8.1 TYPES OF RESPIRATORY SYSTEM

Respiratory structures and their adaptations for gaseous exchange

- The respiratory structure is the respiratory surface that enables gaseous exchange to occur between respiring organism cells and their outer environment
- The ratio of total surface area to volume (TSA/V) depends on the size of the organism
- The bigger the size of the organism, the smaller the ratio of total surface area to volume
- This means that for large and complex organisms, the volume of the body that requires oxygen will increase more than its total surface area.
- This explains why large and complex organisms cannot maintain gaseous exchange by diffusion through body surface only.
- Large organisms require a special respiratory structure for
- the efficient exchange of gases

ADAPTATIONS OF RESPIRATORY STRUCTURES FOR EFFICIENT EXCHANGE OF GASES IN BIG ORGANISMS

- Large ratio of total surface area to volume (TSA/V) for the efficient exchange of respiratory gases.
- A thin respiratory structure that is one cell thick, allows the diffusion of respiratory gases to occur.
- The surface of the respiratory structure is always moist for respiratory gases to dissolve in them.
- The respiratory structure is complete with a network of blood capillaries (except for insects), that allows for the efficient delivery of respiratory gases

The insect respiratory structure and its adaptations

THE BREATHING SYSTEM OF INSECTS IS THE TRACHEAL SYSTEM

- There are small pores in the thorax and abdomen of insects called spiracles.
- The spiracle allows the intake of air into the air tube system, which is the tracheal system.
- the trachea branches out to form finer tubes called the tracheole.
- Tracheole is the respiratory surface.

The tracheole has the following characteristics that allow for efficient respiratory gaseous exchange.

A large number of tracheoles provides a large total surface area for the exchange of gases.

The tracheole wall is thin and moist. This allows oxygen gas to diffuse into the cells while carbon dioxide quickly diffuses out of the cells into the tracheole.

- Some insects have air sacs in their trachea system.
- This sac is filled with air to speed up the delivery of respiratory gas during active body movements

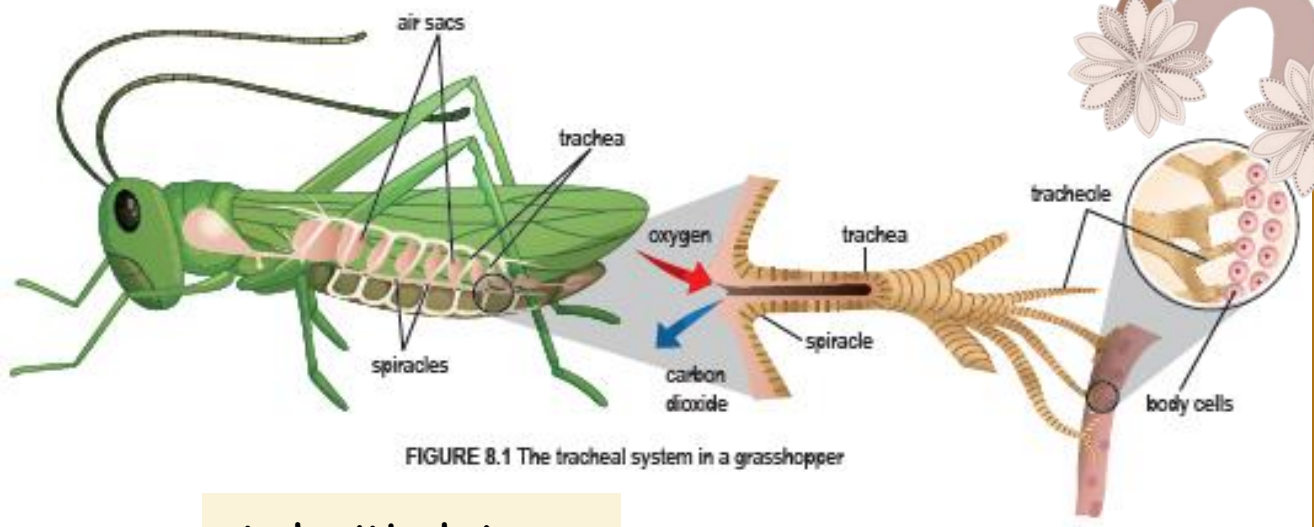


FIGURE 8.1 The tracheal system in a grasshopper

The fish respiratory structure and Its adaptations

- The respiratory structure of fish is the gills .
- The gills are made up of a line of filament that is supported by the gill arch.
- The following characteristics of filament enable the rapid exchange of respiratory gases

- The filament has many thin and flat projections called lamella .
- A large number of filaments and lamellae gives a large total surface area for an efficient gaseous exchange process
- The lamella membrane is thin and supplied with many bloodcapillaries for easy absorption and transport of oxygen and carbon dioxide

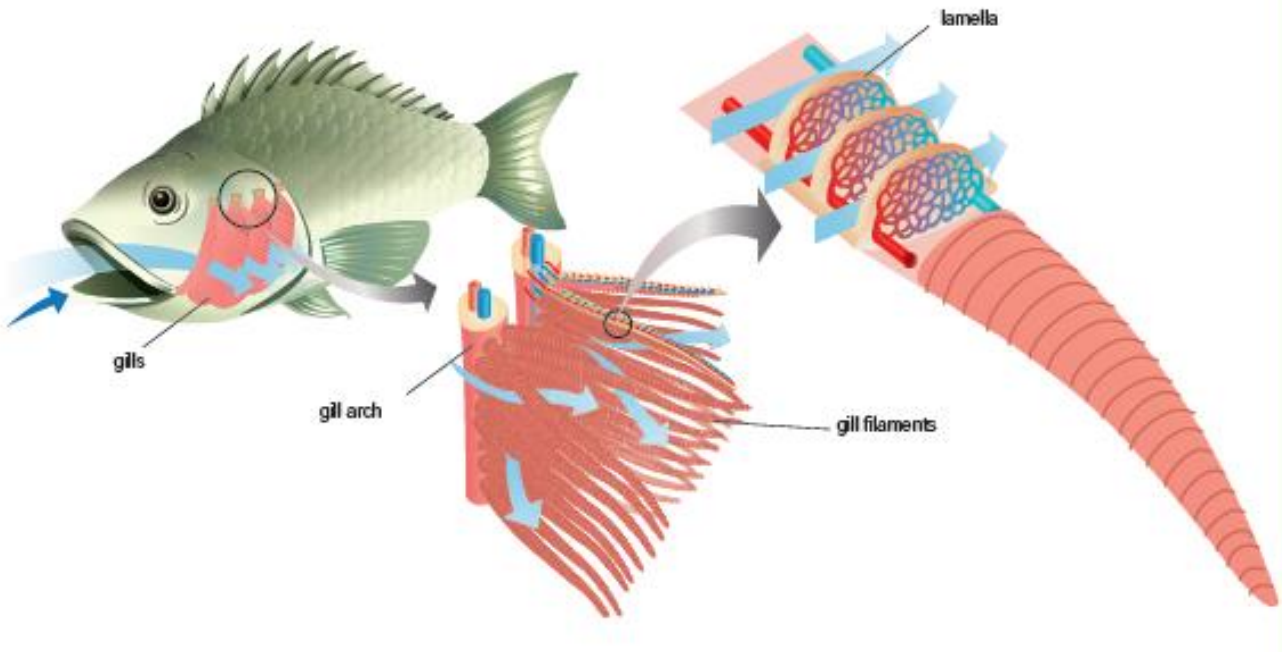


FIGURE 8.2 Respiratory structure of a fish

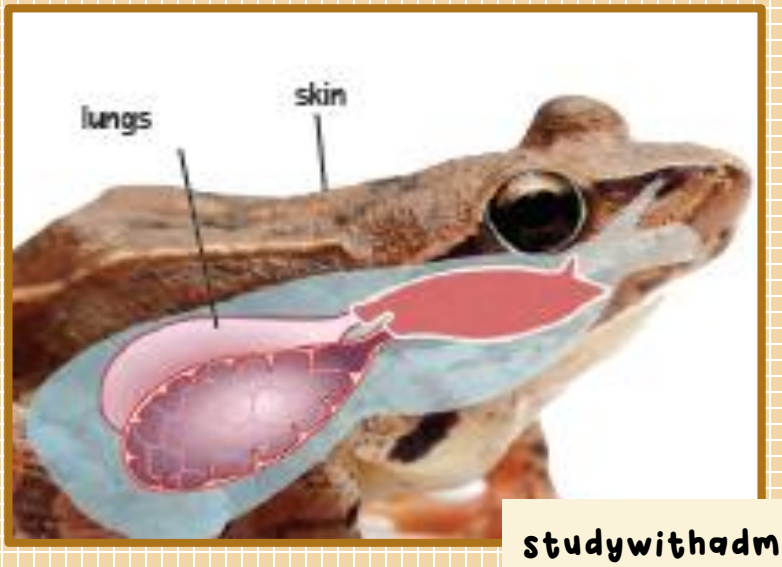
The frog respiratory structure and its adaptations

SKIN

- In an inactive state, the frog uses its skin for gaseous exchange
- The skin is thin and highly permeable to respiratory gases.
- The moist skin allows respiratory gases to dissolve in it.
- Beneath the skin, there are many networks of blood capillaries to transport respiratory gases

LUNGS

- The surface of the lungs is folded to increase the total surface area for the exchange of gases
- The thin lung membrane eases the diffusion of respiratory gases.
- The moist lung walls enable respiratory gases to dissolve in them.
- The lungs are also rich with a network of blood capillaries to transport respiratory gases



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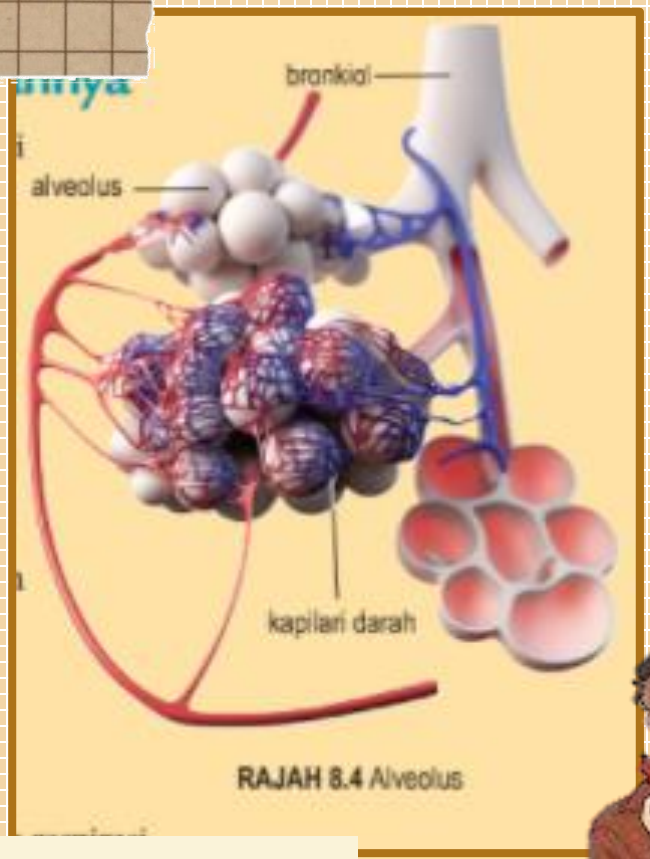
The human respiratory structure and its adaptations

THE HUMAN RESPIRATORY STRUCTURE IS THE ALVEOLUS WHICH HAS THE CHARACTERISTICS FOR EFFICIENT RESPIRATORY GASEOUS EXCHANGE

- A large number of alveoli provides a large total surface area for the diffusion of respiratory gases.
- The alveolus wall is always moist. Oxygen and carbon dioxide can dissolve easily, and diffuse through the walls into the blood capillaries.
- The alveolus is surrounded by a large network of blood capillaries to hasten the diffusion of respiratory gases.
- The thin alveolus wall, that is as thick as one cell, makes the diffusion of gases much easier.



RAJAH 8.4 Alveolus

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Comparison and contrast of respiratory structures in humans and animals

SIMILARITIES

- All respiratory structures have a large ratio of total surface area to volume for an efficient exchange of respiratory gases.
- All respiratory structures are thin and this makes the diffusion of respiratory gases much faster.
- All respiratory structures are moist and this allows respiratory gases to dissolve in them.
- The respiratory structure is complete with a network of blood capillaries (except insects), that allows for efficient transport of respiratory gases.

DIFFERENCES

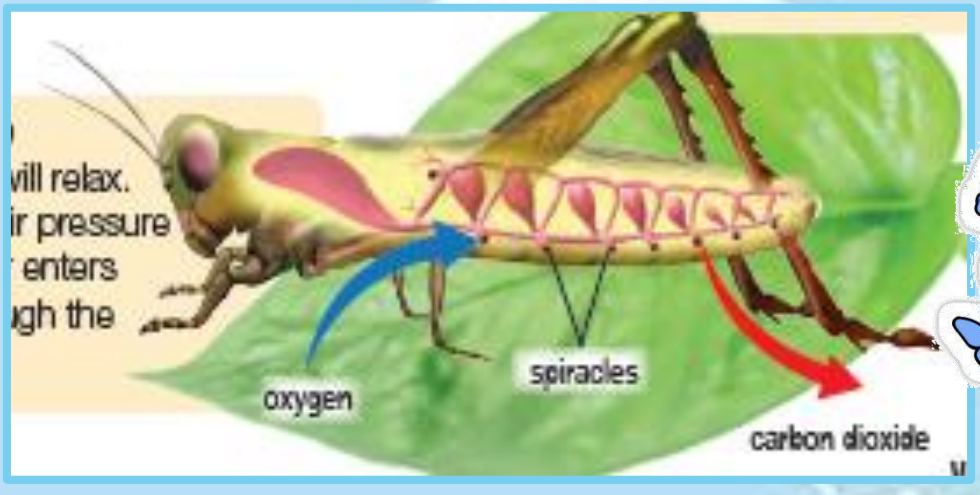
CHARACTERISTICS	INSECT	FISH	FROG	HUMANS
Respiratory structure	Tracheole	Filament and lamella	Skin and lungs	Alveolus
How the large ratio of total surface area to volume for the respiratory structure is achievedh	Large number of tracheoles	Large number of filaments and lamellae	-The surface in the lungs is folded -Overall skin surface	Large number of alveoli

8.2 MECHANISMS OF BREATHING

- Humans and animals have different breathing mechanisms.
- Breathing refers to the repetitive inhalation and exhalation process

Breathing mechanism of insects

- Abdominal muscles that relax and contract enables air to go in and out of the trachea



- When inhaling air, the abdominal muscles will relax.
- This will reduce the air pressure in the trachea and air enters into the trachea through the spiracle

- The abdominal muscles will
- contract when air is exhaled. This
- will increase the air pressure in the
- trachea and subsequently forces air
- out of the spiracle.

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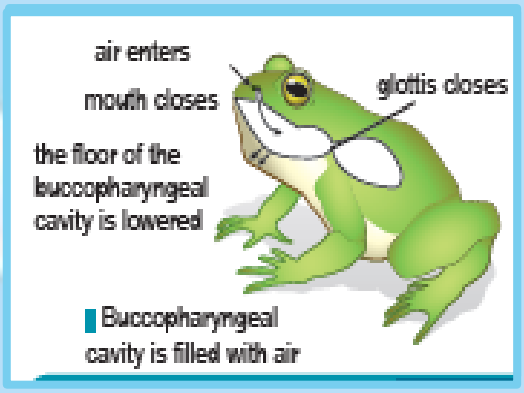
Breathing mechanism of frogs

- **Frogs breathe through the mouth and lungs while in an active state**

INHALATION



- **When the frog breathes through the nostrils, the mouth and glottis are closed and the floor of the buccopharyngeal cavity is lowered.**
- **The low air pressure in the mouth cavity draws air into the buccopharyngeal cavity through the nostrils**

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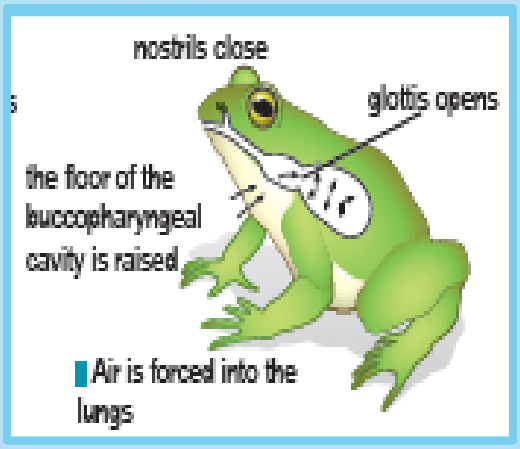
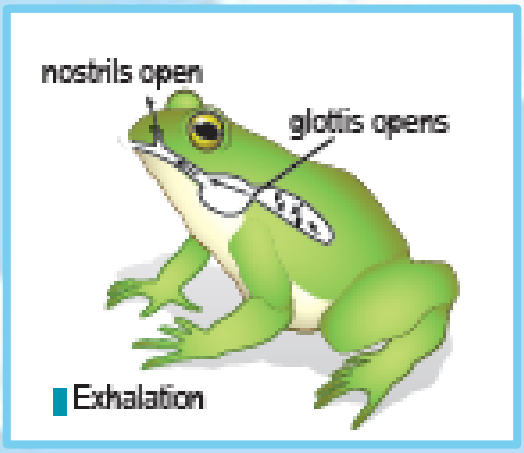
- **When the glottis opens, the nostrils close and the floor of the buccopharyngeal cavity is raised.**
- **The increased air pressure pushes air into the lungs**

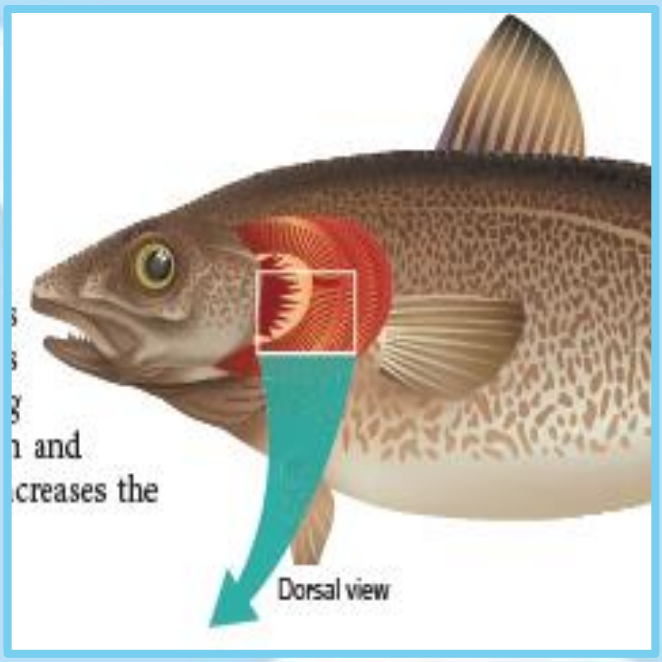


EXHALATION



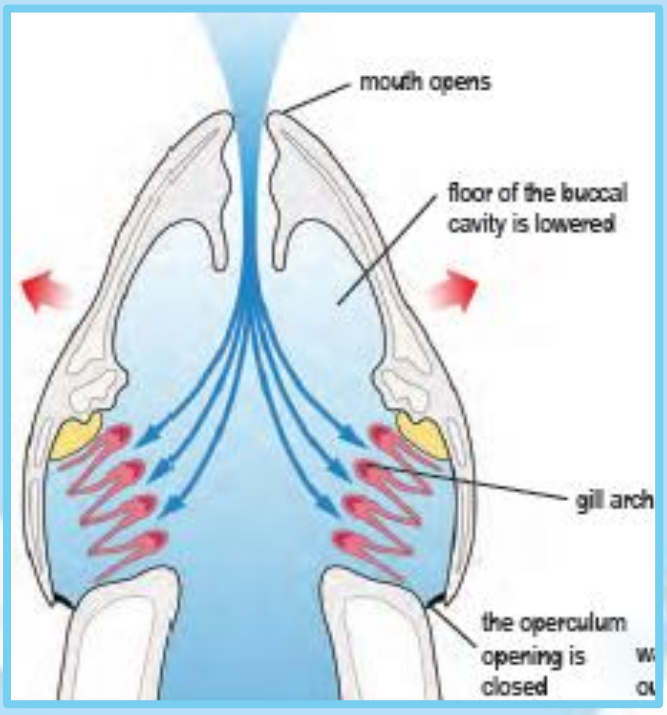
- **When the lungs contract, air is expelled from the lungs.**
- **This is helped by the abdominal pressure and the elasticity of the lungs.**
- **Some air is expelled through the nostrils while the rest is mixed with the air in the buccopharyngeal cavity**

Mekanisme pernafasan ikan



- The breathing mechanism of fish is aided by its mouth movement and operculum.
- Ventilation takes place when the fish swims by opening and closing its operculum.
- This pushes water into the mouth and subsequently through the gills.
- The ventilation increases the flow of water in the respiratory surface

INHALATION



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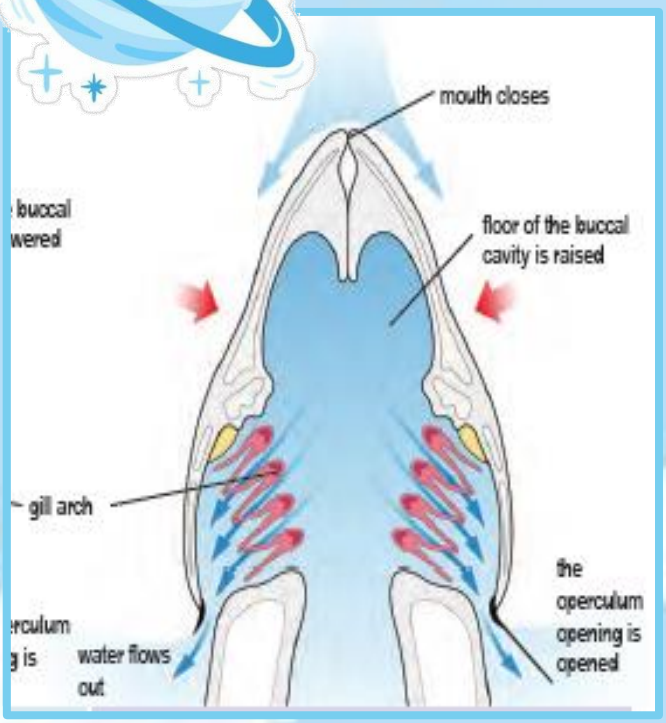
- When the mouth opens, the floor of the buccal cavity is lowered.
- At the same time, the opercular cavity is enlarged and the operculum opening is closed.
- This reduces the pressure in the buccal cavity.
- Water from the outside which contains dissolved oxygen enters the mouth

EXHALATION

- When the mouth is closed, the floor of the buccal cavity is raised.
- Water enters through the gill lamella and gaseous exchange between blood and water occurs through diffusion.
- At the same time, the operculum muscle relaxes and the opercular cavity becomes smaller.
- The volume of the buccal cavity is reduced and the pressure in the buccal cavity becomes higher than the pressure outside.
- The high pressure causes water to flow through the operculum opening



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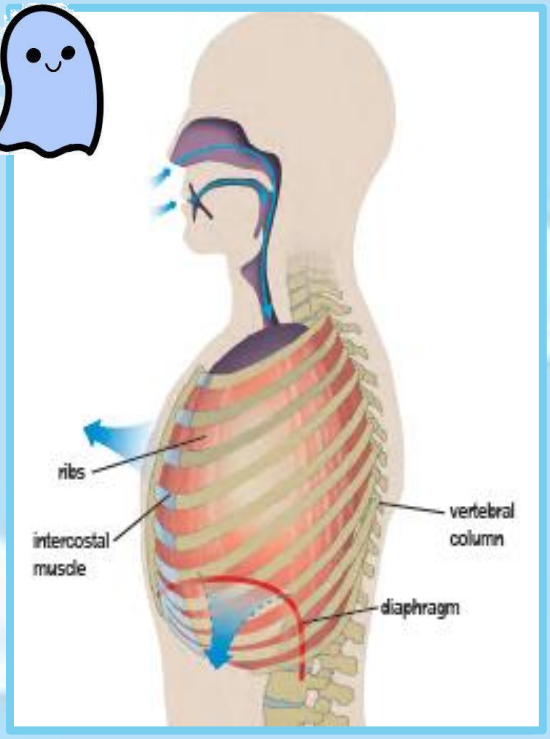
Breathing mechanism of humans

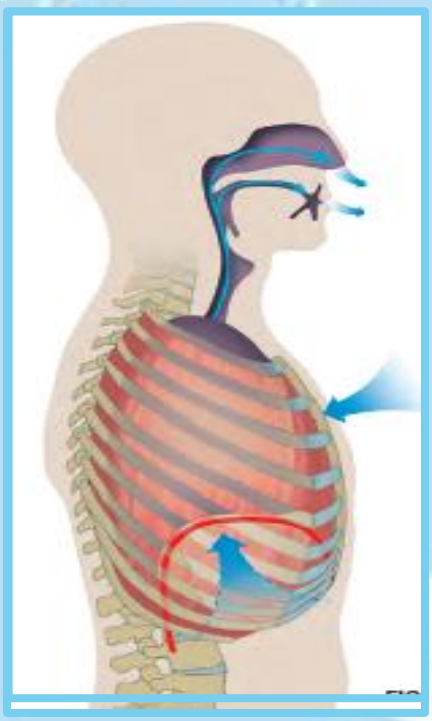
INHALATION



1. The external intercostal muscles contract while the internal intercostal muscles relax
2. This action causes the ribcage to move upwards and outwards
3. At the same time, the diaphragm muscles contract and the diaphragm moves downwards to become flat and horizontal.
4. Both mechanisms cause the volume of the thorax cavity to increase and the pressure of the thorax cavity decreases
5. The higher atmospheric pressure from outside forces air into the lungs

EXHALATION

1. The external intercostal muscles relax while the internal intercostal muscles contract
2. This action causes the ribcage to move downwards and inwards
3. At the same time, the diaphragm muscles relax and the diaphragm curves upwards to form a dome
4. Both movements cause the volume of the thoracic cavity to reduce and the pressure of the thorax cavity to increase
5. Air is pushed out of the lungs.



Compare and contrast breathing mechanisms in humans and animals

SIMILARITIES

- Humans and animals have special muscular structures to expand and contract the respiratory cavity.
- The breathing mechanism involves changes in the volume and pressure in the respiratory cavity.

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DIFFERENCES BETWEEN BREATHING MECHANISMS

CHARACTERISTICS	INSECT	FISH	FROG	HUMANS
Respiratory aperture	Spiracle	Mouth and operculum	Nostrils	Nostrils
Structure that helps breathing	Thorax, abdomen	Operculum and muscular floor of buccal cavity	Muscular buccopharyngeal wall	Diaphragm, ribcage and intercostal muscles
Breathing mechanism	Assisted by the contraction and relaxation of abdominal muscles	Assisted by movements of the floor of the buccal cavity and operculum	Assisted by the rapid movement of the buccopharyngeal cavity floor and elasticity of the Lungs	Assisted by the contraction and relaxation of The intercostal muscles and The diaphragm muscles as well as the movement of the rib cage upward and outward, and downward and Inward

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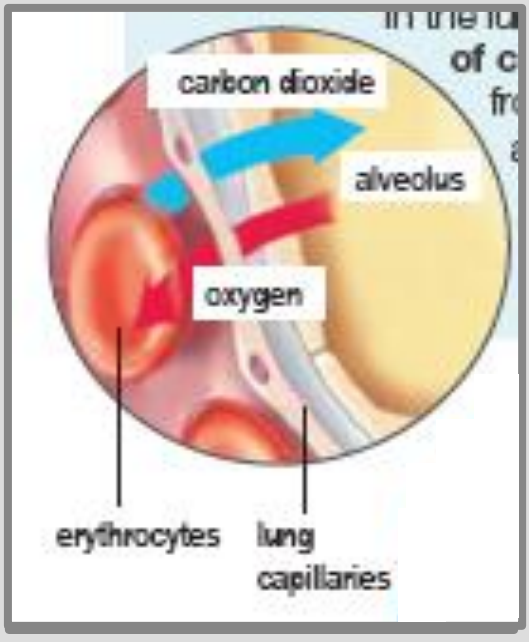
8.3 GASEOUS EXCHANGE IN HUMANS

PARTIAL PRESSURE OF OXYGEN AND CARBON DIOXIDE

- Gas diffusion depends on the partial pressure difference between two areas.
- The gas diffuses from an area where its partial pressure is higher to an area where its partial pressure is lower, which is down a partial pressure gradient

GASEOUS EXCHANGE AND THE TRANSPORT OF RESPIRATORY GASES



- In the lungs, blood that enters the lung capillaries contains a higher partial pressure of carbon dioxide compared to the alveolus.
- Carbon dioxide diffuses out from the lung capillaries and into the alveolus before it is expelled into the atmosphere through the nose and mouth.
- The partial pressure of oxygen in the alveolus is higher than the lung capillaries.
- Oxygen diffuses into the lung capillaries.
- Oxygen combines with haemoglobin in erythrocytes to form oxyhaemoglobin

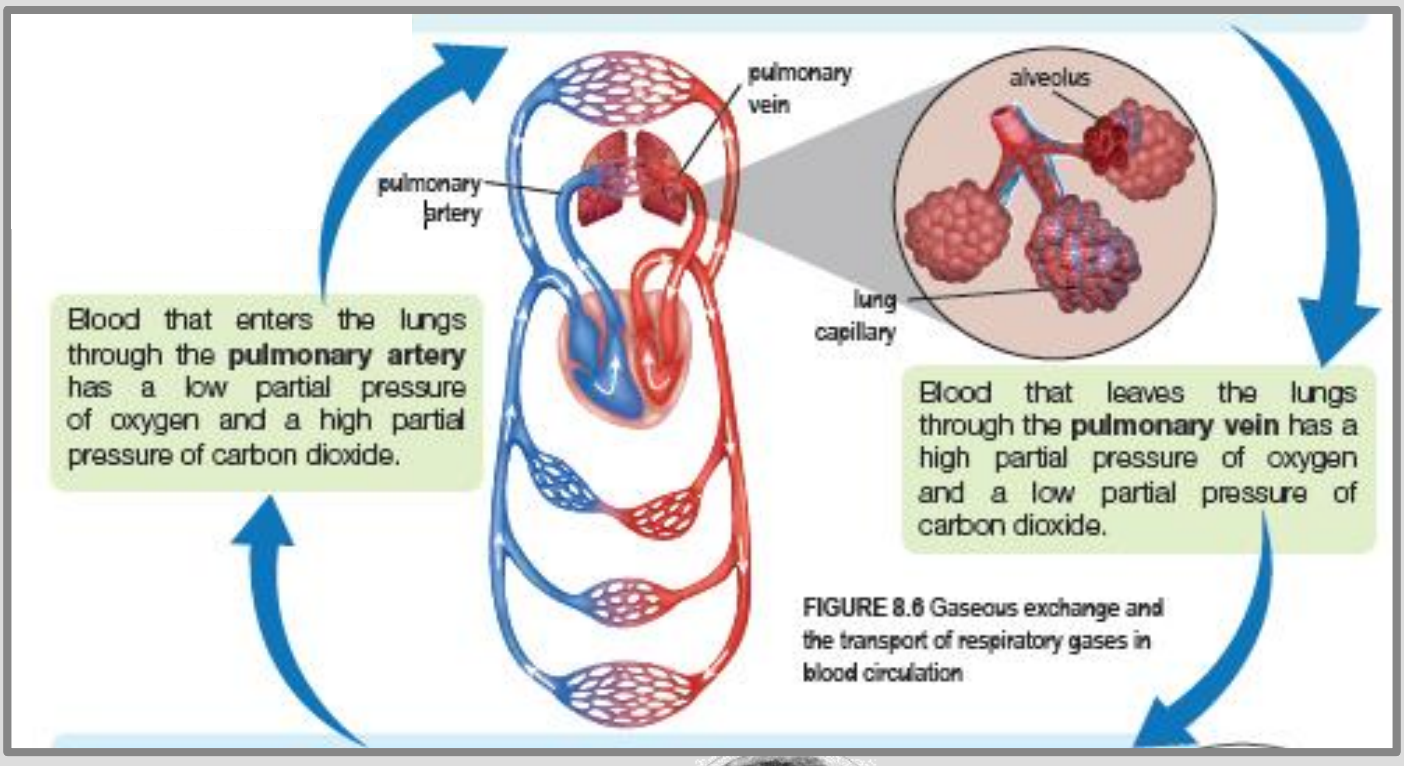
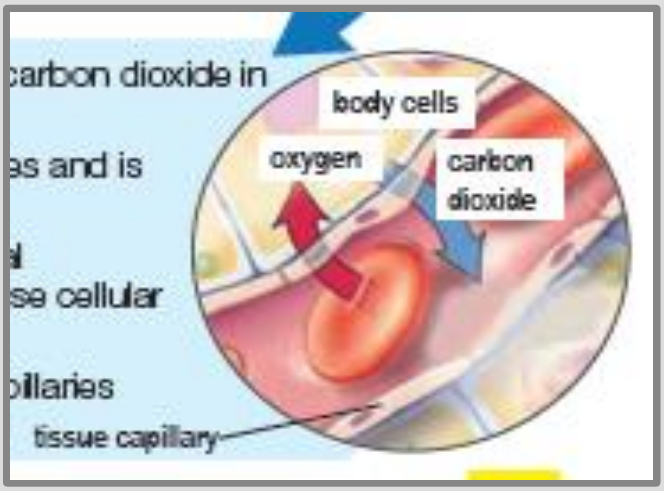


FIGURE 8.6 Gaseous exchange and the transport of respiratory gases in blood circulation

- **Cellular respiration releases carbon dioxide.**
- **The partial pressure of carbon dioxide in cells is higher than tissue capillaries.**
- **Carbon dioxide diffuses out from the body cells into the tissue capillaries and is transported back to the lungs.**
- **When blood reaches the tissue through the tissue capillaries, the partial pressure of oxygen in the blood is higher than that of body cells because cellular respiration uses oxygen.**
- **Oxyhaemoglobin breaks down and oxygen diffuses from the tissue capillaries to the body cells.**



TRANSPORT OF CARBON DIOXIDE IN THE BLOOD CIRCULATORY SYSTEM

- 70% is carried in the form of bicarbonate ion (HCO_3^-)
- 23% carbon dioxide combines with haemoglobin to form carbaminohaemoglobin
- 7% is dissolved and carried as carbonic acid (H_2CO_3)

The transport of carbon dioxide from body cells to tissue capillaries

- Carbon dioxide (CO_2) released by the body cells binds with water (H_2O) in the erythrocyte to form carbonic acid (H_2CO_3).
- The carbonic anhydrase enzyme in erythrocyte catalyses this reaction.
- Carbonic acid (H_2CO_3) will break down into bicarbonate ion (HCO_3^-) and hydrogen ion (H^+).
- Then HCO_3^- diffuses into the blood plasma and is carried to the lungs.

The transport of carbon dioxide from lung Capillaries to the alveolus

- When the bicarbonate ion in blood plasma reaches the lung capillaries, it diffuses back into the erythrocyte.
- The bicarbonate ion combines again with a hydrogen ion (H^+) to form carbonic acid (H_2CO_3).
- Carbonic acid (H_2CO_3) then breaks down into carbon dioxide and water.
- Carbon dioxide diffuses through the lung capillaries into the alveolus and is expelled during exhalation

8.4 Health Issues Related to the Human Respiratory System

- Chronic Obstructive Pulmonary Disease (COPD) comprises asthma, chronic bronchitis and emphysema. In emphysema, the alveolus loses its elasticity and increases in size.
- The alveolus wall is damaged, the total surface area of alveolus decreases and the gaseous exchange becomes less efficient.

- In chronic bronchitis, the bronchiole becomes inflamed, swoll and blocked.
- This reduces the flow of air and causes difficulties in breathing.
- A large amount of mucus formed will cause continuous coughing.
- Damaged cilium causes difficulty in expelling mucus

- For an asthmatic patient, the bronchiole walls become swollen and thick.
- The opening of the bronchiole tube becomes smaller and the air passage becomes narrower.
- This condition leads to difficulties in breathing and causes breathlessness..

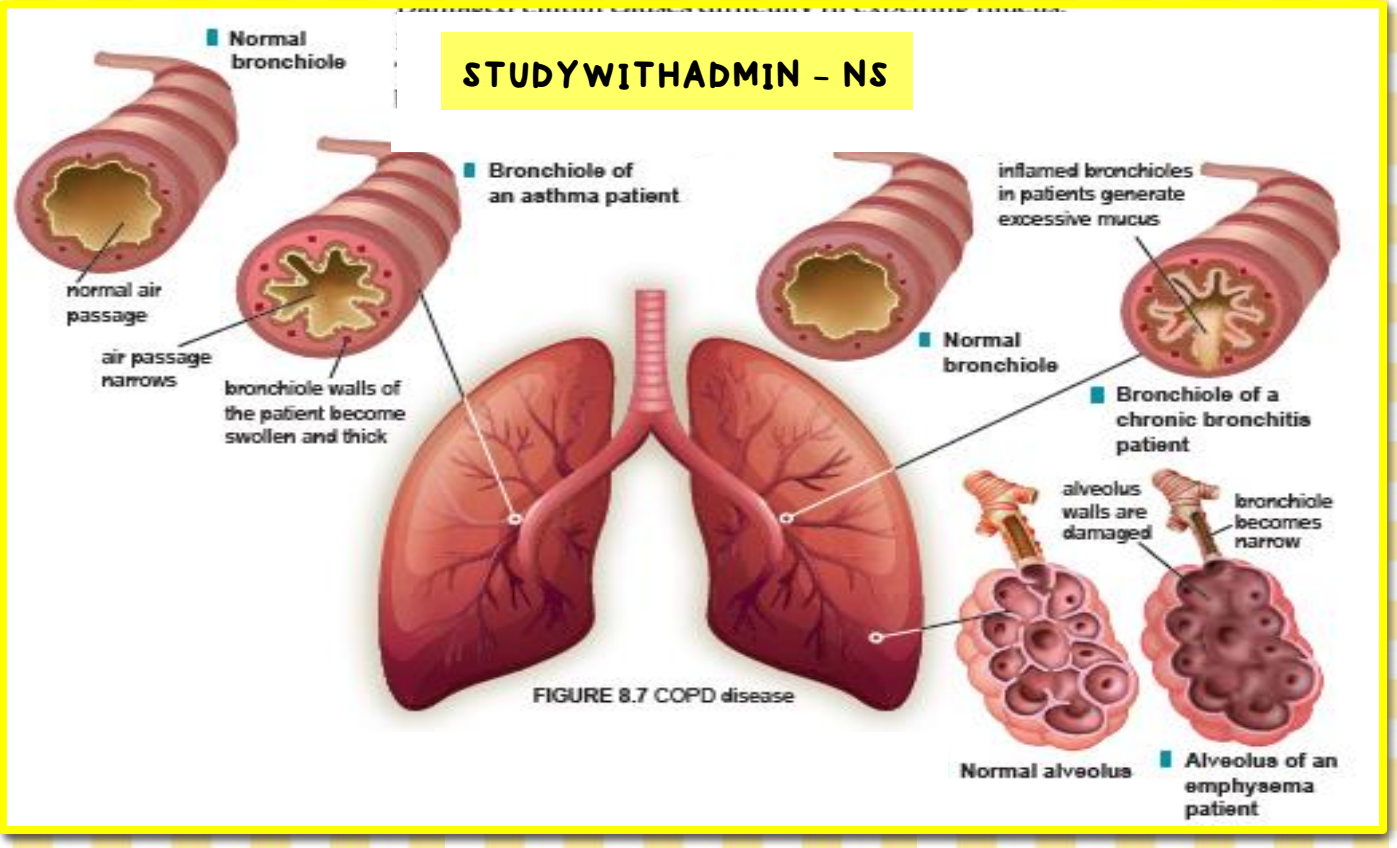


FIGURE 8.7 COPD disease