Recap

- Possible words
  - Tracheae
  - Diffuses
  - Pizza
  - All parts
  - Branch
  - Slower
  - Spiracles
  - Quicker
  - Hydrogen
  - Oxygen
  - Carbon dioxide
  - Atmosphere
  - Diffusion

Answers

- The breathing system in insects consists of a series of tubes called **tracheae.** The tracheae connect to the atmosphere by openings called **spiracles.** Air diffuses through the spiracles and tracheae to all parts of the body supplying the organs directly with air.
- The tracheae branch repeatedly until they end as very fine, thin-walled tubules through which oxygen and carbon dioxide can diffuse freely into and out of the tissues.
- Along a diffusion gradient
  - When cells are respiring oxygen is used up and so its concentration towards the end of the tracheoles falls. This creates a diffusion gradient for O2 towards the cells. CO2 is produced by cells creating a diffusion gradient with the atmosphere (CO2 moves out of the insect). As diffusion in air is much quicker than in water, respiratory gases are exchanged quickly by this method

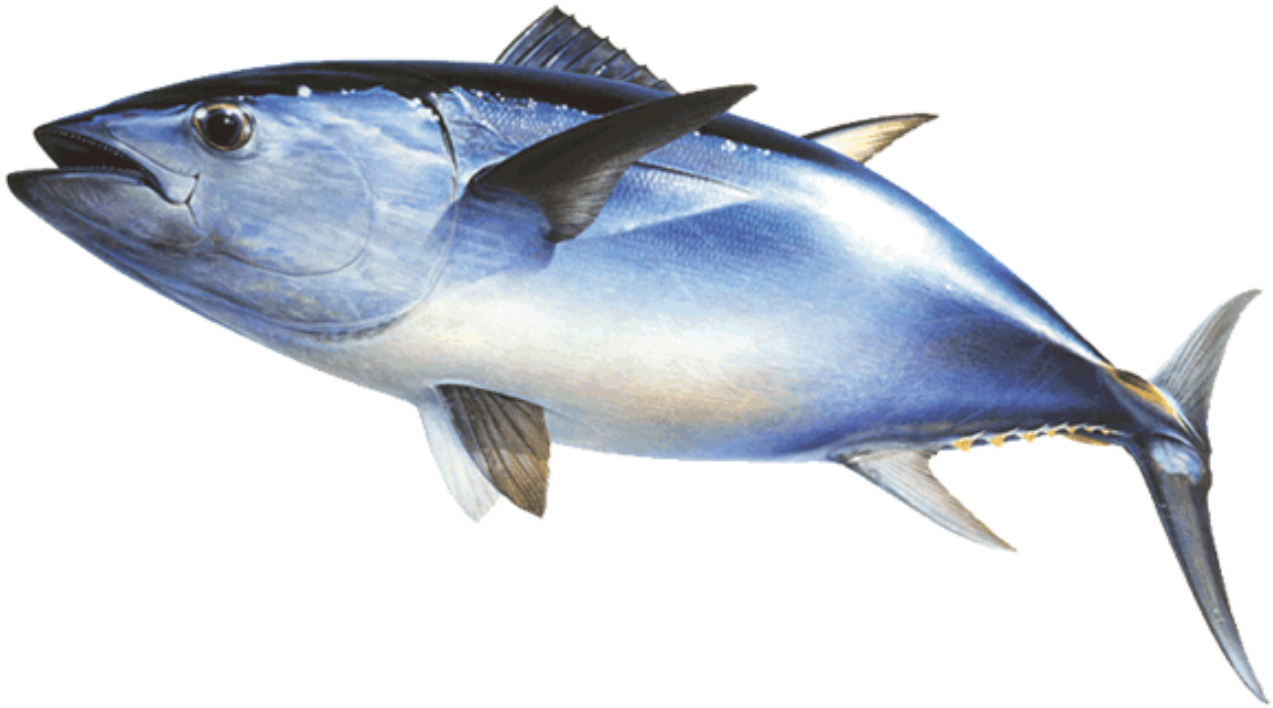
Oxygen vs. Water

Life on land poses a continual conflict between the needs for oxygen and water.

Terrestrial insects have to cope with obtaining oxygen from air without dying from dehydration.

It is vital for terrestrial insects, especially those such as locusts that live in desert conditions, to be able to exchange respiratory gases without losing too much water.

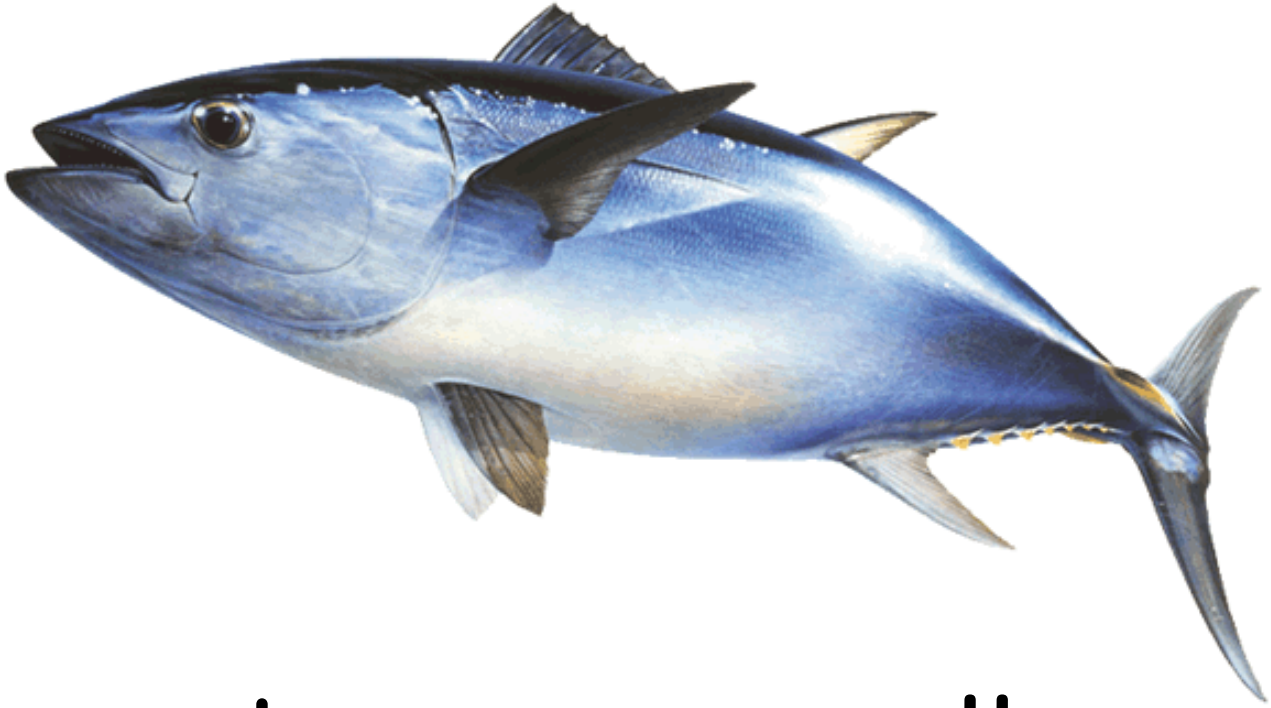
Gas Exchange in Fish



Lesson Objectives

- **(ALL) Practice and develop our dissection skills and anatomical drawing skills.**
- **(D) How are fish gills adapted to maximize gaseous exchange?**
- (C) What is the difference between parallel flow and counter current flow?
- (A/B) How does counter current flow increase the rate of gas exchange?

Waterproof body



Large or small

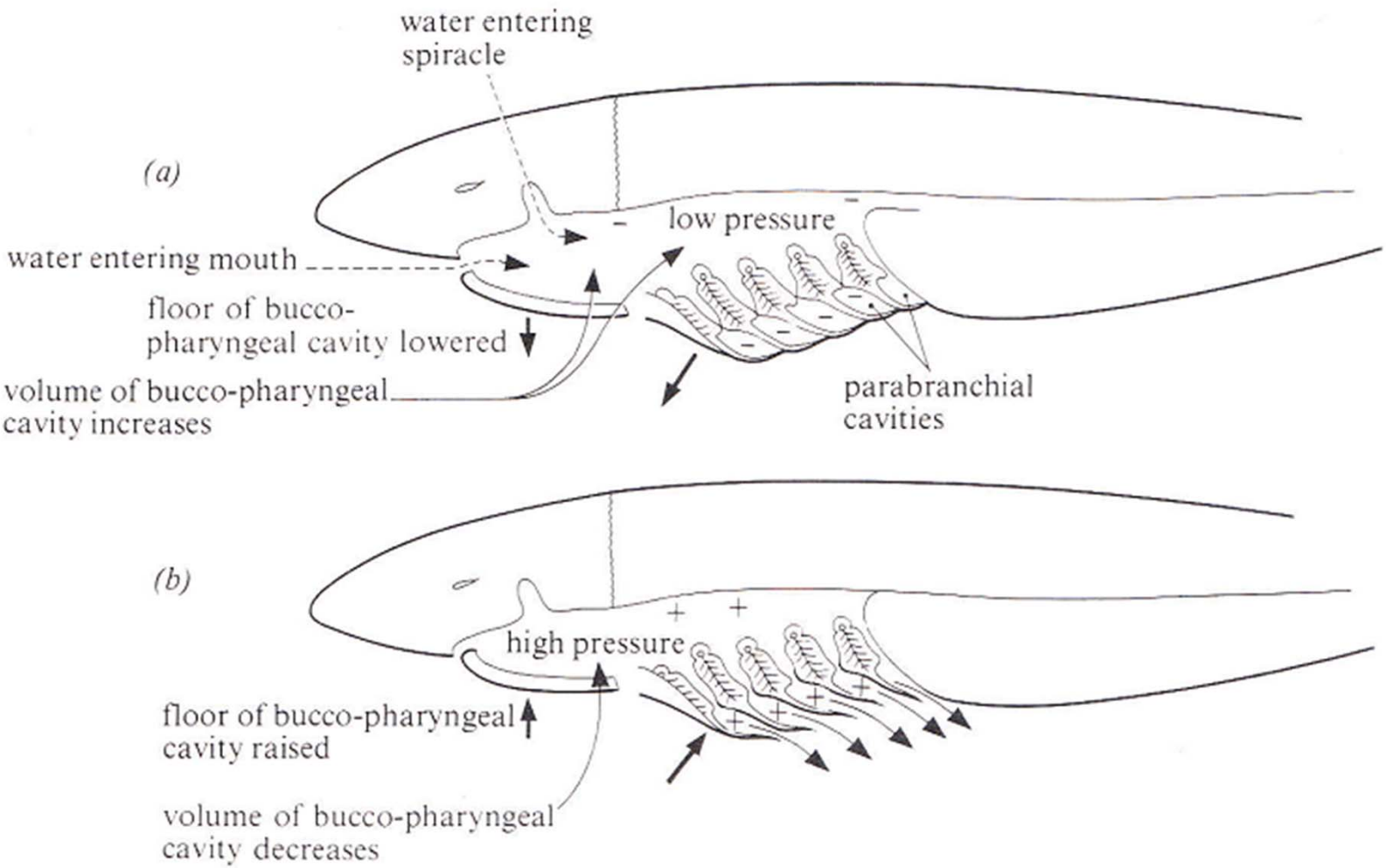
SA:V?

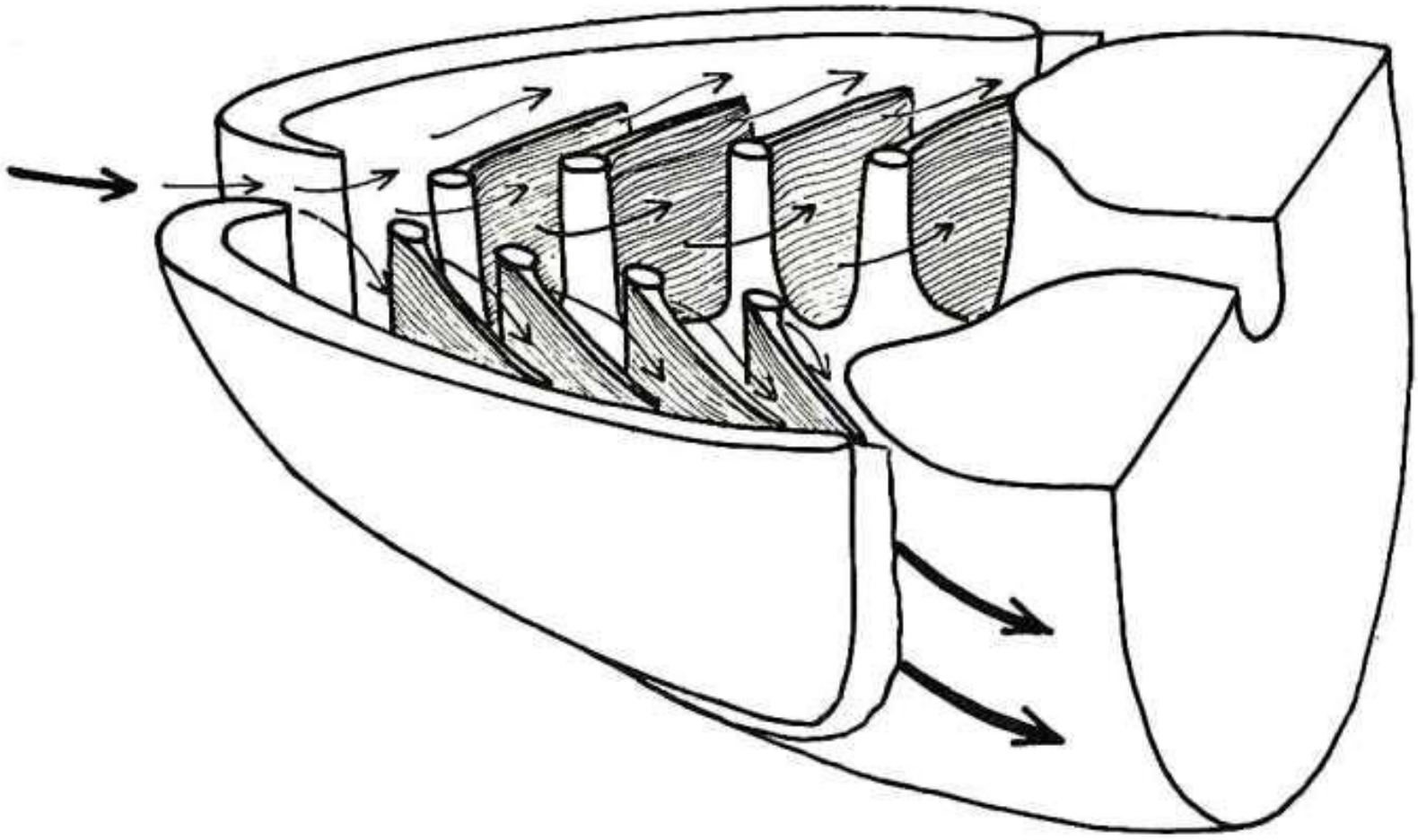
What does that mean for gas exchange?

Fish are aquatic animals adapted to extracting oxygen from water.

- Oxygen content in air; 20.9 %
- Oxygen content in water; approx 0.8 %
- Therefore fish have to pass large volumes of water over their gas exchange systems relative to the volumes of air ventilated by terrestrial animals.

Some fish actively pumping water!!



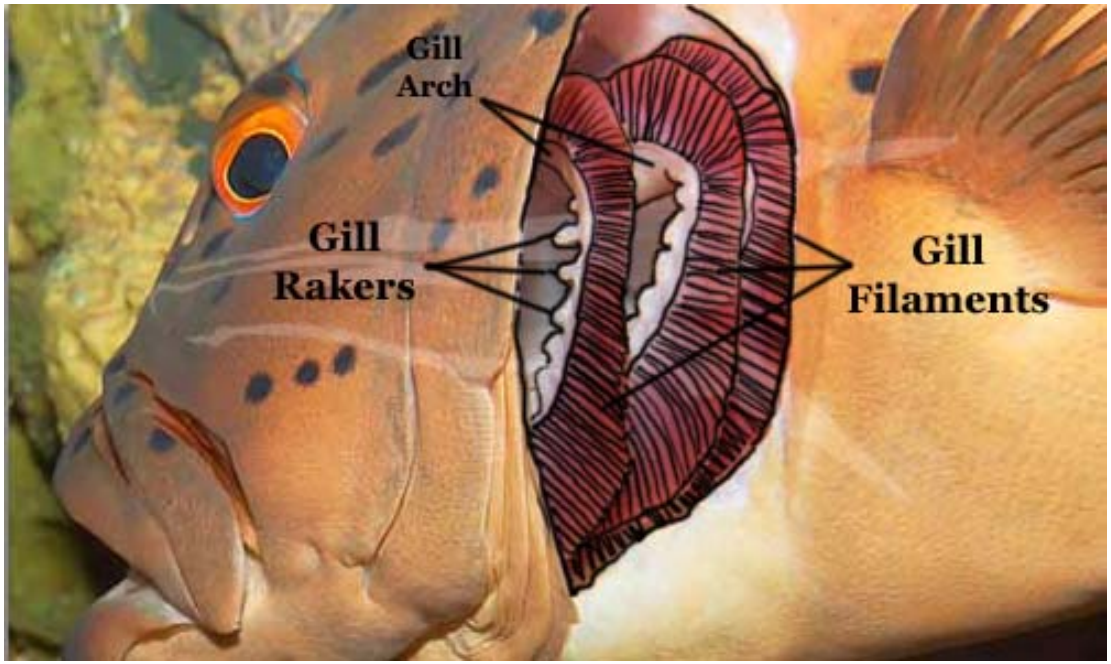


Fish can extract as much as 80% of available oxygen passing through its gills

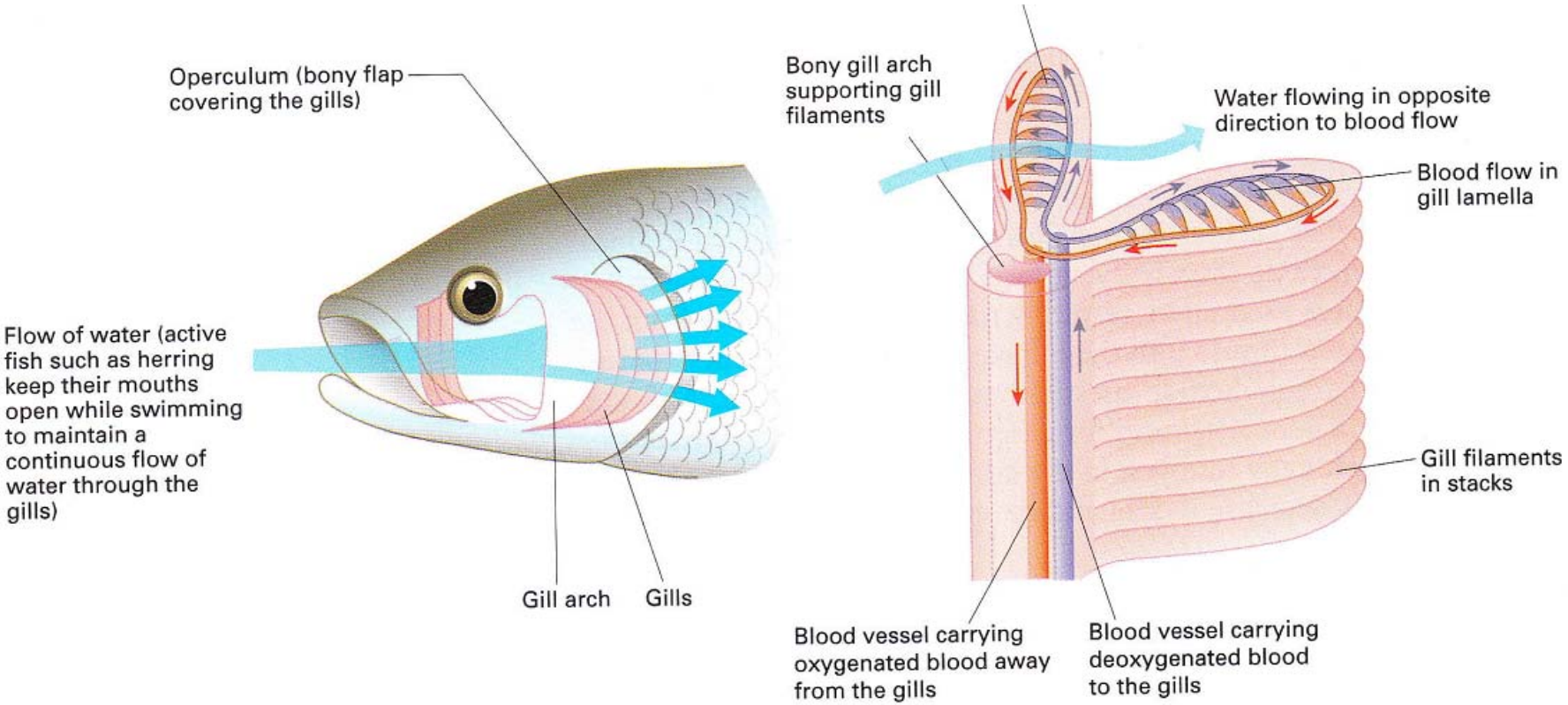
Due to;

1. A very large surface area for gaseous exchange
2. A short diffusion distance across the gaseous exchange system
3. A high concentration gradient between the blood in the gills and the water passing over them

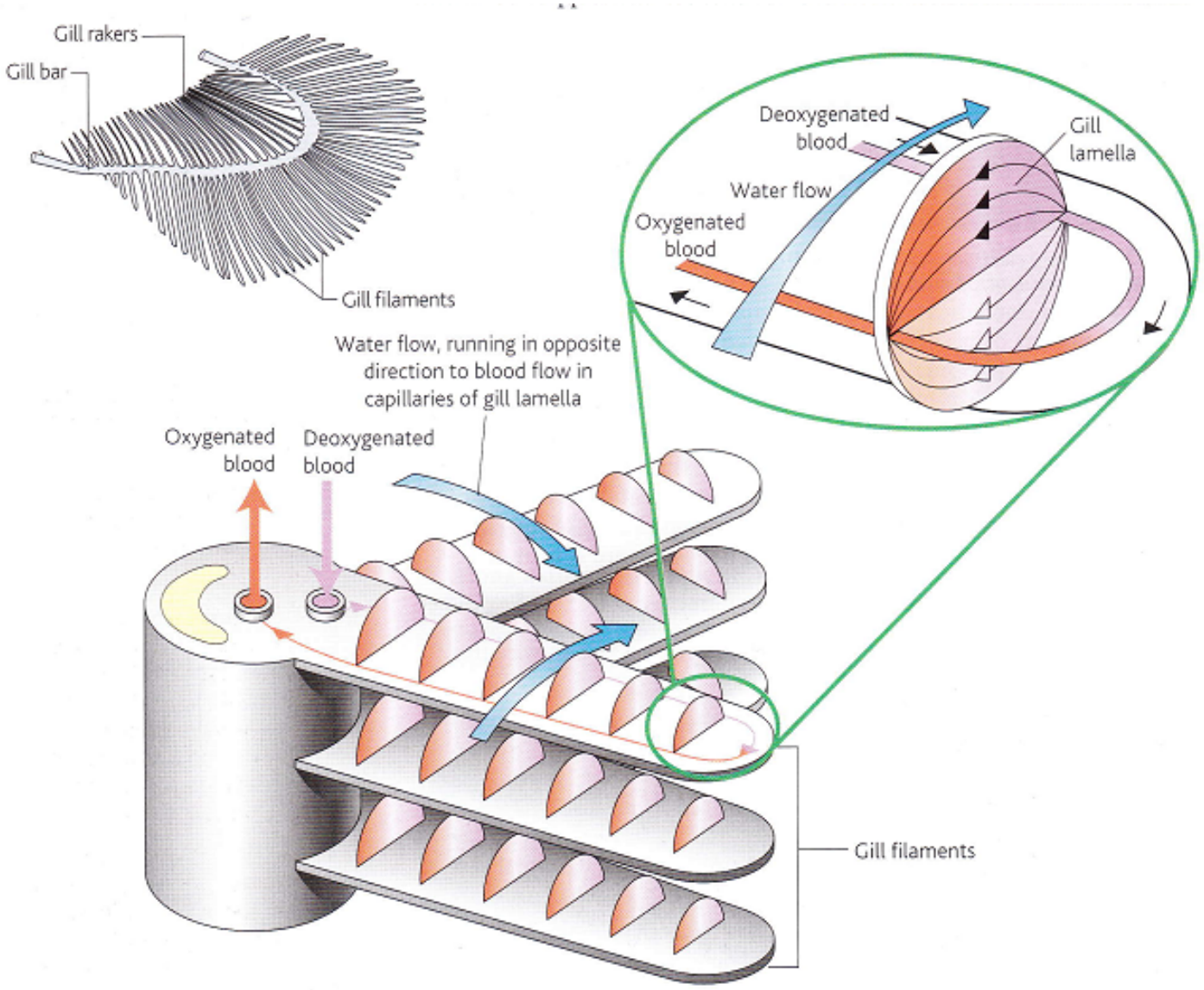
1. Large surface area - Developed a specialised internal gas exchange surface: the gills



Structure of the gill



Gaseous exchange system in a bony fish.



2. Short diffusion distance

- Gill plates – exceedingly delicate and very thin so that blood flowing through them is only a short distance from seawater (about 5µm in active fish such as mackerel).

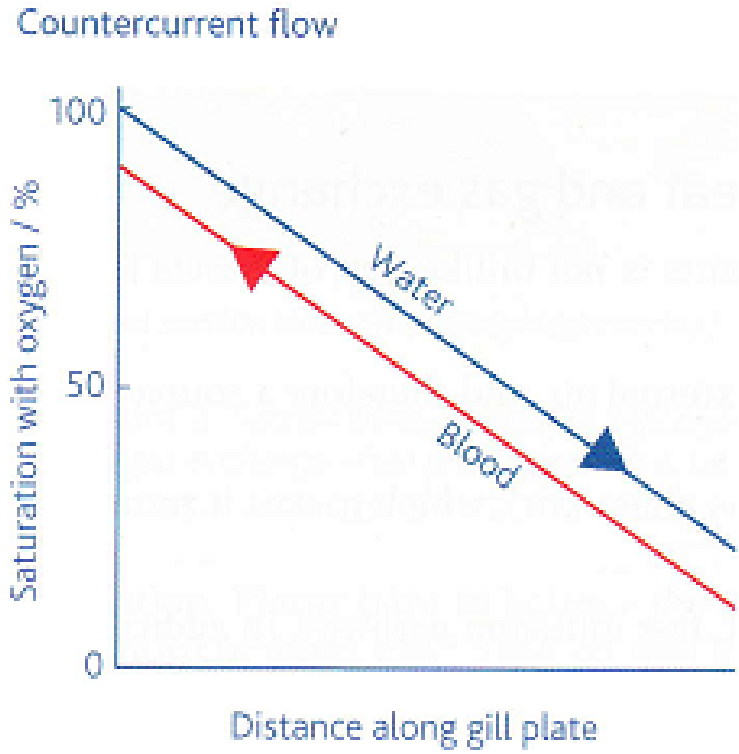
3. High concentration gradient - Countercurrent exchange in bony fish

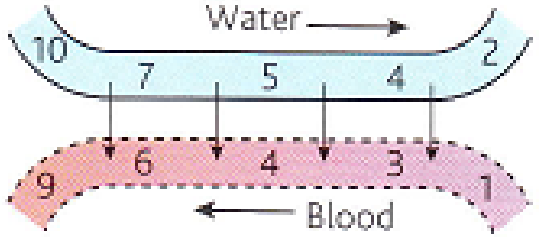
The blood and the water flow over the gill lamella in opposite directions

1. Blood that is already well loaded with oxygen meets water, which has its maximum concentration of oxygen. Therefore diffusion of oxygen from the water to the blood takes place.
2. Blood with little or no oxygen in it meets water which has had the most, but not all, of its oxygen removed. Again, diffusion of oxygen from the water to blood takes place.

Countercurrent exchange

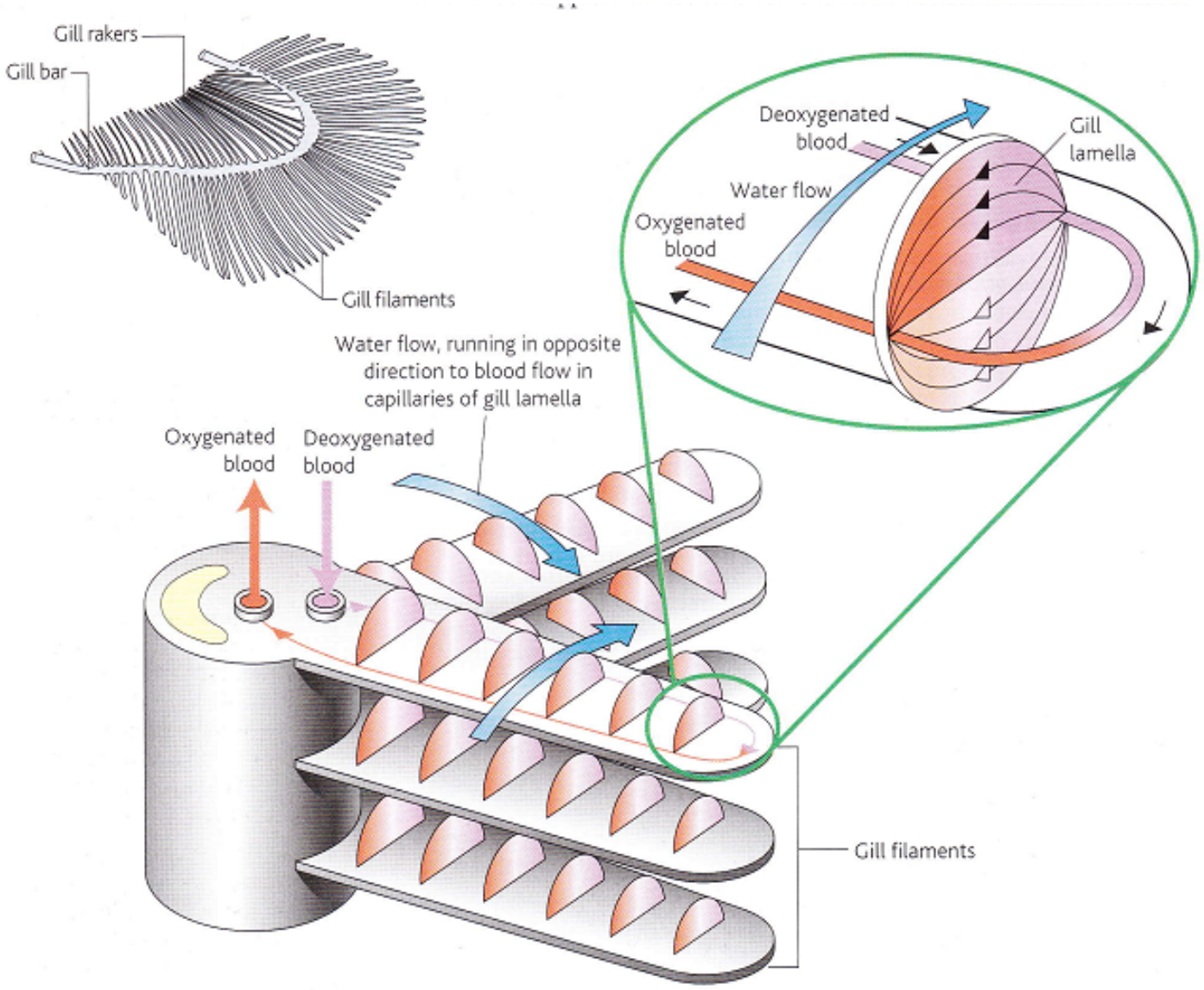
- Relatively constant rate of diffusion





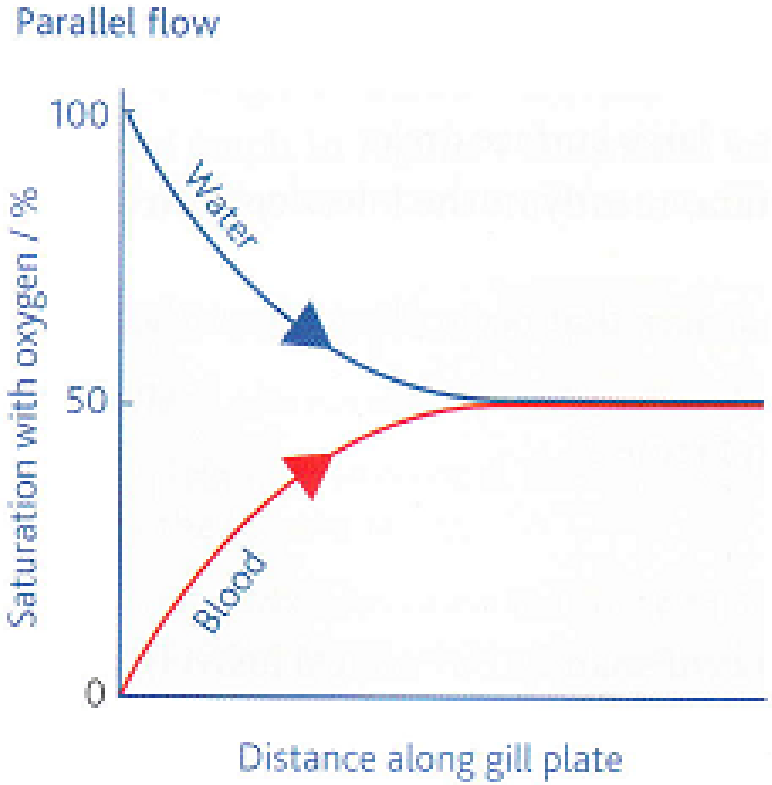
Numbers represent relative oxygen concentrations

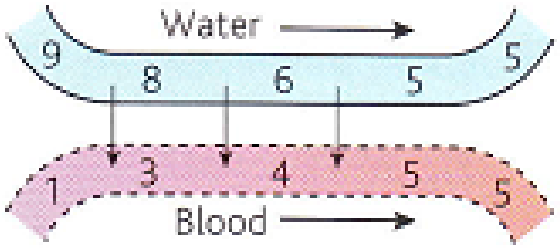
Diffusion of oxygen
There is a diffusion gradient favouring the diffusion of oxygen from water into the blood all the way across the gill lamellae. Almost all the oxygen from the water diffuses into the blood.



Parallel flow system - dogfish

- Blood and water move in the same direction and only about 50% of the oxygen is absorbed.





Numbers represent relative oxygen concentrations

Diffusion of oxygen
There is a diffusion gradient favouring the diffusion of oxygen from water to blood for only part of the way across the gill lamellae. Only 50% of the oxygen from the water diffuses into the blood.

Haemoglobin

- Fish blood contains haemoglobin.
  - Helps to carry oxygen away from the gills and maintain a high concentration gradient.
- Unloading is made easier by the Bohr effect!

Examiners Tips

- Maintaining steep diffusion gradients for oxygen involves bringing it constantly to the exchange surface (by ventilation) and carrying it away from the surface (by mass transport in the blood)
- Always refer to blood and water flowing in opposite directions in the counter current system. Describe how this maintains a difference in oxygen concentration and a diffusion gradient across the whole length of the gill lamella.

Dissection Questions

- Sketch the fish head and label the relevant parts.
  - Add labels to explain how water passes through the gills
- Remove the fish gills and identify the;
  - Gills
  - Operculum
  - Single gill lamella
  - Blood vessels
- Examine a single gill.
  - Can you detect the gill plates? (running a needle along the surface of the lamellae may help)
- Examine the gill under a microscope
  - Approximately how many lamella are there per gill?
  - How many plates per lamellae?
  - Make a detailed and labelled drawing
- Take a horizontal cross section of the gill parallel to the lamellae and examine it under the microscope
- Now take a vertical cross section of the gill (at right angle to the lamellae)
  - Make a detailed and labelled drawings identifying the lamellae and gill plates
  - Examine the blood vessels, how many cells separate the lumen of the vessels and the exterior?

Gas exchange in Leafs

Lesson Objectives

(D) How do plants exchange gases?

(C) What is the structure of a dicotyledonous plant leaf?

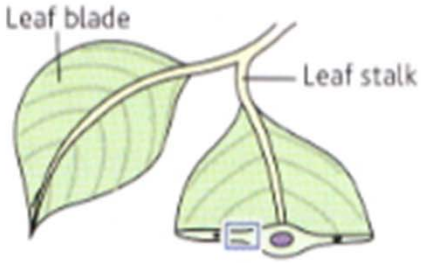
(A/B) How is the leaf adapted for efficient gas exchange?

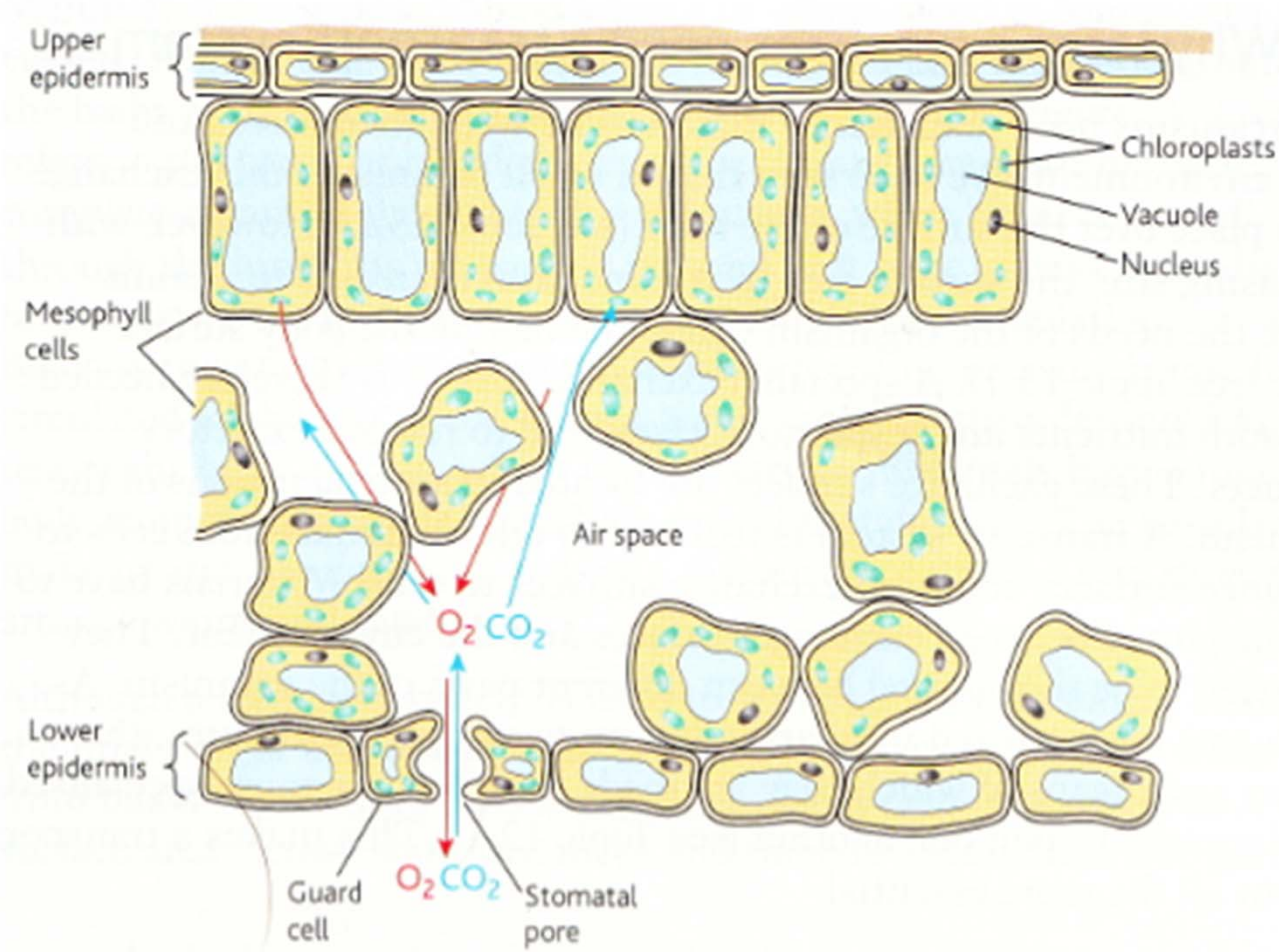
Plant cells

- All respire like animal cells
  - Use oxygen and produce carbon dioxide
- Some carry out photosynthesis
  - Use carbon dioxide and produce oxygen
- Thus, plant cells able to interchange gases between respiration and photosynthesis

Structure of a plant leaf
'short, fast diffusion pathway'

- Very large surface area compared with the volume of living tissue
- Thus, no specialised transport system is needed for gases
- No living cell is far from the external air, and therefore a source of oxygen and carbon dioxide
- Diffusion takes place in the gas phase (air), which makes it more rapid than if it were in water





b *Vertical section through a dicotyledonous leaf*

Adaptations for rapid diffusion;

- Large surface area (thin flat shape of leaves)
- Many small pores, called stomata (mostly in lower epidermis)
- Numerous interconnecting air-spaces that occur throughout the mesophyll.

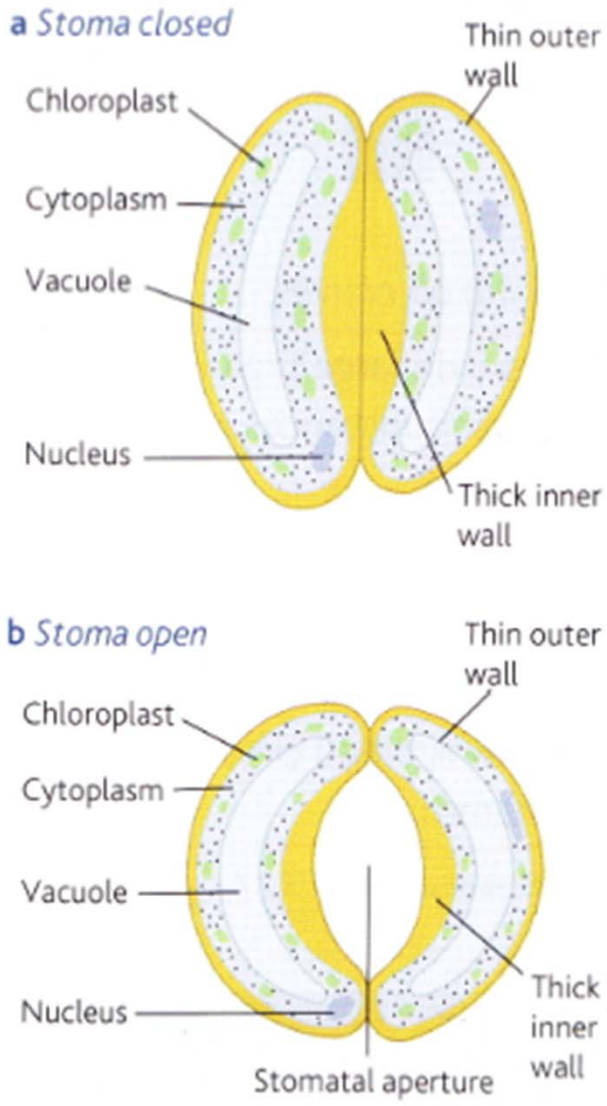


Figure 3 *Surface view of a stoma closed and open*

Examiner's tip

- The diffusion gradients in and out of the leaf are maintained by mitochondria carrying out respiration and chloroplasts carrying out photosynthesis.

Summary Questions

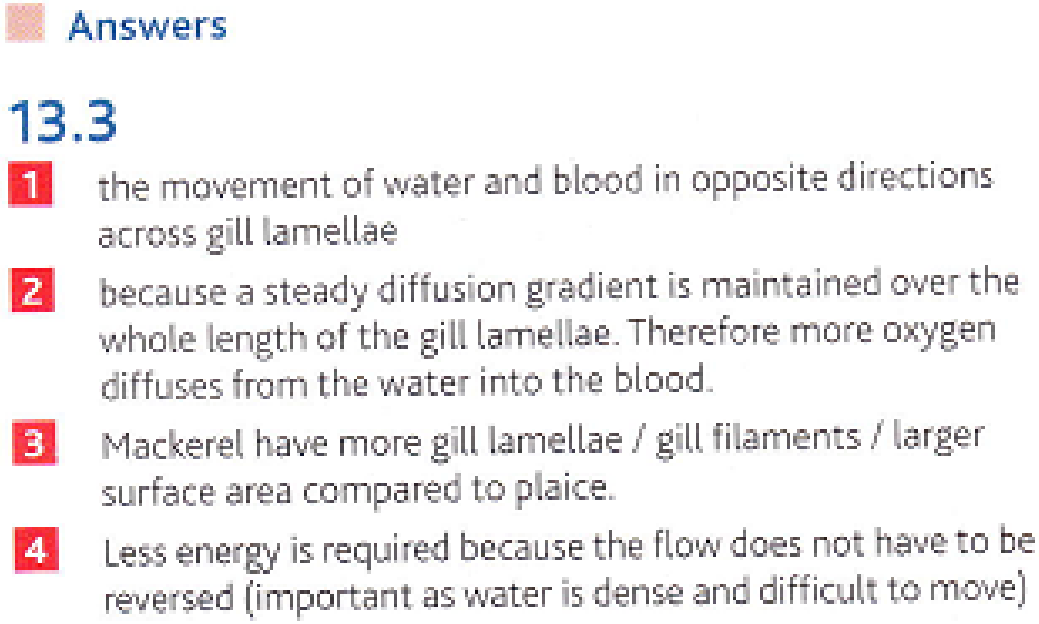
Summary questions

1. In relation to fish gills, what is meant by countercurrent flow?
2. Why is countercurrent flow an efficient means of exchanging gases across the gills of fish?
3. Mackerel are active, fast-swimming fish while plaice spend most of their lives moving slowly on the sea bed. There are differences in the gills of these two types of fish. Suggest what these differences might be.
4. Water flow over fish gills is one-way whereas the flow of air in and out of the lungs is two-way. Suggest why one-way flow is an advantage to fish.

Summary Questions

1. State two similarities between gas exchange in a plant leaf and gas exchange in a terrestrial insect.
2. State two differences between gas exchange in a plant leaf and gas exchange in a terrestrial insect.
3. What is the advantage to a plant of being able to control the opening and closing of stomata?

Answers



Answers

13.3

1. the movement of water and blood in opposite directions across gill lamellae
2. because a steady diffusion gradient is maintained over the whole length of the gill lamellae. Therefore more oxygen diffuses from the water into the blood.
3. Mackerel have more gill lamellae / gill filaments / larger surface area compared to plaice.
4. Less energy is required because the flow does not have to be reversed (important as water is dense and difficult to move)

1. Any 2 from; no living cells is far from the external air / diffusion takes place in the gas phase / need to avoid excessive water loss / diffuse air through pores in their outer covering (can control the opening and closing of these pores).
2. Any 2 from; insects may create mass air flow – plants never do / insects have a smaller surface area to volume ratio than plants / insects have special structures (tracheae) along which gas can diffuse - plants do not / insects do not interchange gases between respiration and photosynthesis – plants do.

Homework Questions

WARNING Some independent research required!

1. Diffusion is a passive, physical process that takes place everywhere. Why is diffusion not the only means of gaseous exchange in large organisms? (2 marks)
2. With reference to surface area and heat exchange explain why having small ears is an adaptaticounter-current exchange with reference to gaseous exchange in fish.
3. By what process does carbon dioxide enter photosynthesizing cells in leaves?
4. Why is there a conflict between obtaining carbon dioxide for photosynthesis and conserving water?
5. Why does the stoma open when guard cells are turgid?
6. How do the stomata in plant cells open and close?
7. What are xerophytes?
8. on to a cold environment. (2 marks)
9. In which structures in the tracheal system does most gaseous exchange take place? Explain why. (2 marks)
10. Name two features of gills that maximize diffusion of respiratory gases across their membranes.
11. Explain the term halophytes?
12. How are xerophytes adapted to minimise water loss?
13. What is the significance of sarguaro cacti being shaped like an organ pipe?

Application

Exchange of carbon dioxide

The graph in Figure 4 shows the volume of carbon dioxide produced by a sample of tomato plants at different light intensities.

1. Which process produces carbon dioxide in the tomato plants?
2. Which process uses up carbon dioxide in the tomato plants?
3. Explain why, at point X, carbon dioxide is neither taken up nor given out by the tomato plants.
4. Some herbicides cause the stomata of plants to close. Suggest how these herbicides might lead to the death of a plant.

stomata?

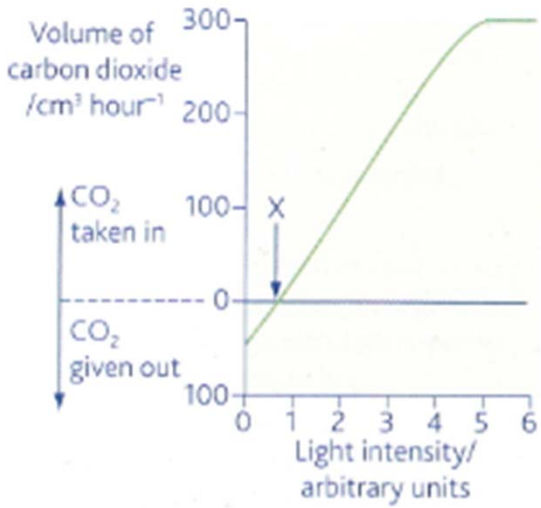


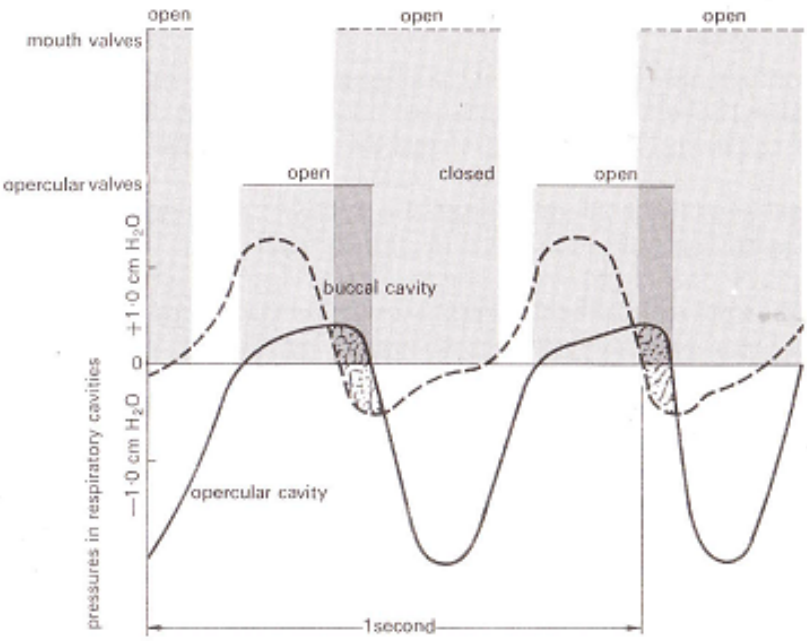
Figure 4

2.8 The breathing mechanism of a fish

Originally it was thought that water entered the buccal cavity and pharynx of a teleost (bony fish, for example, trout and herring) when their floors were lowered; this would reduce the pressure in the pharynx and opercular cavities, compared with that outside the mouth. Water entered when the mouth was opened. The difference in pressure between the opercular cavity and the water outside caused the opercular flaps to close and prevent the entry of water under the operculum due to their valve-like action.

Using these ideas and examining figure 16 first, plot two graphs (pressure: vertical axis; time: horizontal axis) to indicate the pressure changes in the pharynx and opercular cavity, relative to the external pressure. Indicate on the graphs when the mouth and the opercular valves are open.

Hughes and Shelton (1958) measured simultaneously the pressures in the buccal and opercular cavities in trout in relation to external pressure. Their results are described graphically in figure 16 which also shows when the mouth and opercular valves were open. In fishes the buccal and pharyngeal cavities are continuous and the differences in pressure between these two spaces are small. Thus we may consider that measurements of pressure in the buccal cavity will be similar to those in the pharynx.



Figures 16 and 17 are based on Eggleston, J. F. (1968) Quantitative biology, *English Universities Press Ltd.*

Figure 16
Pressure changes in the buccal and opercular cavities of trout *(Salmo trutta)* resulting from respiratory movements. The graphs show variations in pressure in the buccal and opercular cavities relative to the pressure outside the fish. The horizontal plain lines near the top of the figure indicate the time during which the opercular 'valves' were open. The horizontal lines of dashes at the top of the figure indicate the time during which the mouth 'valve' was open.

a What causal relation between the pressure in the buccal cavity and the opening of the opercular valves is indicated in figure 16?

b What is the relation between the buccal pressure and the opening of the mouth?

c In which direction will water flow during the period indicated by the shaded areas between the two curves? Explain why.

d Originally, the mechanism was thought to act as a simple force pump with, as it were, one piston and two sets of valves. Describe how this interpretation must be modified to account for Hughes' and Shelton's observations.