Lesson Description

In this lesson, we:

- Define gaseous exchange
  - Look at the requirements for efficient gaseous exchange
  - Study gaseous exchange in various organisms

Summary

Gaseous Exchange

Define Gaseous Exchange

- Gas exchange is a process that occurs when oxygen and carbon dioxide diffuse across a surface or membrane in opposite directions.
- Gas exchange is needed to provide cells with enough oxygen for cellular respiration, and to remove the carbon dioxide that the cells produce.

(Solutions for all Life Sciences, Macmillan, p204)

- The surface to volume ratio of an organism is important. The surface area indicates how much oxygen the organism can absorb through its surface and the volume is an indication of how much oxygen will be needed by the organism.
- Smaller organisms and unicellular organisms have a larger surface area in comparison to their volume.
- Larger organisms have a smaller surface area than volume so they do not absorb enough oxygen through their surface. Therefore there are modified in other ways to absorb oxygen.
Requirements for Efficient Gaseous Exchange

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Why it is important</th>
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<tbody>
<tr>
<td>Surface area of the gas exchange organ must be large</td>
<td>Allow sufficient oxygen to diffuse in and sufficient carbon dioxide to diffuse out</td>
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<tr>
<td>Surface area must be moist</td>
<td>To prevent desiccation of the gas exchange tissues</td>
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<tr>
<td>Surface must be thin</td>
<td>To allow for rapid diffusion of gases across it</td>
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<tr>
<td>A transport system must be available</td>
<td>To transport the gases to and from the gas exchange surfaces</td>
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<tr>
<td>An adequate ventilating mechanism must be present</td>
<td>To ensure that oxygen-laden air is brought in and carbon dioxide-laden air is driven out</td>
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<td>The gas exchange surface must be protected</td>
<td>Because the gas exchange system is thin and delicate</td>
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Gaseous Exchange in an Earthworm

- The earthworm lives in moist soil and does not need special organs for gaseous exchange.
- The long cylindrical body of the earthworm has a large surface area to volume ratio and the gas diffuses through the permeable body surface.
- There is a network of blood capillaries below the surface. Blood transports the gases through the body.

(Solutions for all Life Sciences, Macmillan, p207)
Gaseous Exchange in a Locust

- The body surface of the locust is impermeable to water and gases.
- A branched network of tubes (tracheae) makes up the gas exchange system.
- The openings of the tubes are called spiracles and air passes through them into the tracheoles (small tubes) that end amongst the body tissues.
- Gases pass across the moist lining to the body cells and back without blood transport.
- Air flow is controlled by the opening and closing of spiracles and the rhythmic body movement to get air into and out of the trachea.

Gaseous Exchange in Bony Fish

- It is difficult to get oxygen out of water because diffusion occurs more slowly.
- Bony fish have specially adapted body parts called gills which are protected by a bony covering called an operculum.
Each gill is made up of two rows of filaments which are made up of thin, flat plates called lamellae.

The lamellae have a rich supply of blood capillaries. The flat plates increase the surface area.

Water flows over the lamellae in the opposite direction to blood flow. This means that when the water flows over the lamellae it has a higher concentration of oxygen than the blood flowing in the other direction.

Blood transports the gases to the rest of the body.

The fish continuously pumps water through their mouths and over their gills by moving their jaws and opercula.

Gaseous Exchange in a Dicotyledonous Plant

Gaseous exchange occurs mainly in the leaves which are thin and flat and have a waxy cuticle on the epidermis to reduce water loss but this interferes with gas exchange.

The leaves have specialised pores called stomata. Each stoma (singular) has guard cells that control the opening and closing of the pores.

Gases diffuse directly from the atmosphere into the cells inside the pore and vice versa.

Once inside the gas diffuses across the membranes of moist cells. The internal surfaces of the cells are increased by the spongy mesophyll cells bordering the air spaces.
Test Yourself

Question 1
The diagram shows a cross-section of a leaf.

Where in the leaf does gaseous exchange occur?
A 1 and 2
B 1 and 3
C 2 and 3
D 3 and 4
Question 2
Where and how does carbon dioxide enter a plant?

<table>
<thead>
<tr>
<th>where</th>
<th>how</th>
</tr>
</thead>
<tbody>
<tr>
<td>A root hair cells</td>
<td>active uptake</td>
</tr>
<tr>
<td>B root hair cells</td>
<td>diffusion</td>
</tr>
<tr>
<td>C stomata</td>
<td>active uptake</td>
</tr>
<tr>
<td>D stomata</td>
<td>diffusion</td>
</tr>
</tbody>
</table>

Question 3
In grasshopper, gaseous exchange takes place through
A. Gills
B. Spiracles
C. Trachea
D. Lungs

Question 4
The source of oxygen for the aquatic animals is
A. Atmosphere
B. Soil
C. Water
D. None of the above

Question 5
The surface area of the gills increase due to the presence of
A. Lamellae
B. Alveoli
C. Arches
D. Slits

Question 6
The direction of flow of water is _________ that of the flow of blood in the capillaries in gills.
A. Is in the same direction as
B. Is opposite to
C. Not connected to
D. None of the above

Question 7
The number of pairs of spiracles in a grasshopper are:
A. 10
B. 20
C. 6
D. 8
Question 8
Maximum carbon dioxide concentration will be in the
A. Expired air  
B. Inspired air  
C. Dead space air  
D. All will be the same

![Image]

Improve your Skills

Question 1

1.1 Give one similarity between the way in which oxygen from the atmosphere reaches a muscle in an insect and the way it reaches a mesophyll cell in a leaf. (1)

1.2 Give one difference in the way in which carbon dioxide is removed from a muscle in an insect and the way in which it is removed from a muscle in a fish. (1)

The diagram shows the way in which water flows over the gills of a fish.

![Diagram]

The graph below shows the changes in pressure in the buccal cavity and in the opercular cavity during a ventilation cycle.

![Graph]

1.3 Use the graph to calculate the rate of ventilation in cycles per second. (1)

1.4 For most of this ventilation cycle, water will be flowing in one direction over the gills explain the evidence from the graph that supports this. (2)

1.5 Explain how the fish increases pressure in the buccal cavity. (2)
Question 2

The drawing shows a 24-hour cycle for the opening and closing of stomata from the same plant.

2.1 Explain how this opening and closing of stomata is advantageous to the plant. (2)

The diagram shows the potassium (K⁺) ion concentrations in the cells around an open and closed stoma in Commelina. The concentrations are in arbitrary units.

2.2 Explain how the movement of K⁺ ions accounts for the opening of the stoma. (2)

2.3 Explain how K⁺ ions are moved against a concentration gradient. (5)

Question 3

3.1 How do earthworms maintain their moist gaseous exchange surfaces? (2)

3.2 The way in which earthworms prevent desiccation to their bodies is different to how they maintain moist gaseous exchange surfaces. How do earthworms prevent desiccation? (2)

3.3 How are insects adapted for:
   i) the prevention of desiccation? (2)
   ii) the maintenance of moist gaseous exchange surfaces? (2)