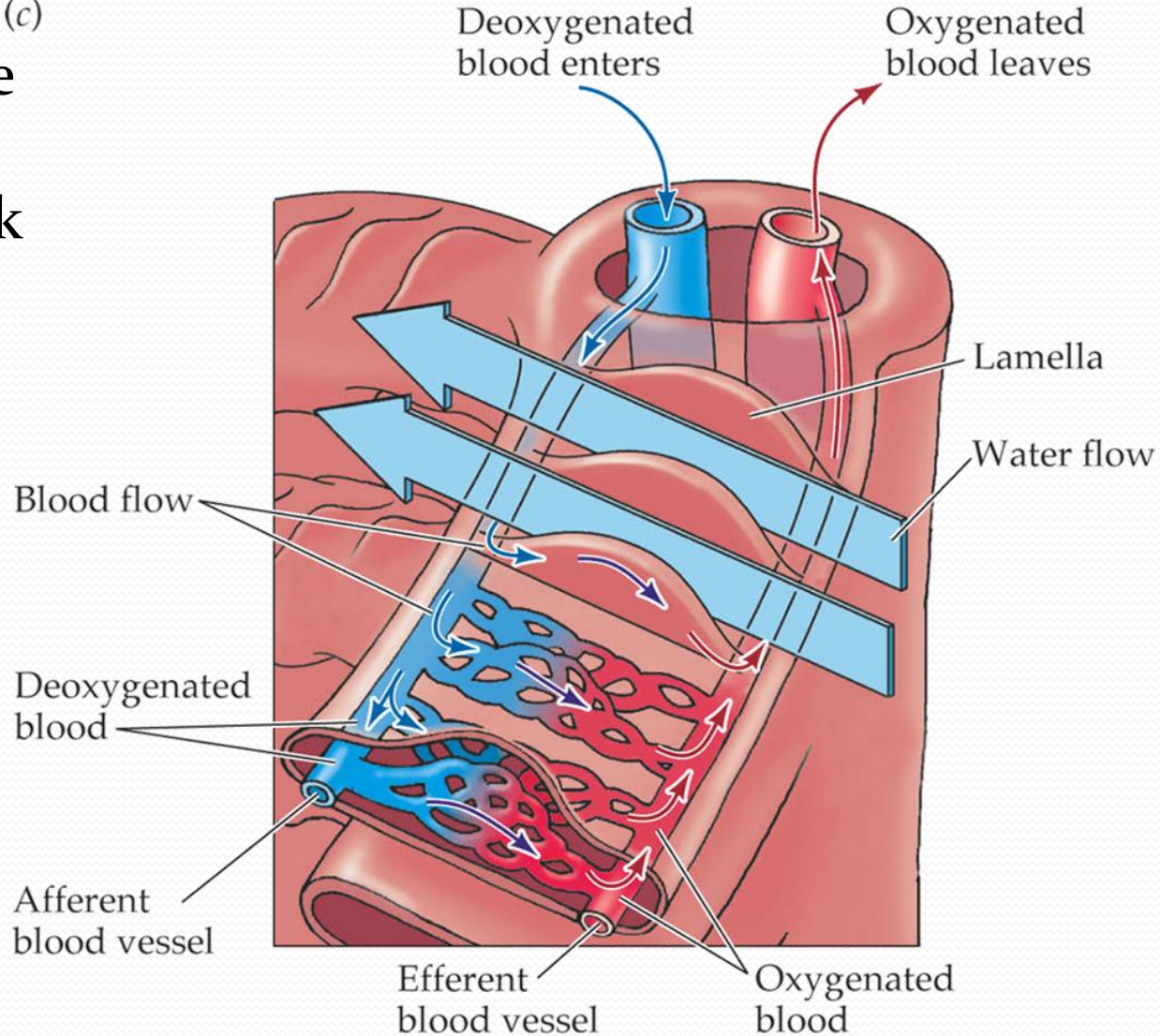


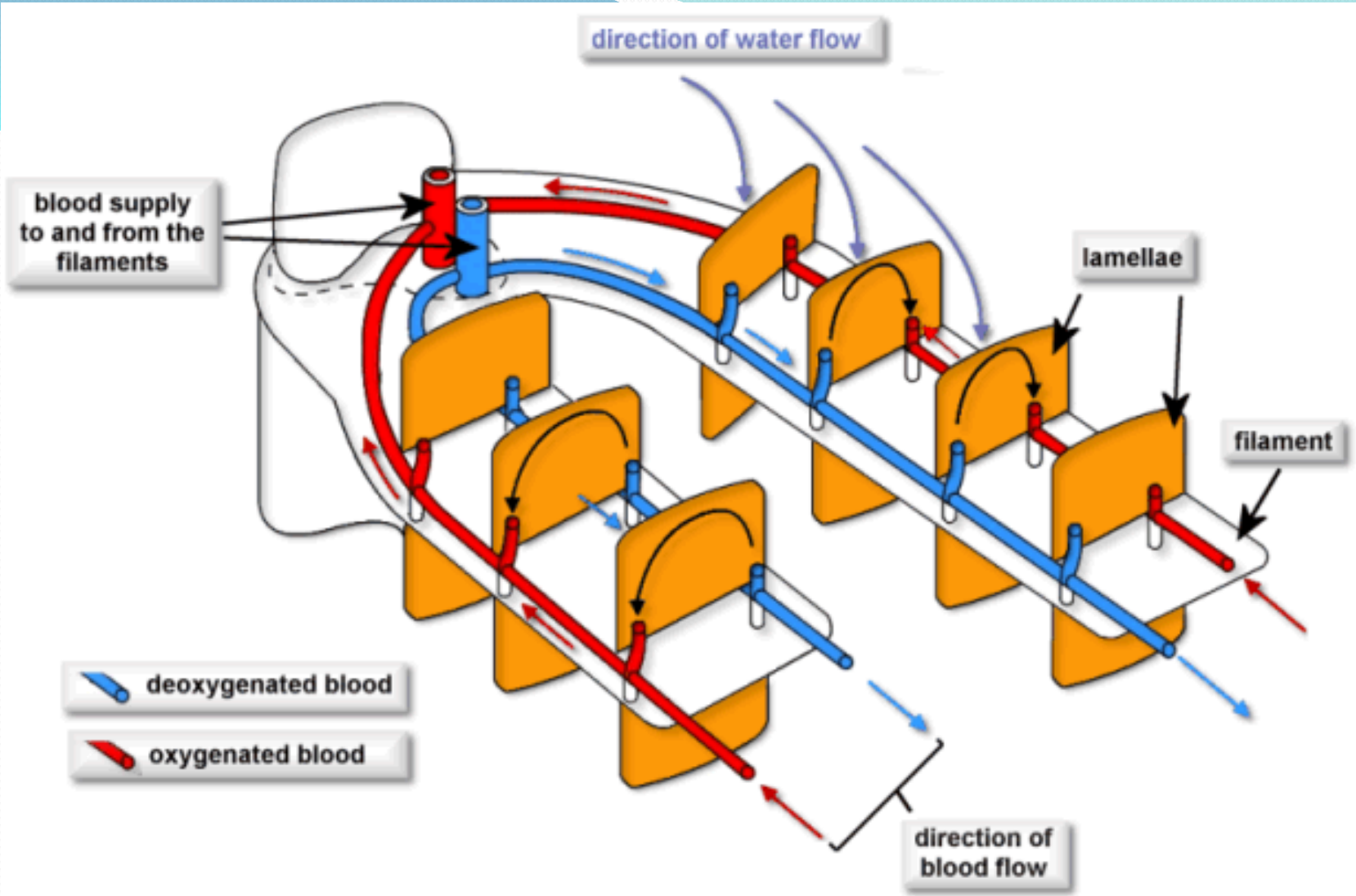


GETTING OXYGEN FROM WATER: FISH GILLS

(c)

- 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.





Each gill arch has many filaments
Each filament has many lamellae