

CHAPTER 8.1 – TYPES OF RESPIRATORY SYSTEM

Respiratory structures and their adaptations for gaseous exchange

RESPIRATORY STRUCTURES

- ✚ The respiratory structure is the respiratory surface that enables gaseous exchange to occur between respiring organism cells and their outer environment
- ✚ Amoeba sp. do not need a special respiratory structure because it has a large total surface area to volume ratio for gaseous exchange through diffusion
- ✚ 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

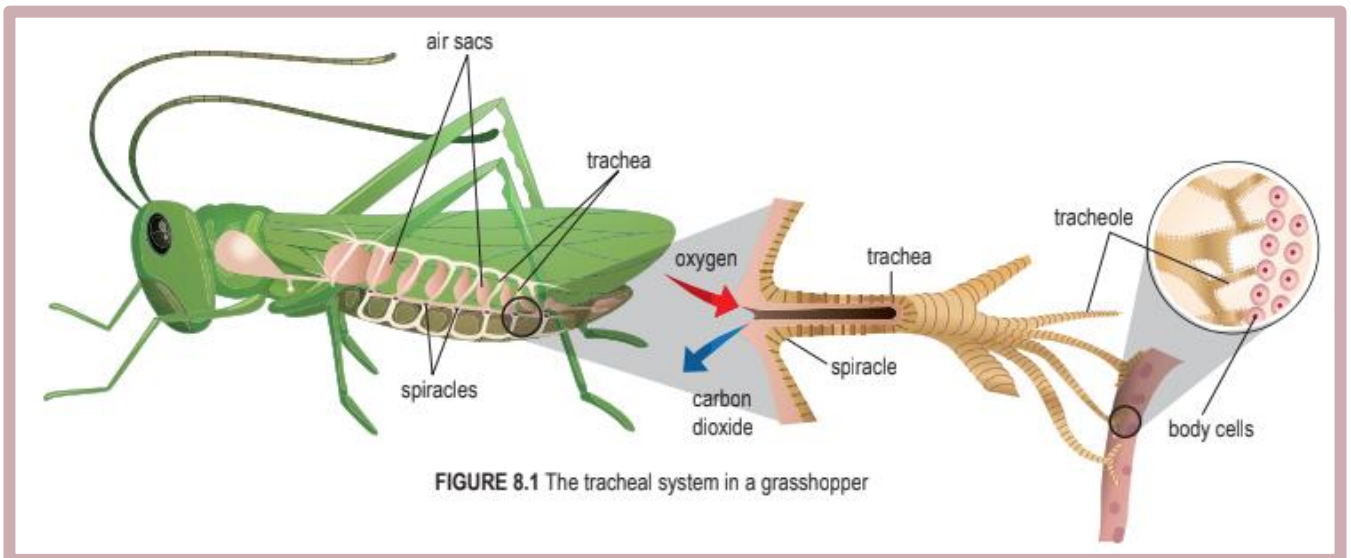
- ☐ The breathing system of insects in the tracheal system
- ☐ The characteristics of tracheal system
 - There are small pores in the thorax and abdomen of insects called spiracles
 - The spiracle allows the intake of air into the air tube system, which is the tracheal system

- The **trachea branches out** to form finer tubes called **tracheole**
- Tracheole is the respiratory surface
- The tracheole has the following characteristics that allow for efficient respiratory gaseous exchange

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

- b. 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

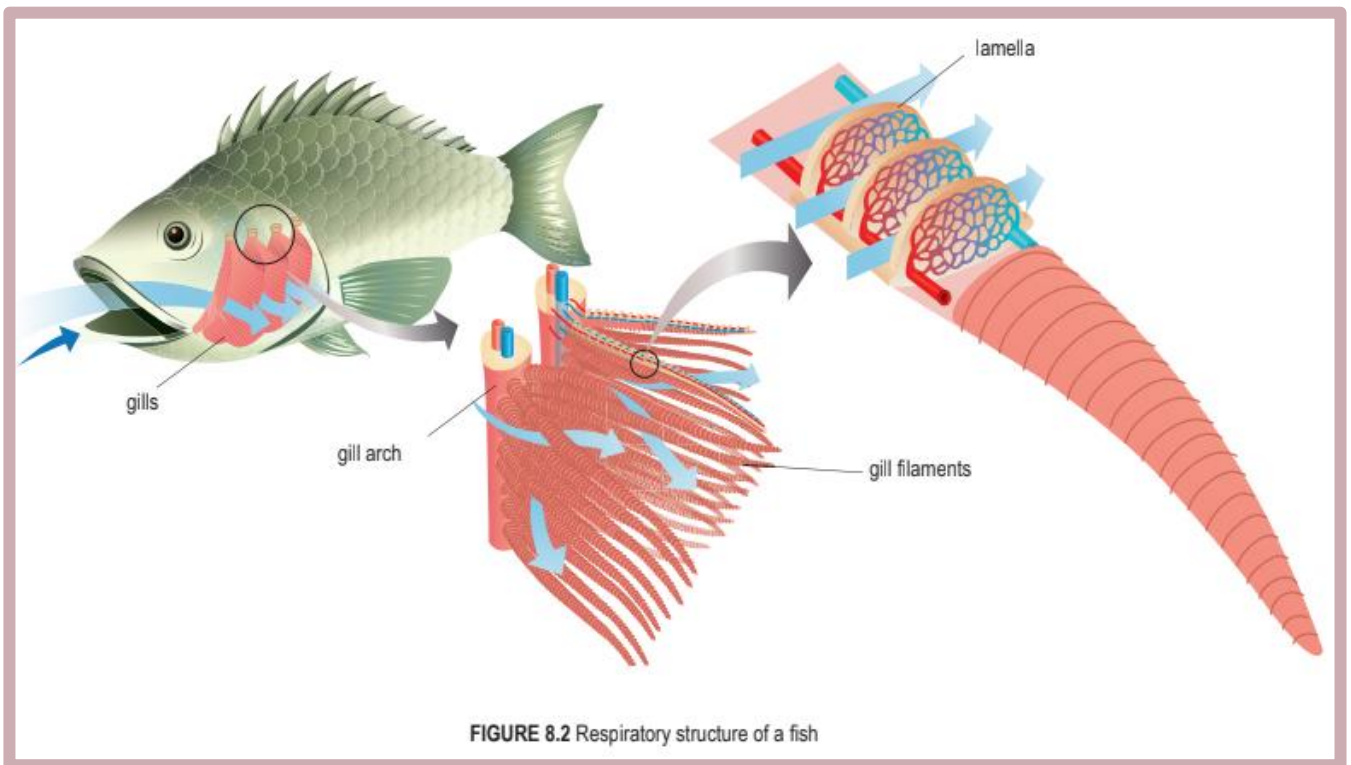
- Some insects have **air sacs** in their trachea system
- This **sac is filled with air** to speed up the delivery of respiratory gas during active body movements



The fish respiratory structure and its adaptations

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

- » The filament has many **thin and flat projections** called **lamella** (plural: lamellae)
- » 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 blood capillaries** for easy **absorption and transport** of oxygen and carbon dioxide



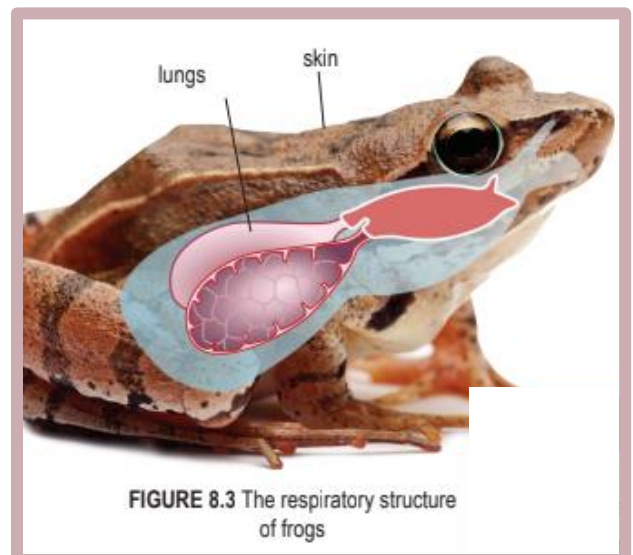
The frog respiratory structure and its adaptations

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

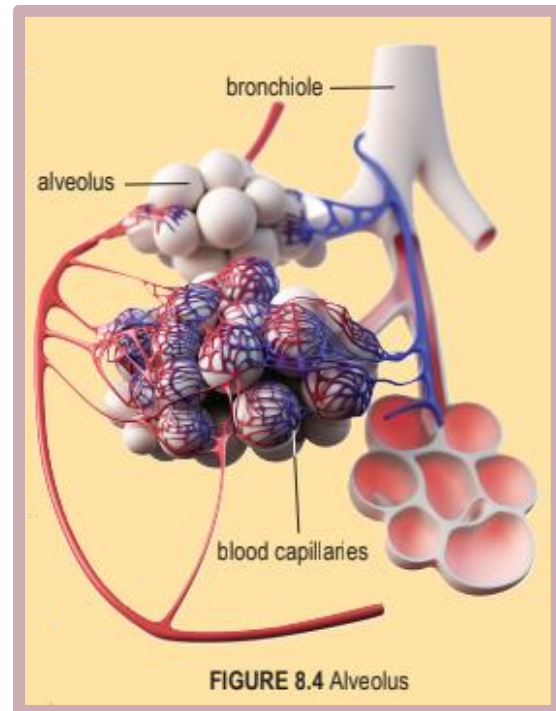


The human respiratory structure and its adaptations

- 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



Comparison and contrast of respiratory structures in humans and animals

SIMILARITIES

SIMILARITIES
<ul style="list-style-type: none">○ 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

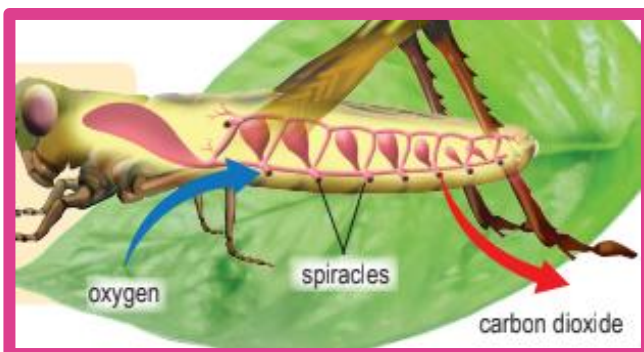
DIFFERENCES				
Characteristics	Insects	Fish	Frogs	Humans
Respiratory structure	Tracheole	Filament and lamella	Skin and lungs	Alveolus
How the large ratio of total surface area to volume for the respiratory structure is achieved	Large number of tracheoles	Large number of filaments and lamellae	<ol style="list-style-type: none"> 1. The surface in the lungs folded 2. Overall skin surface 	Large number of alveoli

CHAPTER 8.2 – MECHANISMS OF BREATHING

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
- ✎ 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
- ✎ 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



Breathing mechanism of frogs

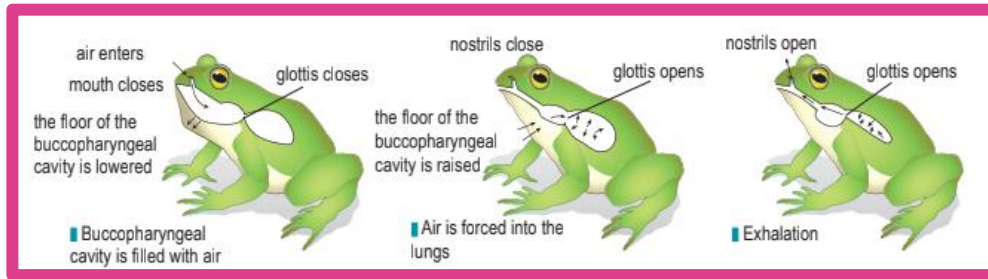
- ⊡ Frogs breathe through the **mouth** and **lungs** while in an active state

INHALATION

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



Breathing mechanism of fish

- ❖ 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

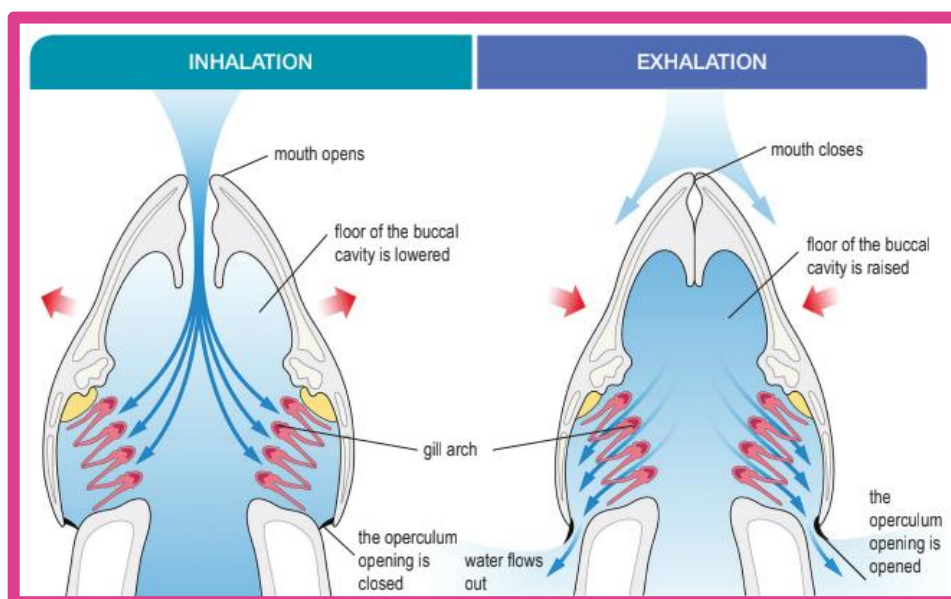
INHALATION

- ◇ 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

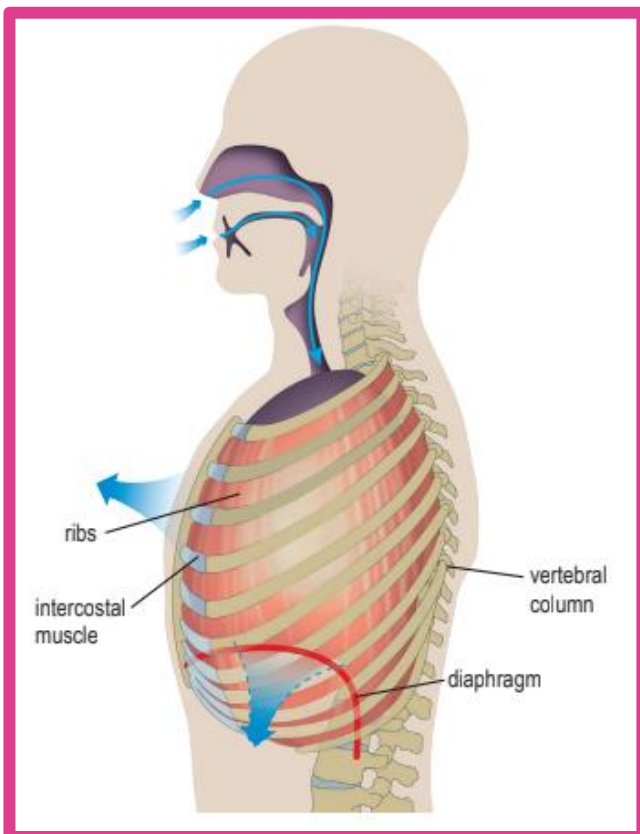
- When the mouth is closed the floor of the buccal cavity is raised
- Water enters through the gill lamella and gaseous exchange between blood and water occurs through diffusion
- At the same time, the operculum muscle relaxes and the opercular cavity becomes smaller
- The volume of the buccal cavity 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



Breathing mechanism of humans

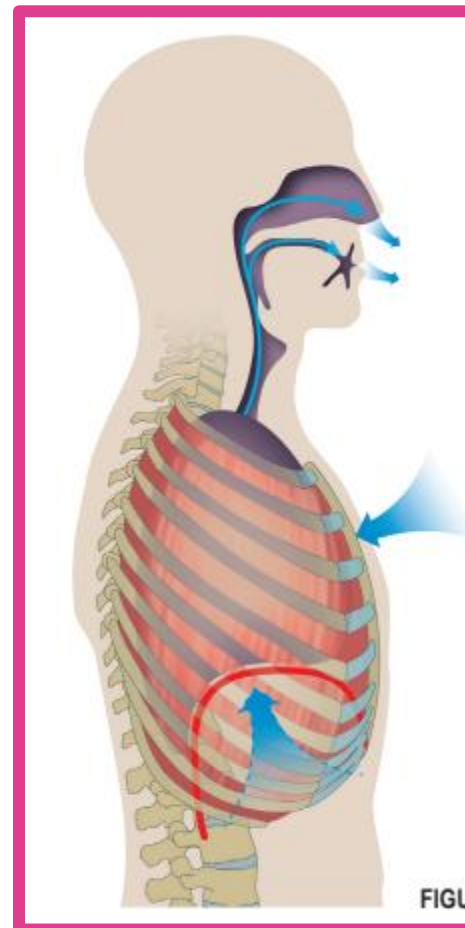
INHALATION

- 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 the 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 thorax 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

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

DIFFERENCES

DIFFERENCES				
Characteristics	Insects	Fish	Frogs	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 ribcage upward and outward, and downward and inward

CHAPTER 8.3 – GASEOUS EXCHANGE IN HUMANS

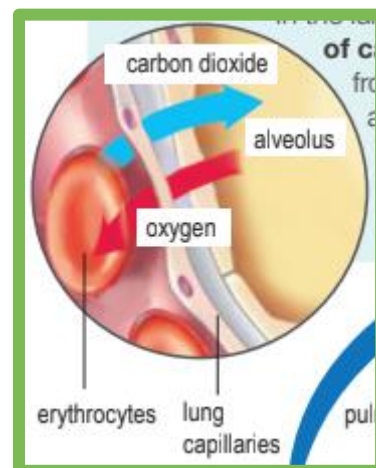
Partial pressure of oxygen and carbon dioxide

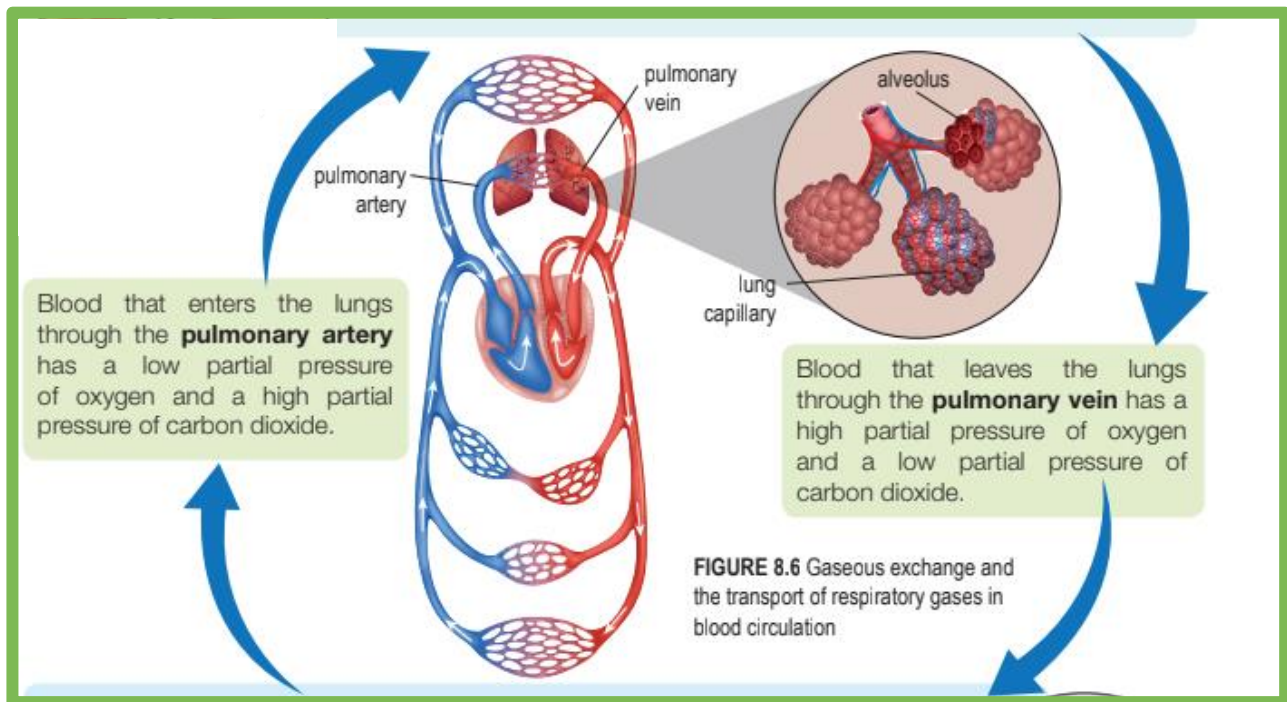
- ♥ Gas diffusion depends on the partial pressure difference between two areas
- ♥ The gas diffuses from an area where its partial pressure is higher to an area where its partial pressure is lower, which is down a partial pressure gradient

Gaseous exchange and the transport of respiratory gases

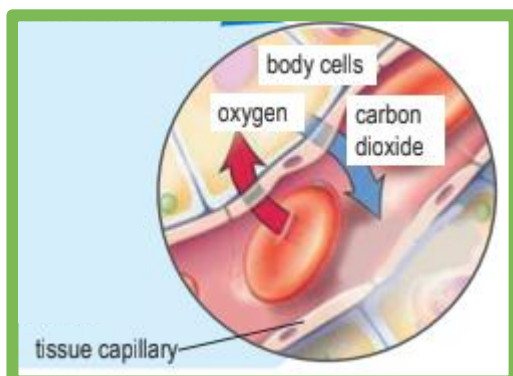
- In the lungs, blood that enters the lung capillaries contains a higher partial pressure of carbon dioxide compared to the alveolus

- 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





- » 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 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

Carbon dioxide is transported in three ways:

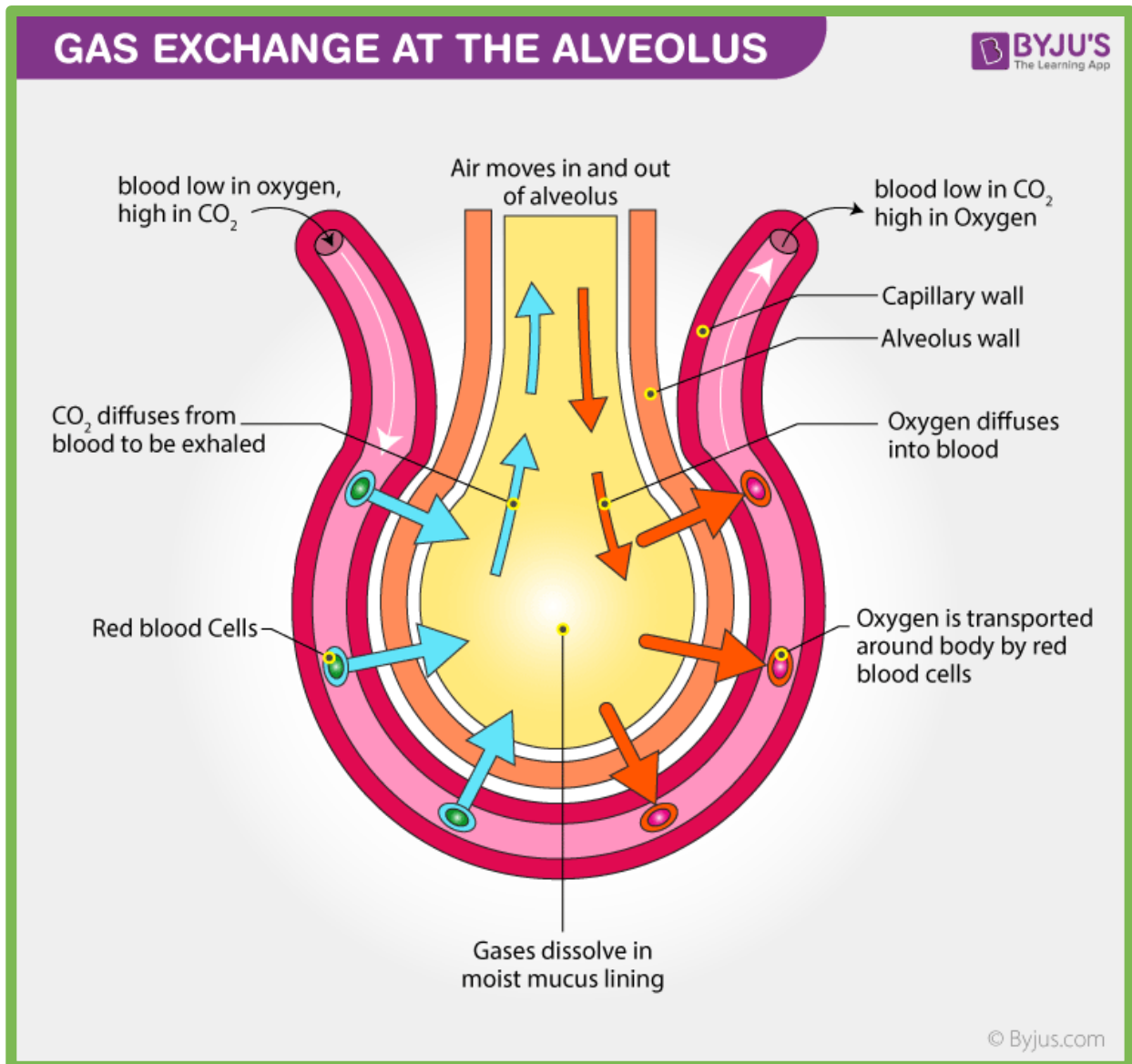
1. 70% is **carried** in the form of bicarbonate ion (HCO_3^-)
2. 23% carbon dioxide **combines** with **haemoglobin** to form **carbaminohaemoglobin**
3. 7% is **dissolved**

THE TRANSPORT OF CARBON DIOXIDE FROM BODY CELLS TO TISSUE CAPILLARIES

- Carbon dioxide (CO_2) **released** by the body cells 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 (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 the carbon dioxide and water
- Carbon dioxide diffuses through the lung capillaries into the alveolus and is expelled during exhalation



CHAPTER 8.4 – HEALTH ISSUES RELATED TO THE HUMAN RESPIRATORY SYSTEM

Chronic Obstructive Pulmonary Disease (COPD)

- ◇ Comprises emphysema, chronic bronchitis and asthma

EMPHYSEMA

- ❑ In emphysema, the alveolus **loses** its elasticity and **increases** in size
- ❑ The alveolus wall is **damaged**, total surface area of alveolus **decreases** and the gaseous exchange becomes **less efficient**

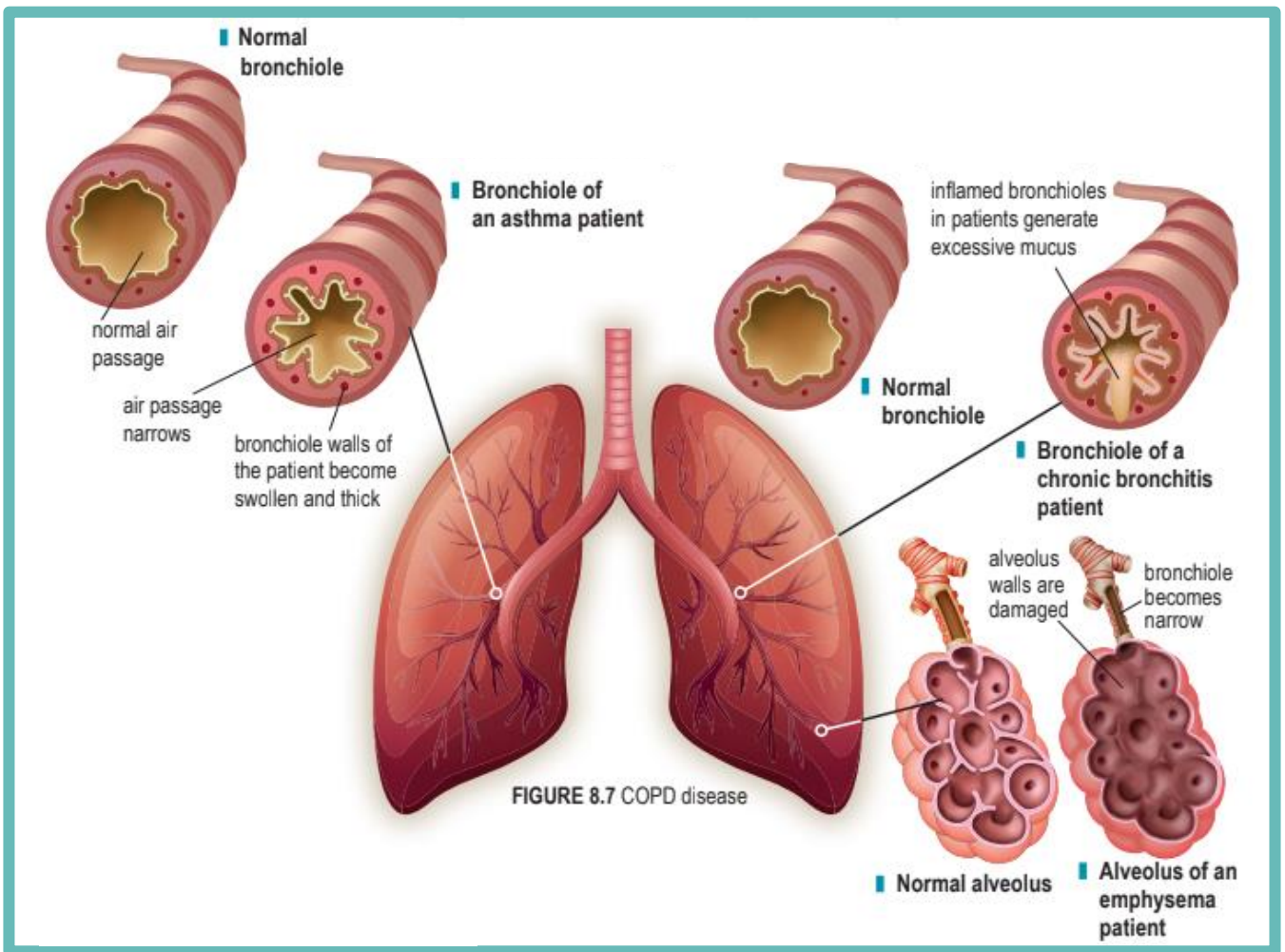
CHRONIC BRONCHITIS

- » In chronic bronchitis, the bronchiole becomes **inflamed**, **swollen** 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

ASTHMA

- 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**





Summary

RESPIRATORY SYSTEMS IN HUMANS AND ANIMALS

