

Fundamentals of Fish Biology

FT 273

9 February 2015

Respiration and Circulation

Module Objectives

1. describe the anatomy and function of the fish gill
2. explain how fish ventilate and extract oxygen from the water
3. describe the oxygen requirements for fish ecology
4. describe fish blood and cells and differentiate from our blood
5. differentiate P50 and PCO₂
6. explain circulatory control in fish (heart structure and type of circulation)

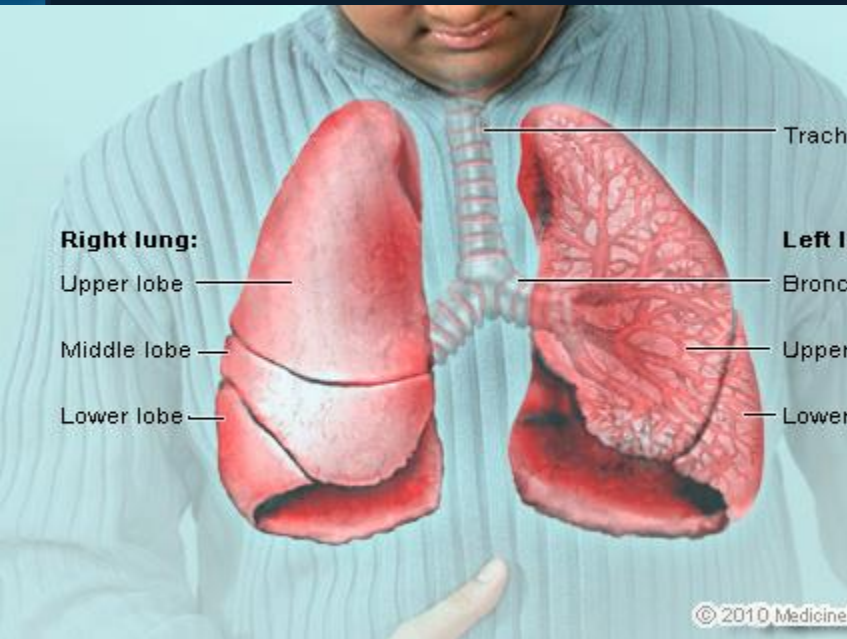


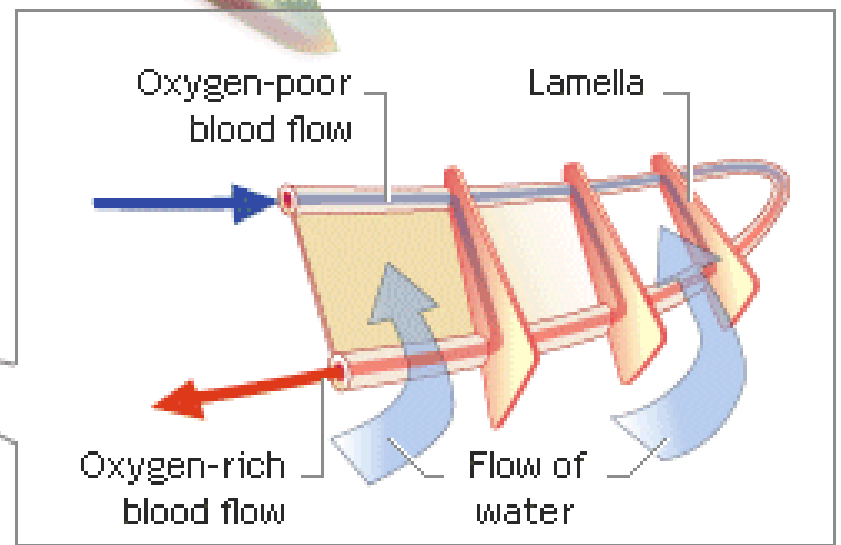
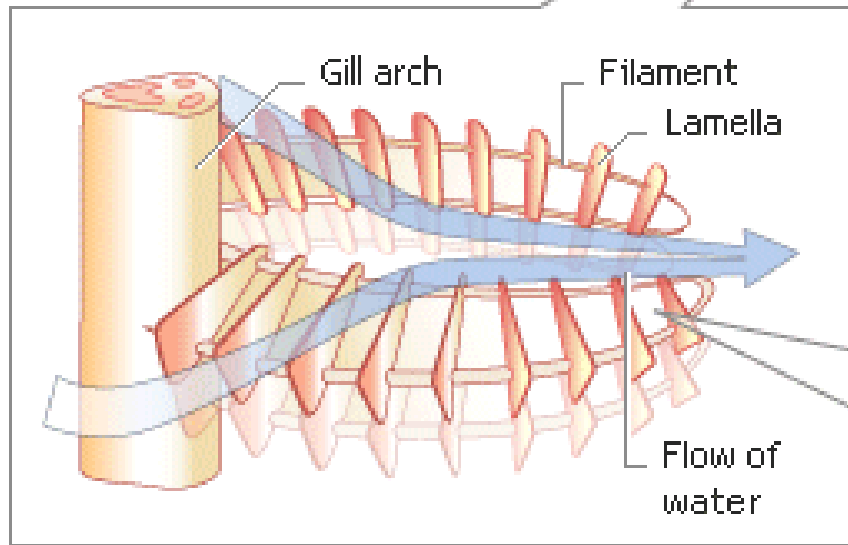
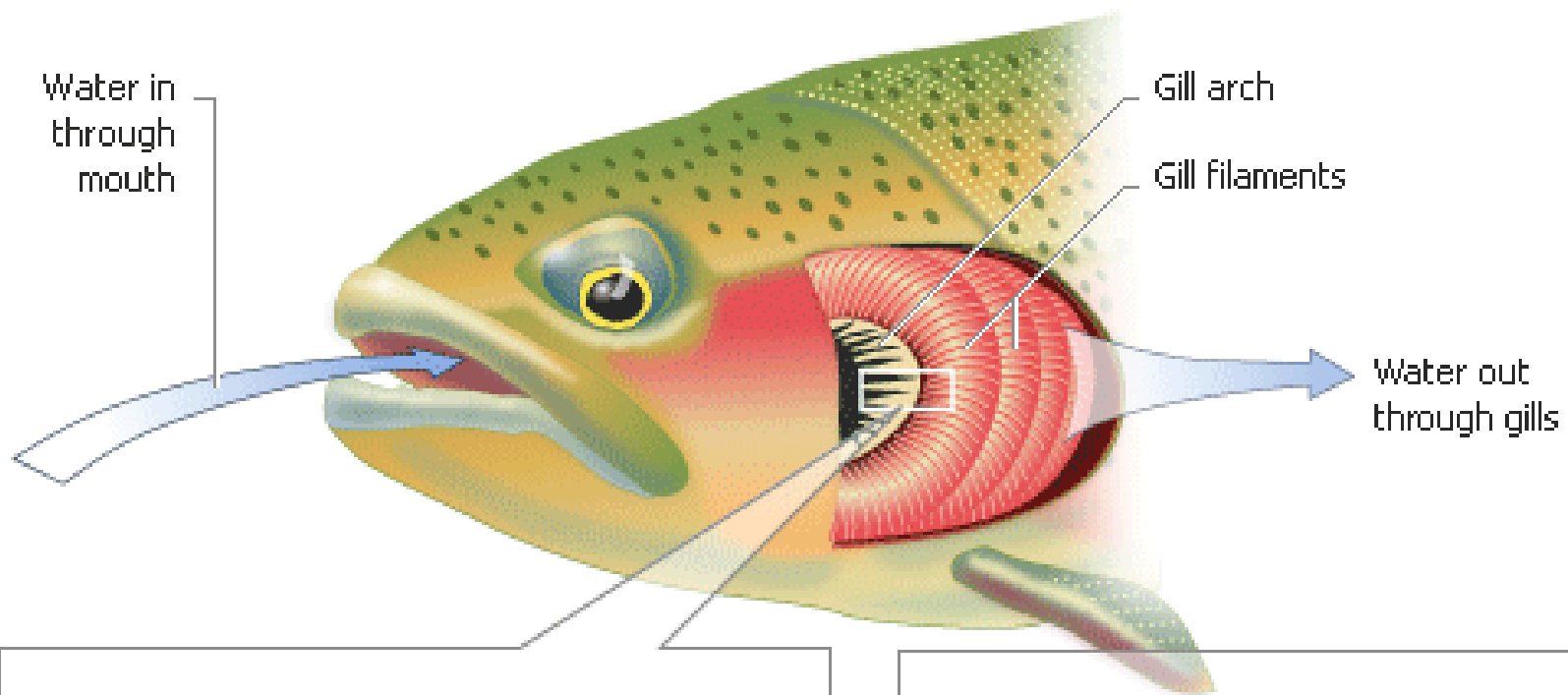
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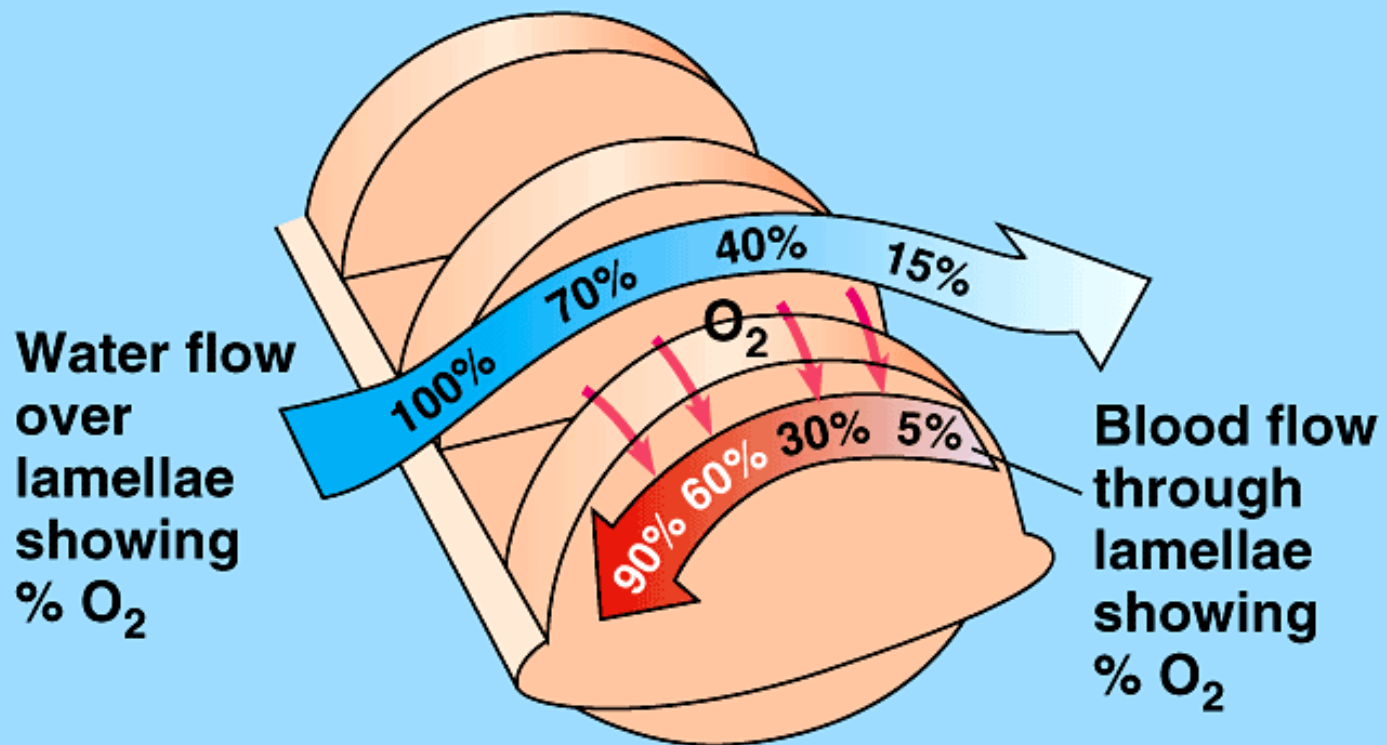
TARNOWSKI

Oxygen extraction



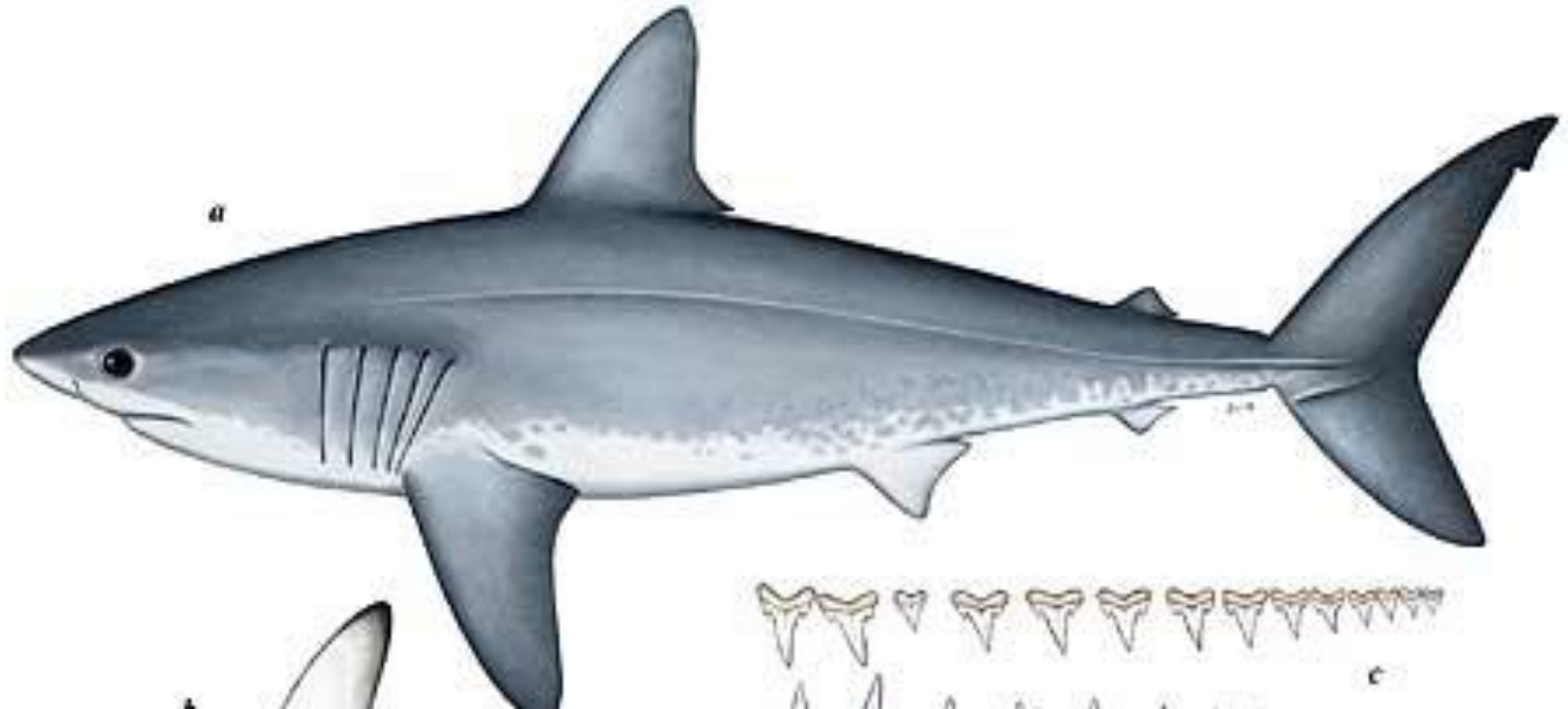


Counter Current Exchange

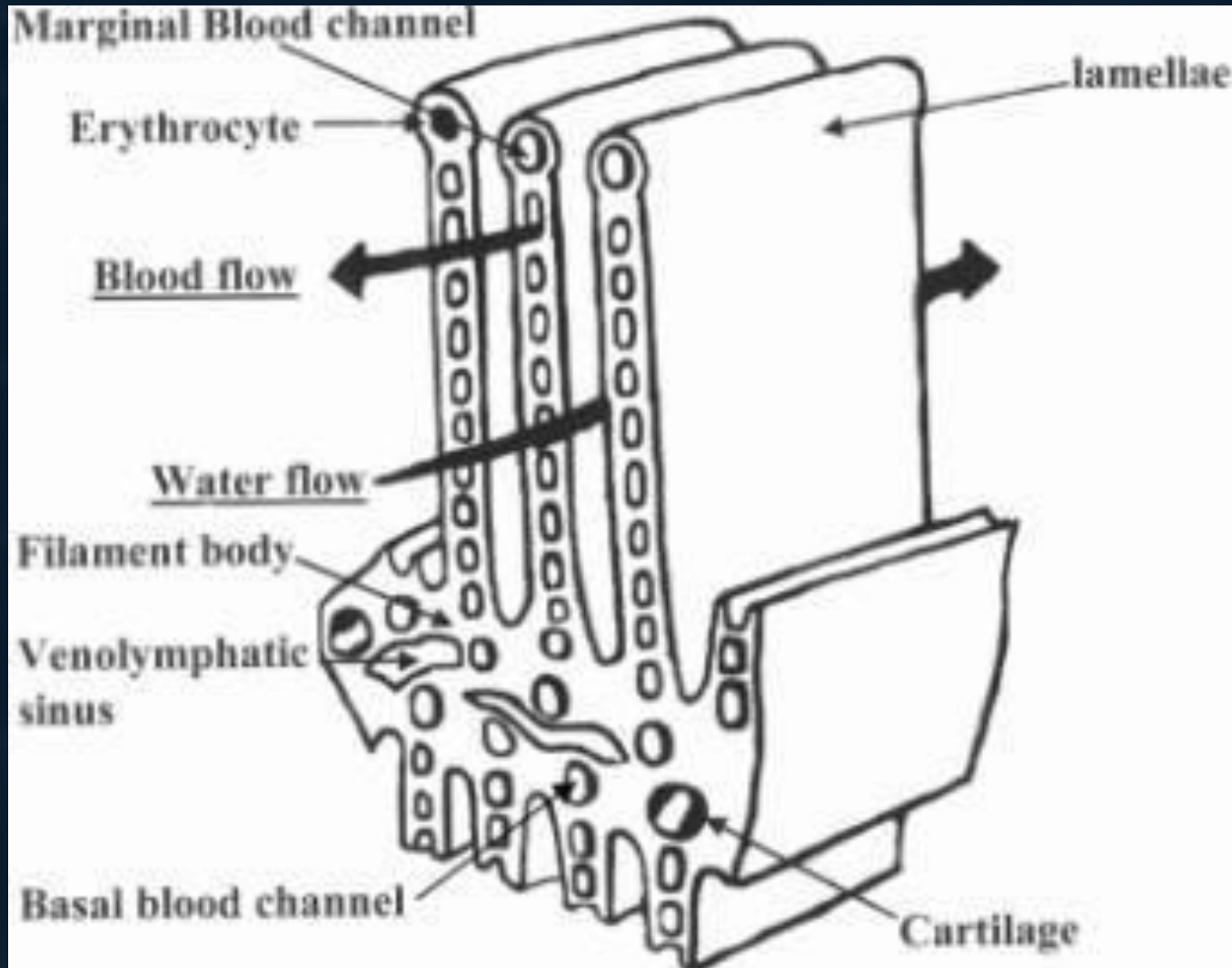


Gill Surface Area

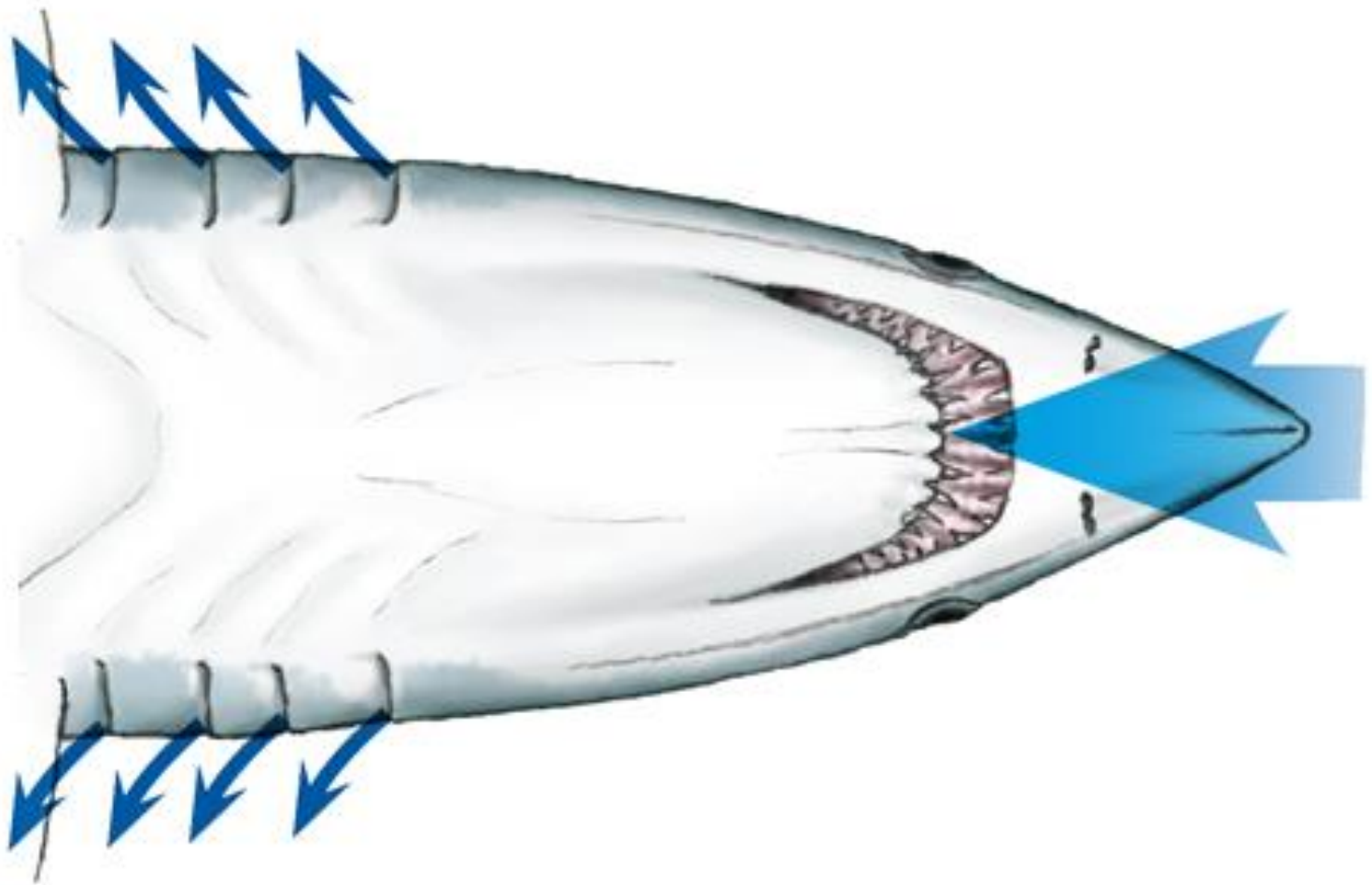
little sleeper shark
(*Somniosus rostratus*)



Fish have 2 choices (evolutionary)



Gill Ventilation



RAM ventilation

ARKive
www.arkive.org



© James D. Watt / imagequestmarine.com

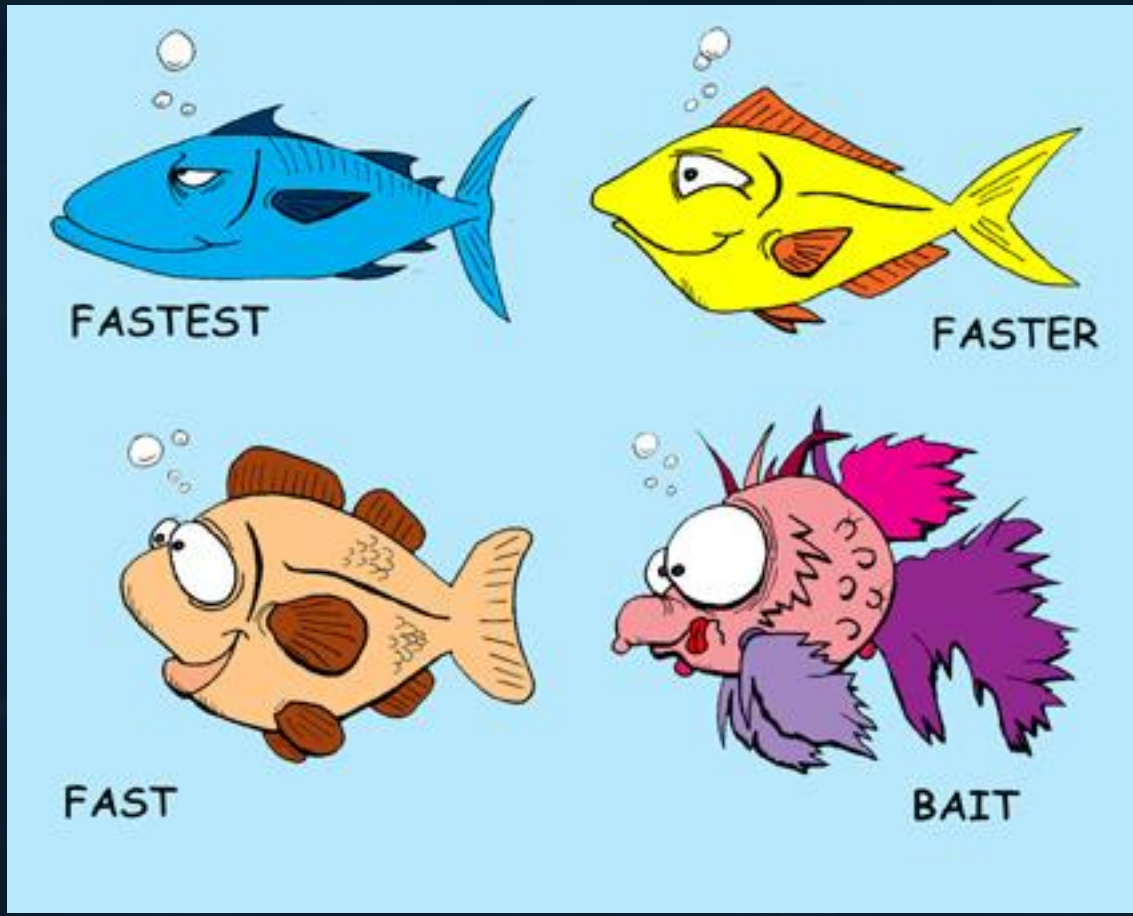
Ram-gill ventilation

- At least 8 families of teleosts cease brachial movements and passively ventilate (ram-gill ventilation) at high threshold swimming velocity
- These threshold swimming speeds may be evolutionary driven – maximizes energy efficiency if fish can use swimming musculature and ventilate gills at same time

Buccal Pumping



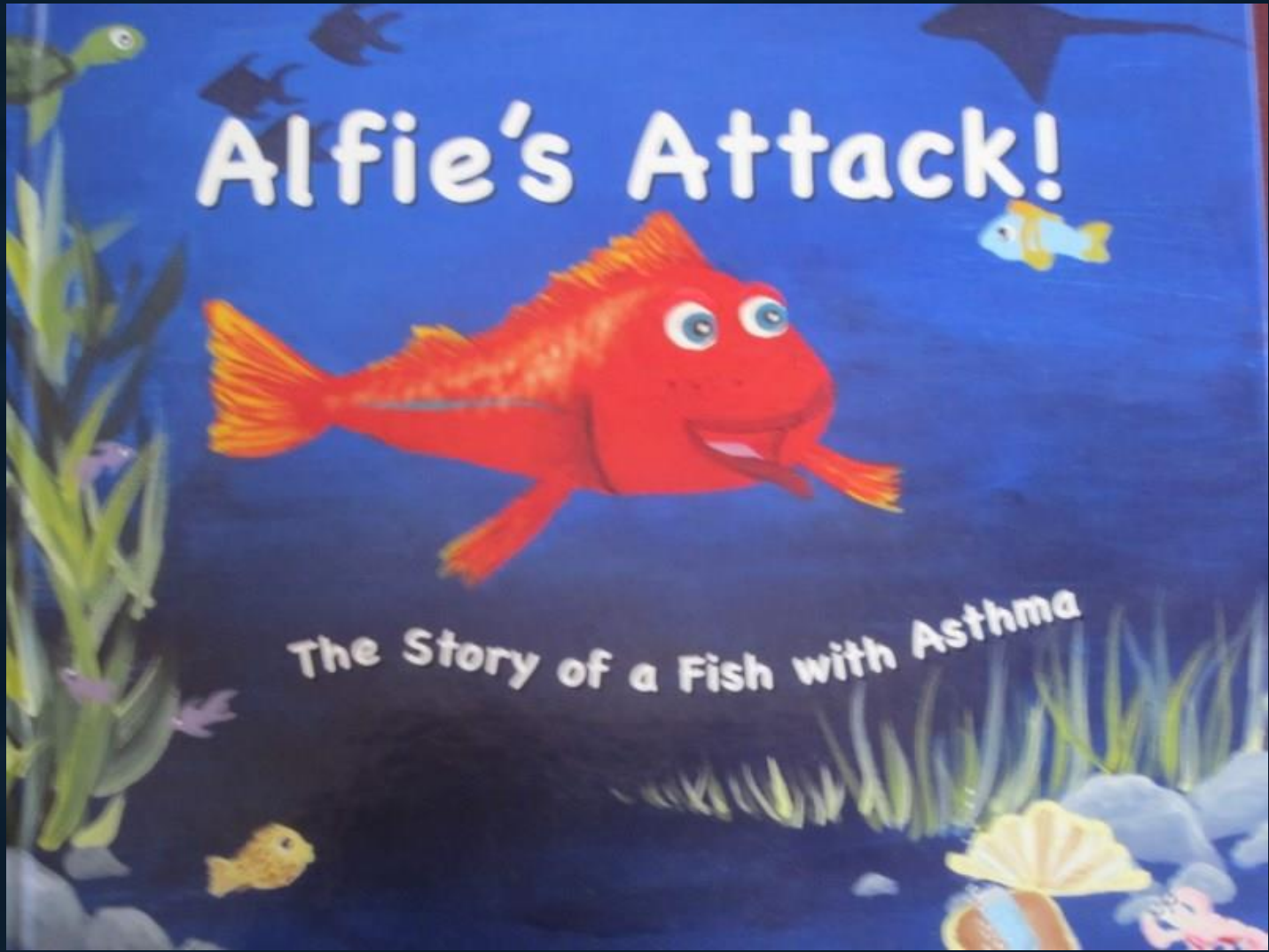
Ways to change gas exchange at gill



Alfie's Attack!



The Story of a Fish with Asthma



Break 1

Break 1

Oxygen through the skin

- Important in larval fish



Black Bullhead



AIR BREATHING FISH



Terms

- Hypoxic - reduced oxygen content of air or a body of water detrimental to aerobic organisms
- Anoxic - total depletion in the level of oxygen, an extreme form of hypoxia or "low oxygen"
- Obligate = "by necessity"

Oxygen in Water



Modified gills



Skin breathing







Mouth breathing





Lungs



sweetwaterfishing.com.au





Gut breathers



Break 2

Break 2

Fish Oxygen requirements



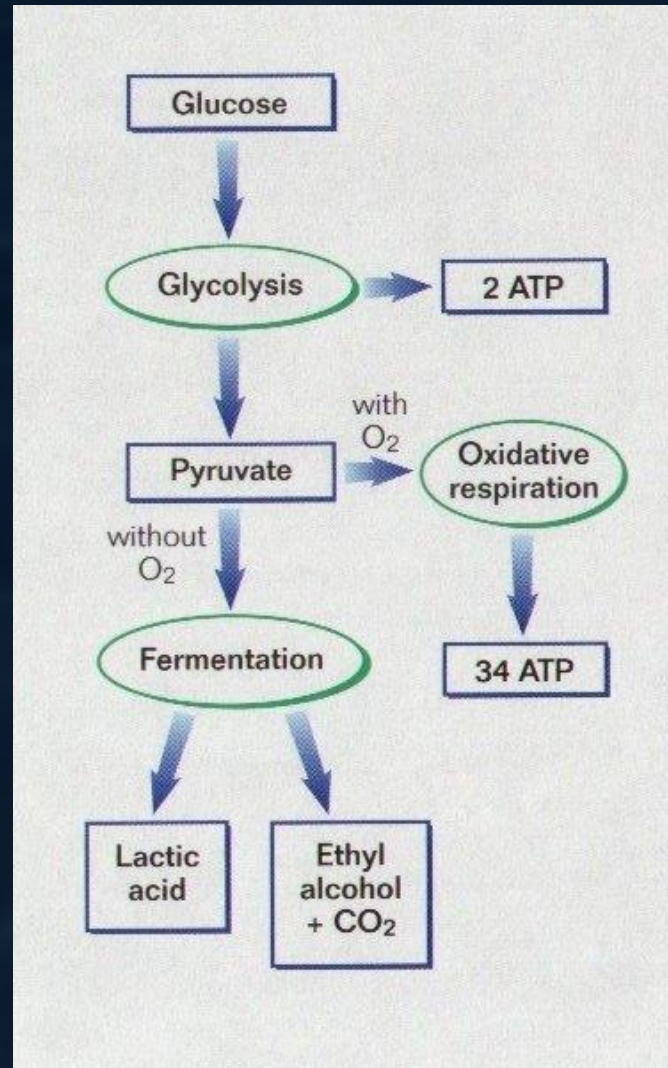
"Of course I'll go back to your place.
I'm running out of oxygen."

Why do fish need oxygen???

Why do fish need oxygen

- Movement
- Find food
- Digestion
- Growth
- Reproduction
- Interior body functions

Metabolic pathways

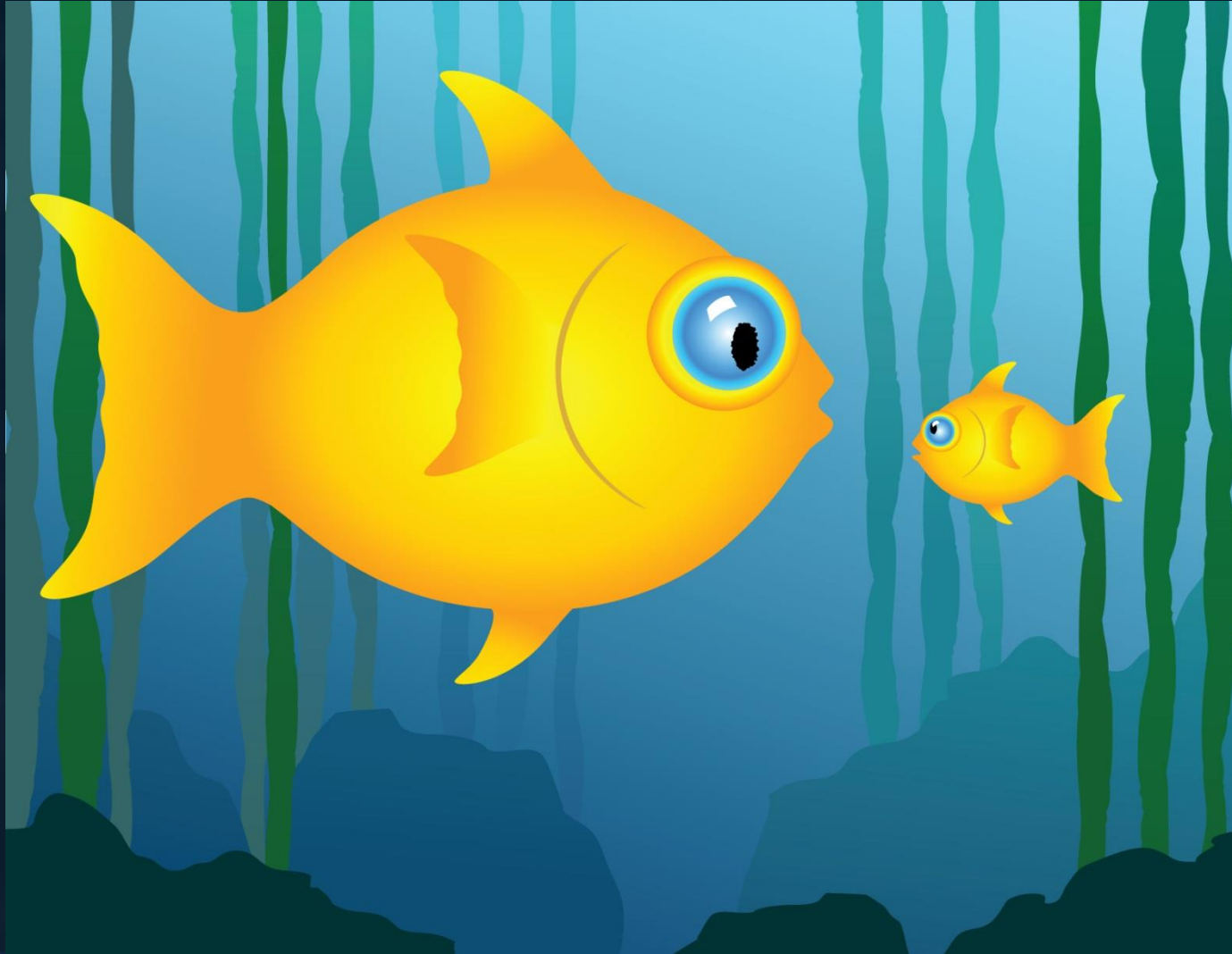


Oxygen consumption rate depends on?

Oxygen consumption rate depends on? LIFE STAGE



Oxygen consumption rate depends on?
SIZE



Oxygen consumption rate depends on? ACTIVITY



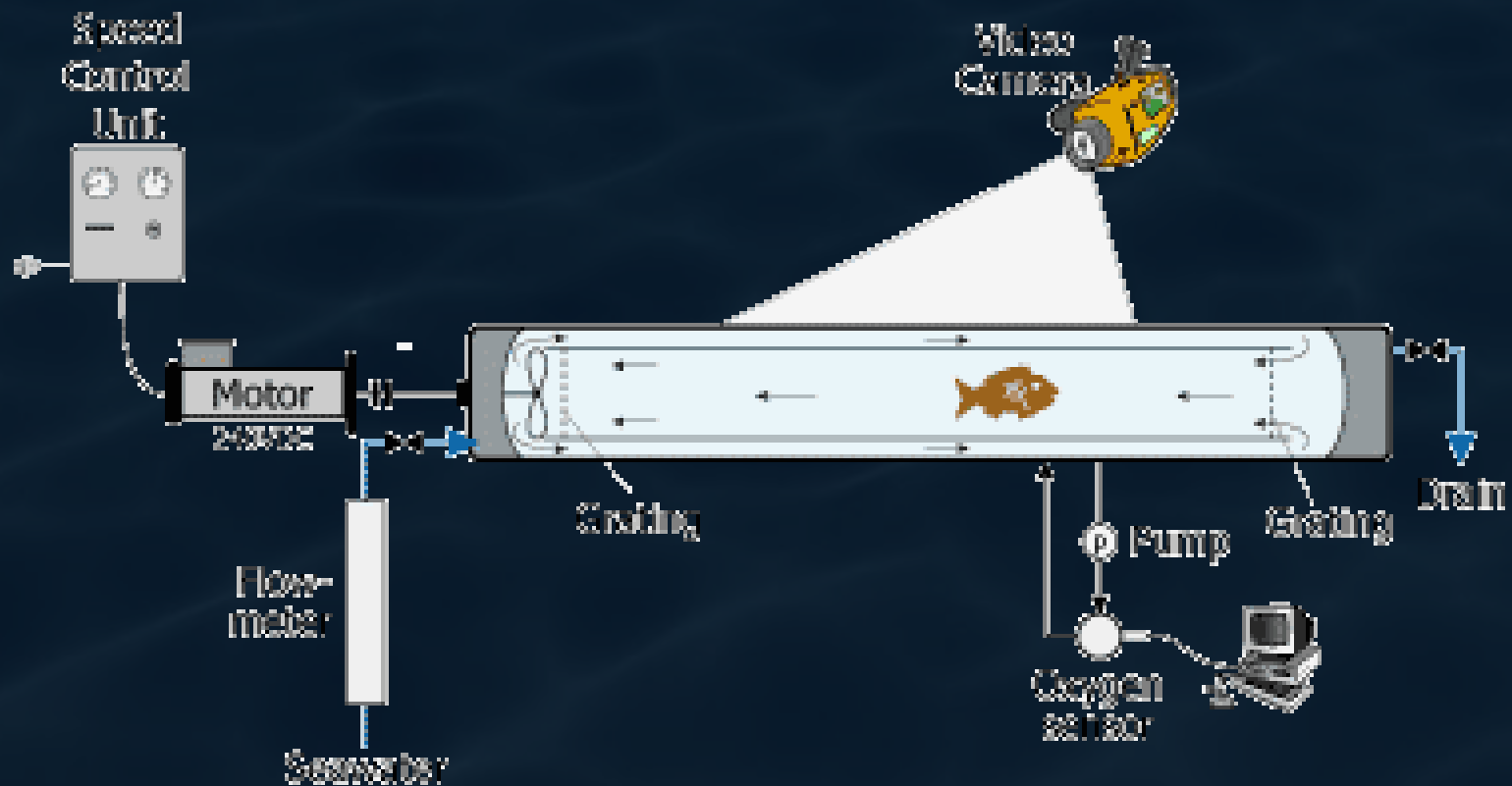
Oxygen consumption rate depends on? TEMPERATURE OF ENVIRONMENT

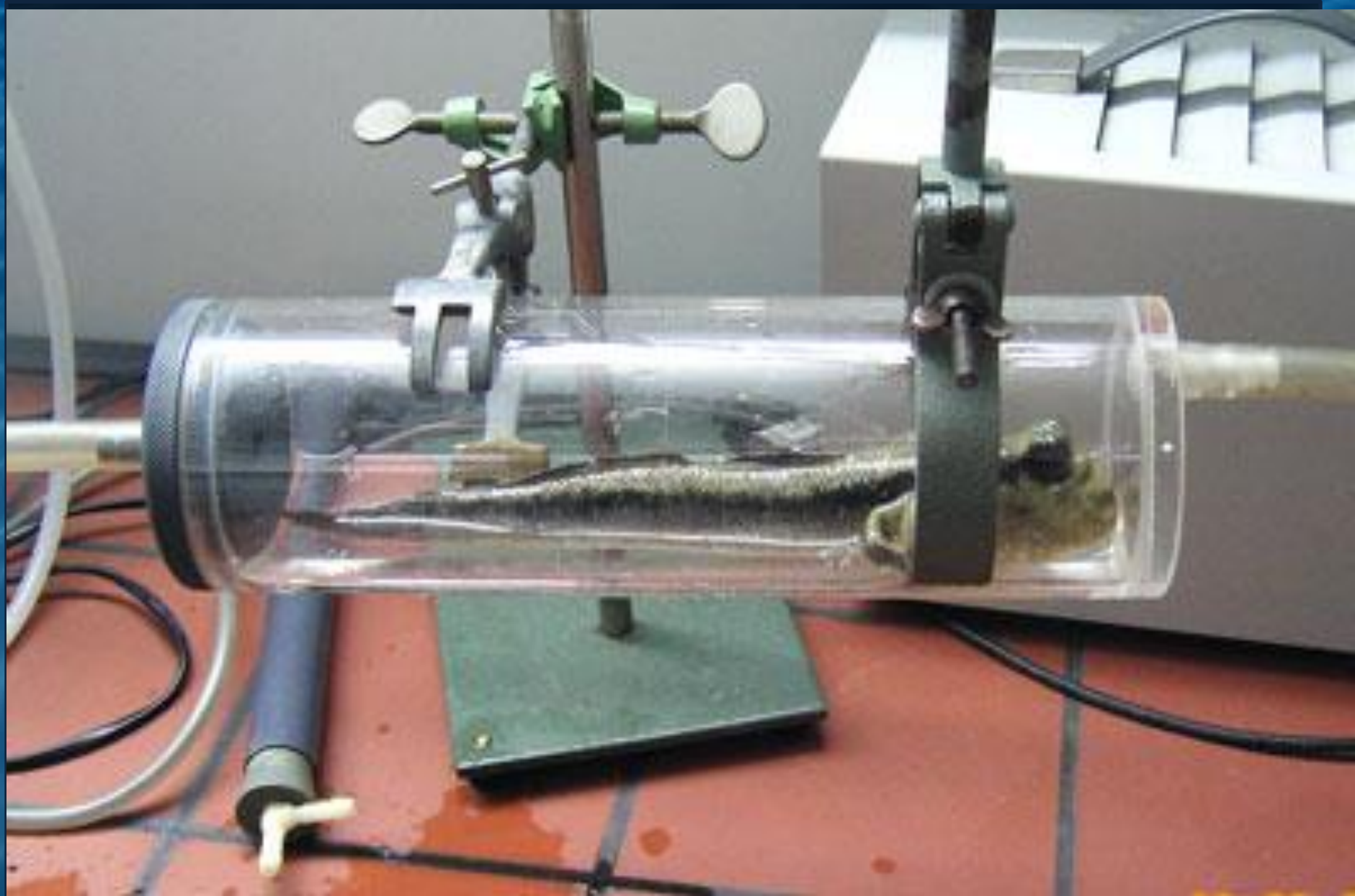


Main factors affecting oxygen consumption rate

1. life stage
2. body weight
3. level of activity
4. environmental temperature
5. diet

So, how do we measure oxygen consumption?





Break 3

Break 3

Blood and Circulation

Fish blood





Fish, Blood & Bone

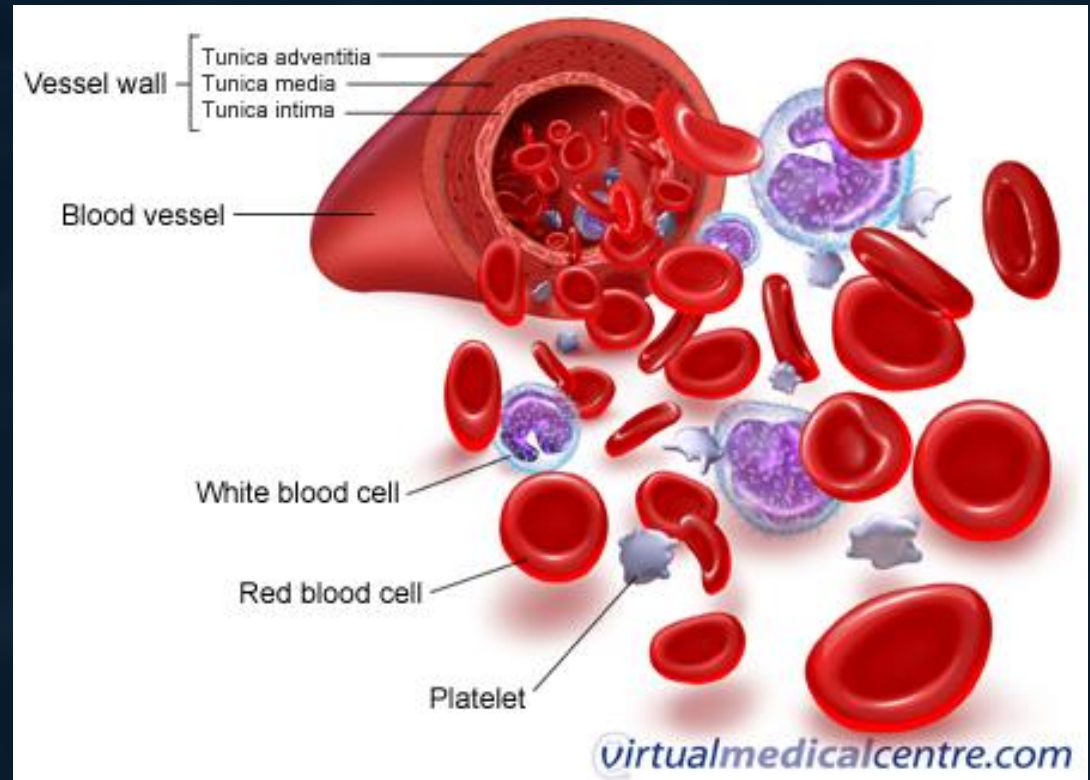
All Purpose Plant Food

- Boosts soil fertility for healthy growth
- Produces more flowers, fruit & veg
- Easy to use pellets

10kg e

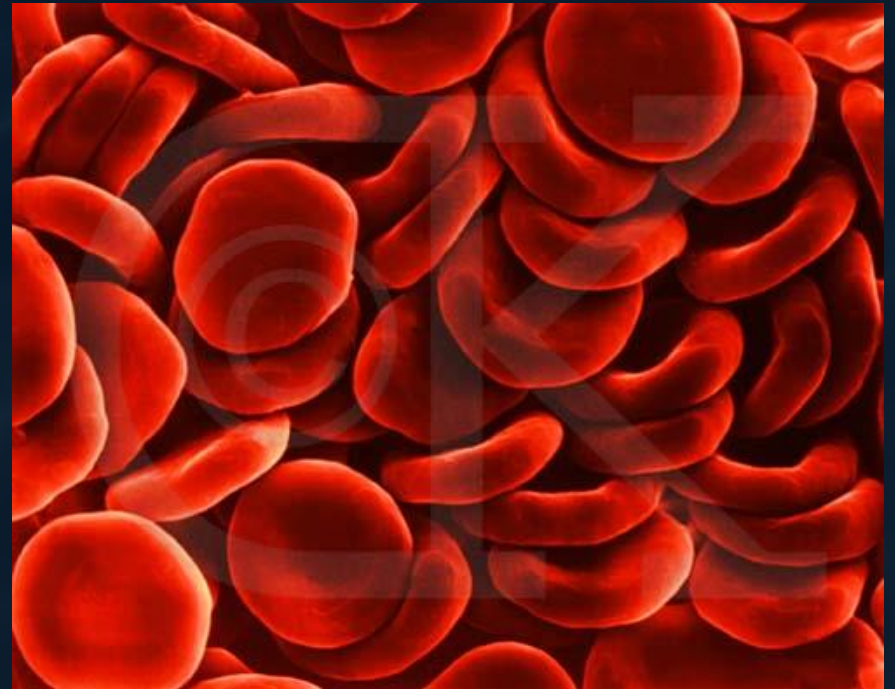
Two basic cell types

- Erythrocytes – Red Blood cells
- Leukocytes – White Blood cells



Erythrocytes

- Most abundant in fish blood
- Contain hemoglobin
- Carry oxygen from gills to tissues



Shape and size of RBCs?

- Elasmobranch have fewer and larger cells
- More active species have more and smaller cells
- Some use red blood cells for special needs



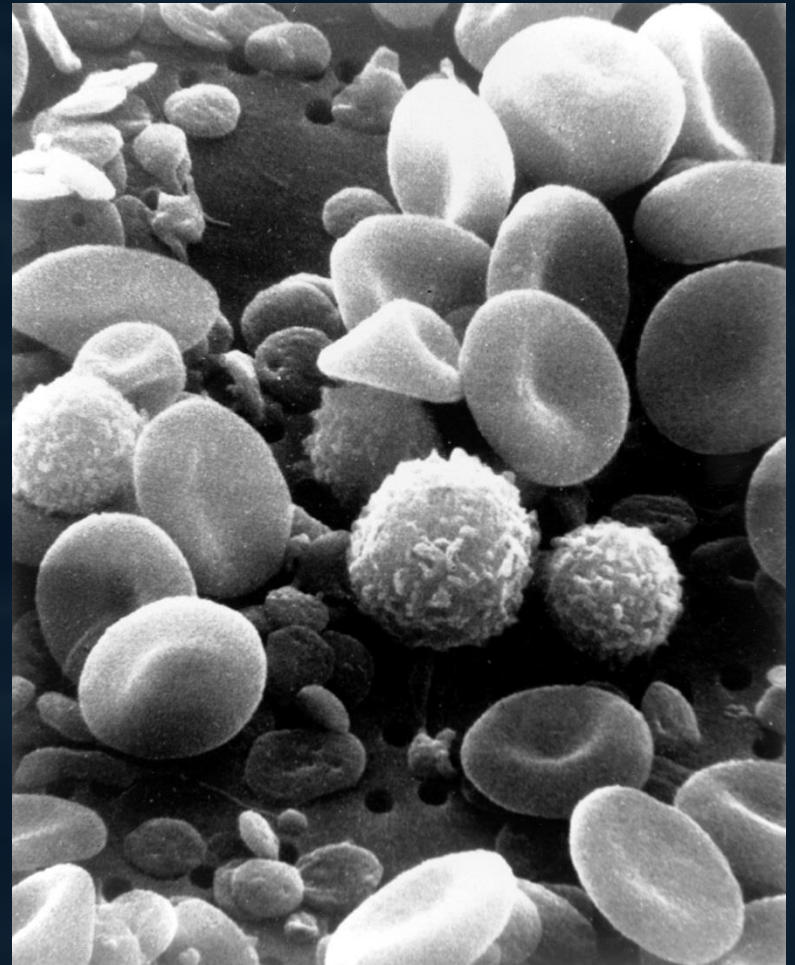
Can the number of RBCs change?

Can the number of RBCs change?

- Stage in life-history
- Low oxygen environments
- Activities for high oxygen demand
- Seasonal changes in temperature
- Spawning activity
- Pollutants

Leukocytes

- WBCs
- less abundant than rbc's
- Several types of wbc's are found in fish blood
- Different roles for different types of wbc's



HEMOGLOBIN

- Increases the blood oxygen carrying capacity
- Two types of hemoglobin structure in fish
 - Monomeric - characteristic of lampreys and hagfish
 - Tetrameric - characteristic of all other fishes

Hemoglobin vs Plasma

- Hemoglobin = 93% of oxygen
- Plasma = 7% of oxygen



Antarctic Crocodile Icefish



Blood Oxygen Affinity

- Affinity = the ability of blood to bind oxygen for transport
- Each hemoglobin molecule has the ability to bind four oxygen molecules
- As blood circulates through the body, the oxygen is pulled from the hemoglobin by the tissues that need the oxygen (as a result of CO₂)

P50?

- P50 is the measure of the affinity of hemoglobin for oxygen (50% saturation)
- The higher the P50 the lower the affinity of hemoglobin for oxygen; the lower the P50, the higher the affinity

Factors Affecting Affinity



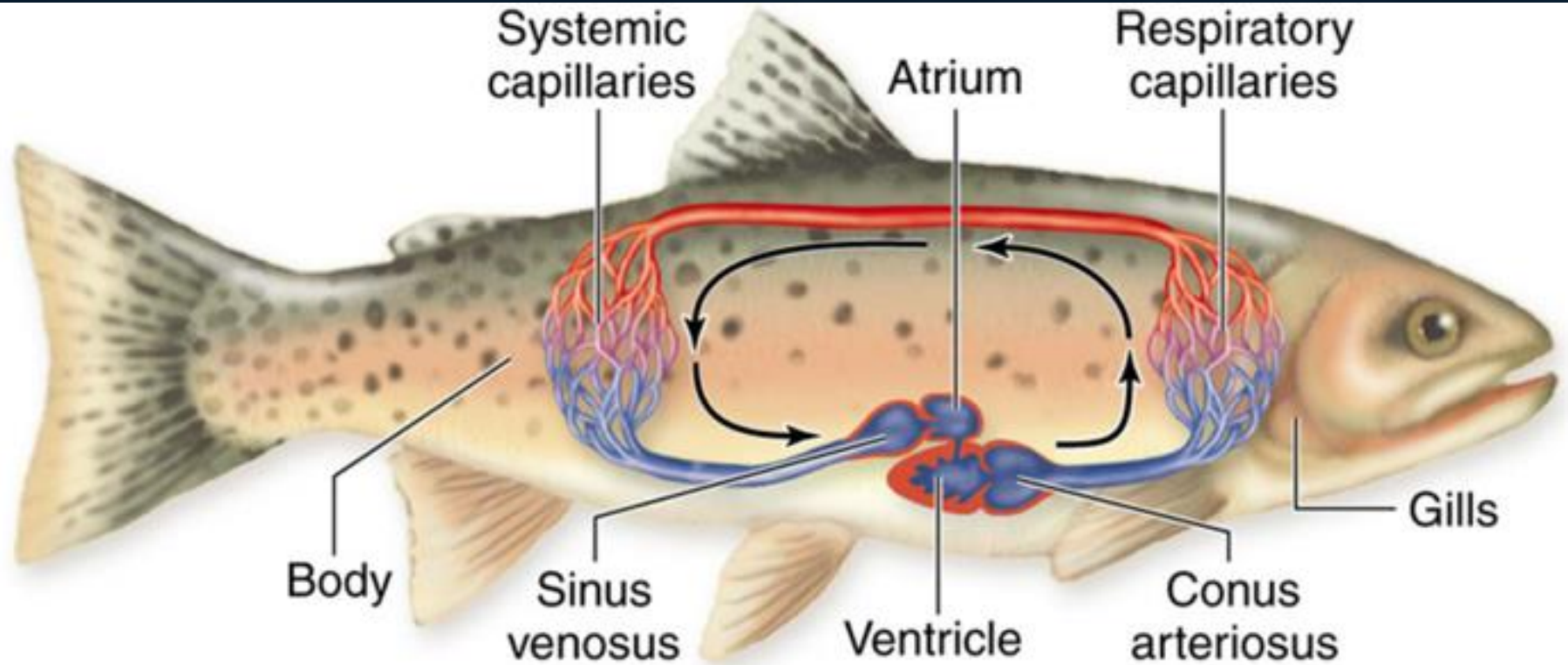
Bohr and Root Effect

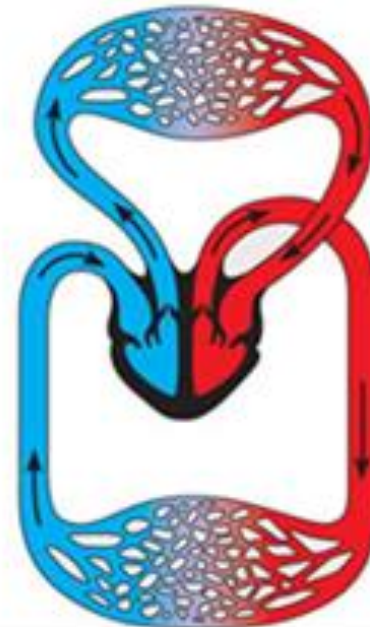
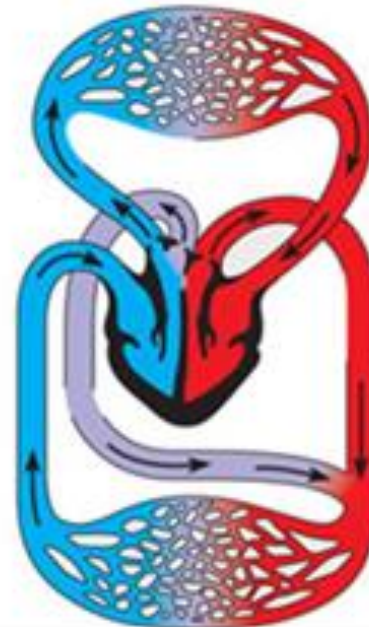
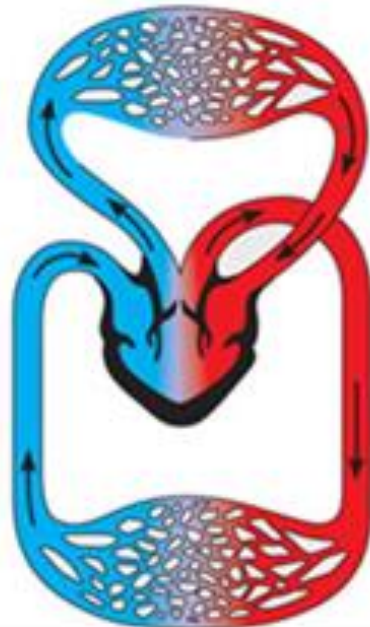
- Hemoglobin has lower affinity for oxygen in acidic conditions due to configuration of oxygen binding sites of hemoglobin. -Bohr Effect
- At low pH a change in hemoglobin configuration prevents oxygen from binding –Root Effect
- Bohr – decrease in affinity
- Root – decrease in capacity

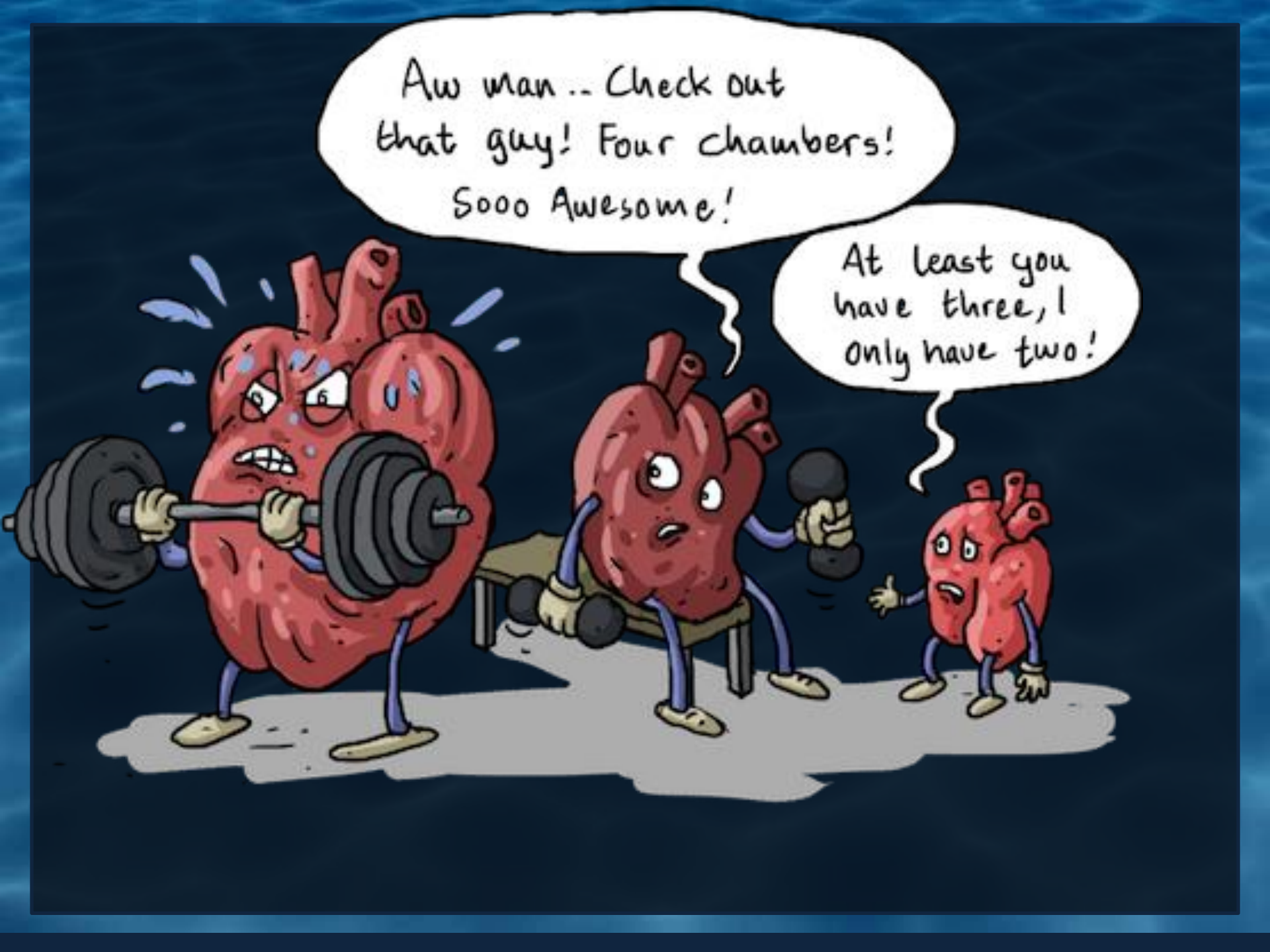
Temperature effects

- An increase in temperature can
 - Depress oxygen affinity
 - Depress oxygen capacity

Circulation







Aw man.. Check out
that guy! Four chambers!
Sooo Awesome!

At least you
have three, I
only have two!