Theme: Respiration in plants and animals

S3 New Curriculum Biology-Chapter 1– Gaseous exchange

Gaseous exchange

Gaseous exchange in biology refers to the process by which living organisms take in oxygen (O_2) and release carbon dioxide (CO_2). This is crucial for respiration, where oxygen is used to generate energy, and carbon dioxide—produced as a waste product—is expelled.

In animals, gaseous exchange occurs in **specialized organs/gaseous exchange surfaces** like lungs (in mammals), gills (in fish), or through the skin (in some amphibians). In humans, for example, oxygen moves from the air in the lungs into the blood, while carbon dioxide is transferred from the blood to the lungs to be exhaled.

Plants also undergo gaseous exchange, but in a slightly different way. They absorb carbon dioxide for photosynthesis during the day and release oxygen as a byproduct. At night, when photosynthesis halts, plants take in oxygen for respiration and release carbon dioxide.

Adaptations of a respiratory surface.

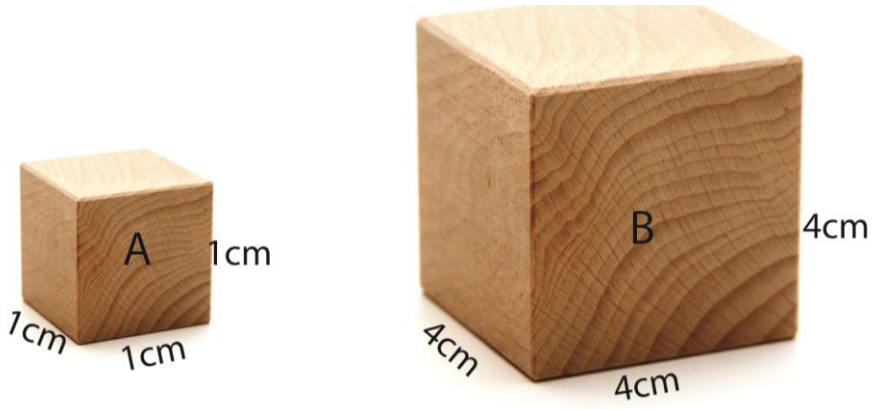
- It must be **permeable,** so that gases can pass through.
- It must be **thin,** because diffusion is only efficient over distances of 1mm or less.
- It should possess **a large surface area** so that sufficient amounts of gases are able to be exchanged according to the organisms need.
- It must be **moist to ease diffusion** of gases across the respiratory surface.

In small animals, the surface area to volume ratio is large enough for diffusion across the external surface to satisfy their respiratory need. But in larger animals, particularly active ones, the surface to volume ratio is too small for this to be so, and special **respiratory surface** has been developed.

Trial 1

(a) Calculate
  (i) Total surface area of cube A and B
  (ii) Volume of B

(iii) Surface area to volume ratio of cube A and to cube B.



(b) What is the relationship between
   (i) Surface are and rate of gaseous exchange
   (ii) Surface area to volume ratio and the rate of gaseous exchange
   (iii) Which of the two, cubes A and cube B would need a specialised system for gaseous exchange if they were living organism?

(c) Which of the two, cube A and cube B represent;
   (i) Unicellular organism
   (ii) Multicellular organism

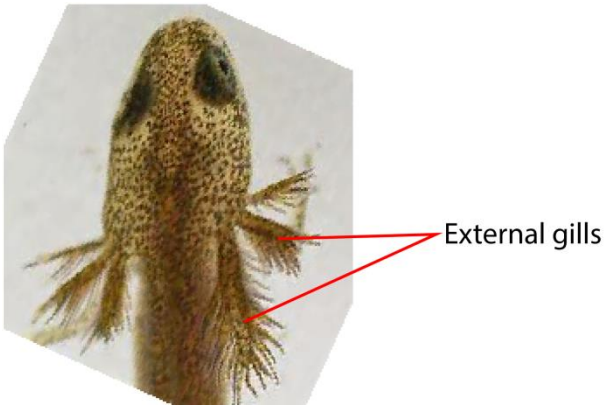
(d) From your findings above, why do multicellular organisms need specialized gaseous exchange system?

Specialised gaseous exchange surfaces

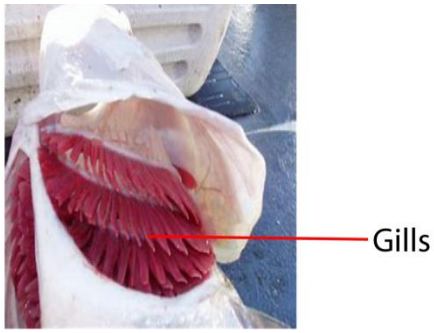
The specialised gaseous exchange surfaces provide large surface area by developing flaps, sac or tubes.

Examples

1. Body surface is usually sufficient gaseous exchange surface for small animals such as protozoa, earthworm, flatworms with larges surface-volume ratio.
2. Aquatic organism such as Lung worm and tadpole use external gill which are epidermal outgrowth from the surface of the body

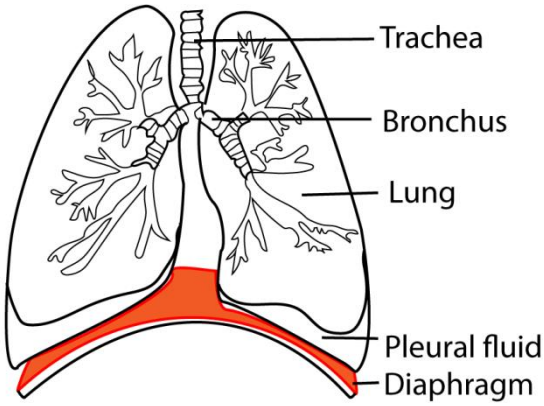


3. Fish use internal gills which are enclosed within the body and protected from damage.



4. Air-breaking vertebrates have developed **lungs** which develop as sac-like outgrowth of the pharynx in which air is brought close to the blood to allow gaseous exchange.

Respiratory system



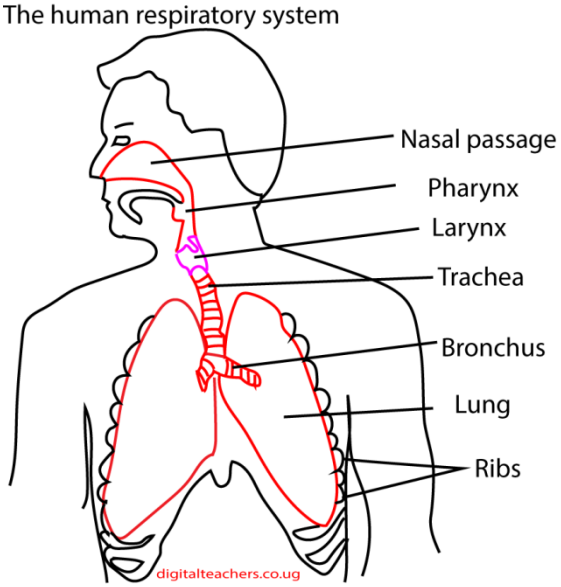
The biggest problem of gaseous exchange through by the lung is that energy is required for ventilation especially during inspiration and leads to water loss.

5. Insects have developed a tracheal system, penetrating and ramifying and delivering oxygen to tissue cell

6. The frog and other amphibians use the skin and buccal cavity in addition the lungs

Gaseous exchange in man

The human respiratory system



The human lungs and associated structure are shown in figure above. The **lungs** are situated in the **thorax,** the walls of which are formed by the **ribs** and **intercostal muscles** and the floor of the **diaphragm.** The lungs are surrounded by a very narrow **pleural cavity** lined by **pleural membranes.** The pleural cavity contains a thin layer of lubricating which allows the pleural membranes to slide easily over each other as the thorax expands and contracts during breathing.

Inspiration

Air is drawn into the lungs via the **trachea** and bronchi.

1. External intercostal muscles contract and rise the ribs upwards and outwards.
2. The radial and circular muscles of the diaphragm contract and diaphragm flattens.
3. There is an increase in volume of the thoracic cavity and a decrease in pressure in the lungs.
4. Air is drawn into the lungs to equalise the pressure to atmospheric pressure.

Expiration

- This is a reverse of the inspiration process; air being expelled from lungs.
- It is mainly a passive process resulting from elastic recoil of the tissues that have been stretched during inspiration.
- However, in forced breathing or when breathing tubes are blocked, expiration is aided by contraction of the internal intercostal muscles and **abdominal muscles.**
- Contraction of the latter raises the pressure in the abdominal cavity, forcing the diaphragm upwards.

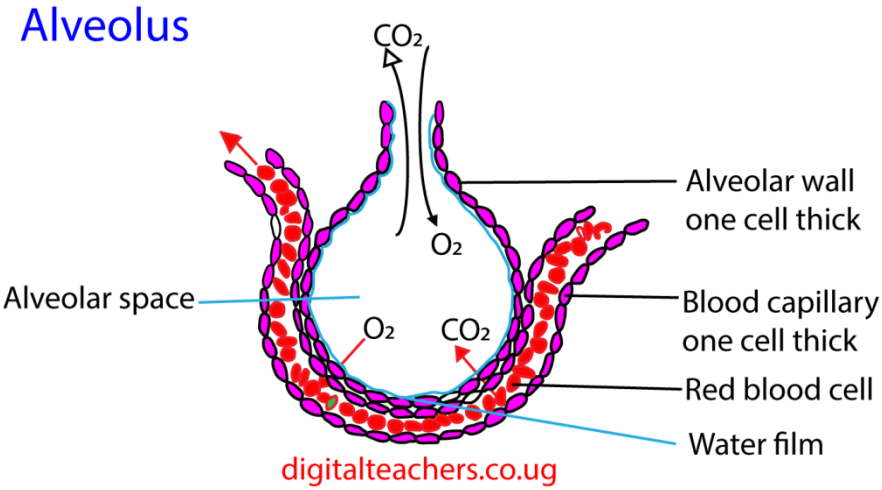
Alveoli.

Alveoli (singular alveolus) are numerous hollow, lobed air sacs that form the gaseous exchange surface in the lungs.

They occur at the terminal end of the tracheal branching and come in close association with extensive capillary system.

This makes them efficient apparatus for gaseous exchange.

Diagram of alveolus showing intimate association between alveoli and blood capillaries.



Adaptations of the alveolus to efficient gaseous exchange

1. They are very numerous that they offer a big surface area for gaseous exchange
2. Alveolar epithelium is covered internally with a thin layer of fluids in which oxygen dissolves before diffusing into the blood which create high diffusion gradient.
3. Alveolar fluid contains surfactants that prevent alveolar form collapsing
4. Alveolus is separated form blood capillaries by thin membrane that offer minimum resistance to diffusion of gases.
5. The blood capillaries of the alveolus are smaller than the red blood cells such that when cell squeeze through the capillaries, they make intimate contact with capillary membranes that ease gaseous diffusion.

Air pollution

Air pollution occurs when harmful substances—such as chemicals, smoke, dust, or gases—contaminate the air we breathe. It affects both human health and the environment.

Causes of Air Pollution

- **Vehicle emissions**: Cars, trucks, and buses release carbon monoxide and other pollutants.
- **Industrial activity**: Factories and power plants emit smoke, sulfur dioxide, and nitrogen oxides.
- **Burning fossil fuels**: Coal, oil, and gas used in energy production contribute to air pollution.
- **Deforestation**: Fewer trees mean less oxygen production and higher carbon dioxide levels.
- **Agricultural activities**: Pesticides, fertilizers, and livestock waste release pollutants into the air.
- **Wildfires**: Produce smoke and particulate matter that can spread over large areas.

Effects of Air Pollution

- **Health issues**: Causes respiratory problems, heart diseases, and worsens conditions like asthma.
- **Climate change**: Greenhouse gases trap heat, leading to global warming.
- **Damage to ecosystems**: Acid rain affects soil, water, and wildlife.
- **Reduced visibility**: Smog and haze make it harder to see in polluted areas.
- **Harm to plants and animals**: Pollutants affect photosynthesis and disrupt food chains.

How to reduce air pollution

Reducing air pollution is essential for a healthier environment and better quality of life. Here are some effective ways to help:

Individual Actions

- **Use public transportation or carpool**: Fewer vehicles on the road mean less pollution.
- **Switch to clean energy sources**: Using solar or wind power reduces reliance on fossil fuels.
- **Limit burning activities**: Avoid burning trash, leaves, or wood, which release harmful pollutants.
- **Save electricity**: Using energy-efficient appliances and turning off unused devices helps reduce emissions.
- **Plant trees**: Trees absorb carbon dioxide and produce oxygen, improving air quality.

Community and Government Initiatives

- **Promote sustainable urban planning**: More green spaces and better public transport systems help reduce pollution.
- **Regulate industrial emissions**: Governments can enforce stricter pollution controls on factories and power plants.
- **Encourage renewable energy**: Investing in wind, solar, and hydroelectric power reduces air pollution.

- **Support clean fuel technology**: Electric vehicles and biofuels create less pollution than traditional fuels.
- **Educate and advocate**: Raising awareness encourages communities to take action.

Cleaner air benefits everyone!

Gaseous exchange in plants

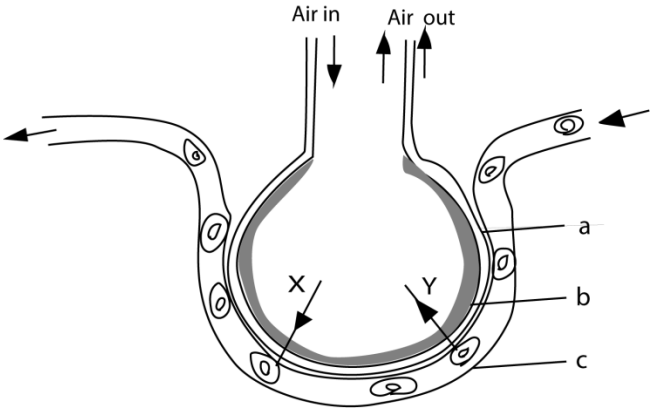
Gaseous exchange in plants takes place in stomata

Adaptation of animals to low oxygen tension

1. High haemoglobin concentration in blood
2. Have myoglobin that store oxygen
3. Fish e.g. trout store oxygen in swimming bladder
4. Have haemoglobin with high affinity for oxygen e.g. lungworm
5. Fish air breath: when oxygen in water is low fishes break the surface and trap air inside the mouth.
6. Decreased activities. Animals tend to be sluggish
7. Increased ventilation rate i.e. fast and deep breathing to reduce oxygen requirement
8. Aquatic surface respiration: fish stay on the surface leave snout at air water surface taking in water richer in oxygen.

Revision questions

1. The figure below shows a structure in the mammalian lung, study the figure and use it to answer questions that follow:



(a) Name
  (i) Parts a, b, and c. (1 ½ marks)
  (ii) Gases indicated by arrows x and y (01marks)
(b) Explain how features shown in the figure, enable the structure to function efficiently (5 ½ marks)
(c) State four differences between the air that goes into the structure and that which goes out of the structure (03mark)

2. (a) Explain how lungs are adapted to their functions as respiratory organs (10marks)
   (b) Explain why amoeba does not have respiratory system

3. (a) outline the mechanism of
   (i) Inspiration
   (ii) Expiration in bony fish
   (b) How are gills adapted for gaseous exchange in a bony fish?

Thanks

Dr. Bbosa Science