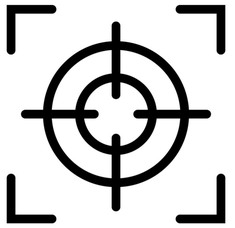
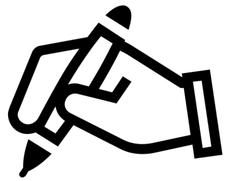
Topic 8:
Respiration in Humans

Chapter Analysis



FOCUS

- straightforward chapter
- linked to transport in humans chapter



EXAM

- commonly tested in MCQ and structured questions
- tested once in section B in the past 5 years

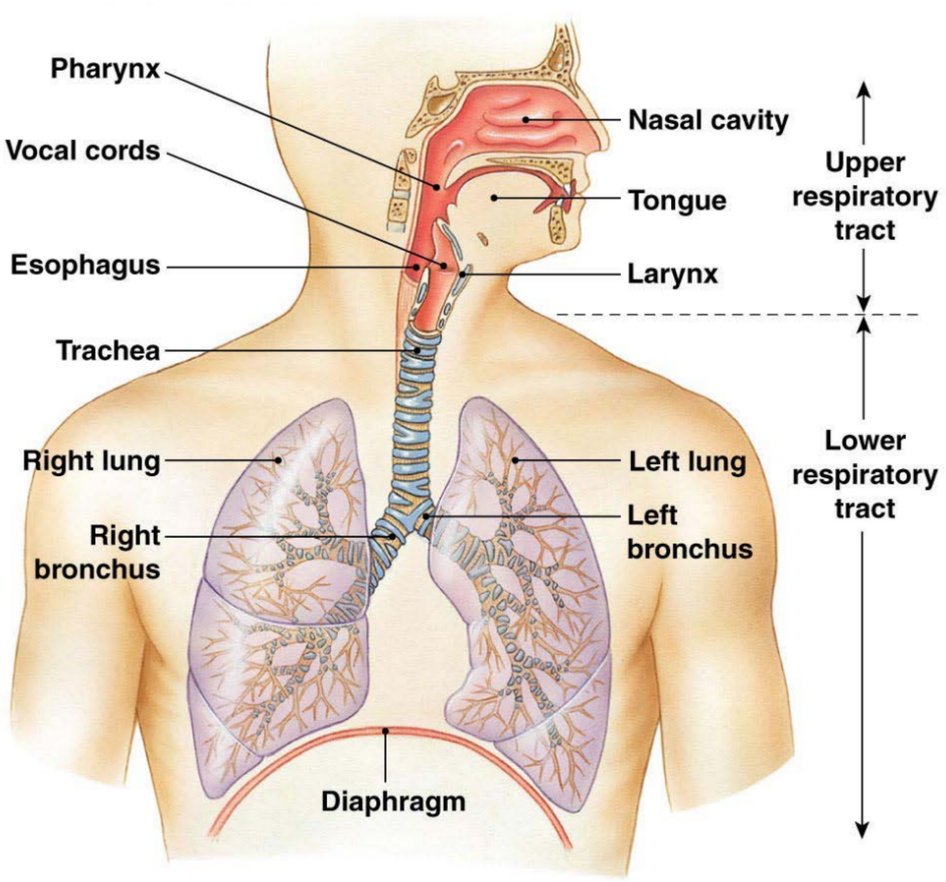
WEIGHTAGE

- Constitute to around 9% in Paper 2 in the past 5 years

Key Concept

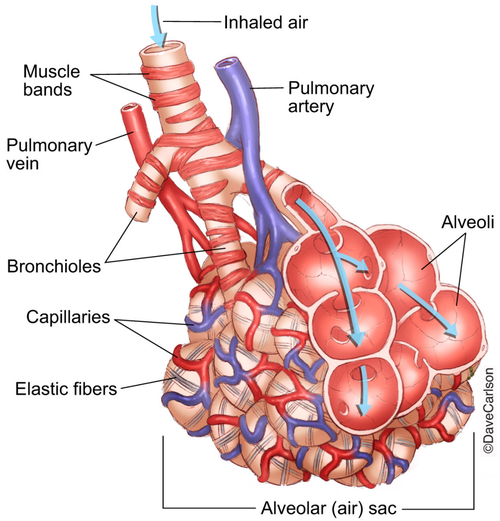
human respiratory system
alveoli
gaseous exchange

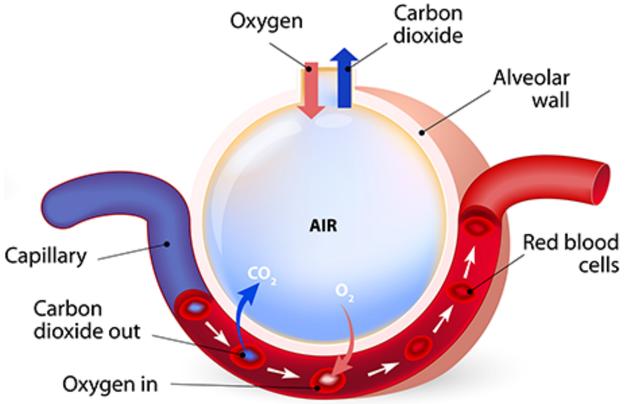
Respiratory System



Nasal passages	Passages leading from the nostrils lined with a moist mucous membrane
Pharynx	Common passage for the opening to oesophagus and trachea
Larynx	Voice box containing vocal cords
Trachea	• Breathing tube supported by **C-shaped cartilage** which **prevents the trachea from collapsing** as the air pressure in the lungs changes. • branches into two bronchi, one to each lung.
Bronchi	• Branches repeatedly within the lungs to produce numerous finer tubes called bronchioles. • The bronchioles at the end of the branching terminate in clusters of air sacs called **alveoli.**
Cilia (not pictured)	Hair-like structures that **cover the epithelial lining** of the trachea and bronchi. The **mucus traps dust, pollen and other particles** and the **cilia sweeps it upwards** into the pharynx

Alveoli



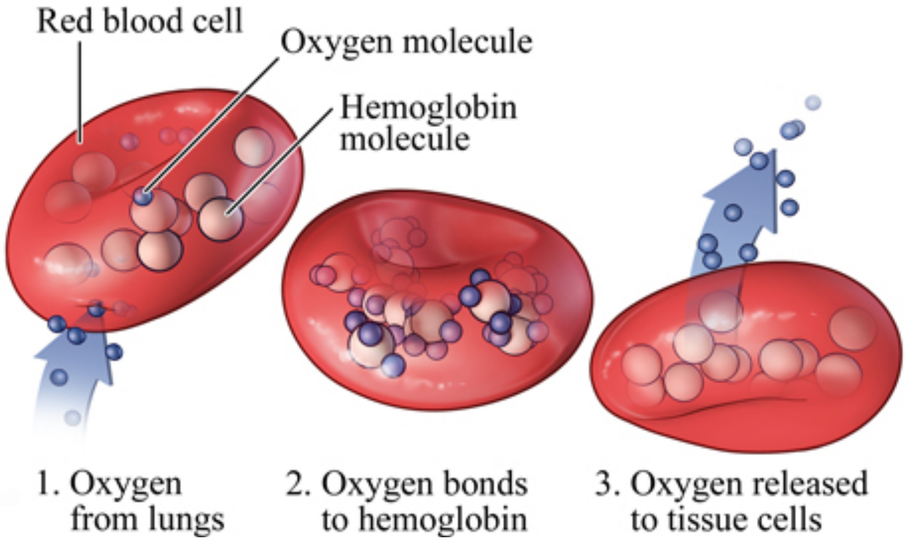


- **Sites of gaseous exchange** in the lungs.
- Blood entering the lungs from the heart has a **lower concentration of oxygen** and a **higher concentration of carbon dioxide** than the atmospheric air entering the alveoli in the lungs.
- Oxygen **diffuses from the alveolar air into the blood capillaries**
- Carbon dioxide **diffuses from blood capillaries to the alveoli**
- Oxygen and carbon dioxide **concentration gradients** are maintained by:
  - Continuous flow of blood through the blood capillaries.
  - Movement of air in and out of the alveoli, caused by breathing.

ADAPTATION OF LUNG FOR GASEOUS EXCHANGE

1. The numerous alveoli in the lungs provide a large surface area to volume ratio for gaseous exchange.
2. The wall of the alveolus is only one cell thick. This provides a short diffusion distance for gases, ensuring a faster rate of diffusion.
3. A thin film of moisture covers the surface of the alveolus. This allows oxygen to dissolve in it.
4. The walls of the alveoli are richly supplied with blood capillaries. The flow of blood maintains the steep concentration gradient of gases.

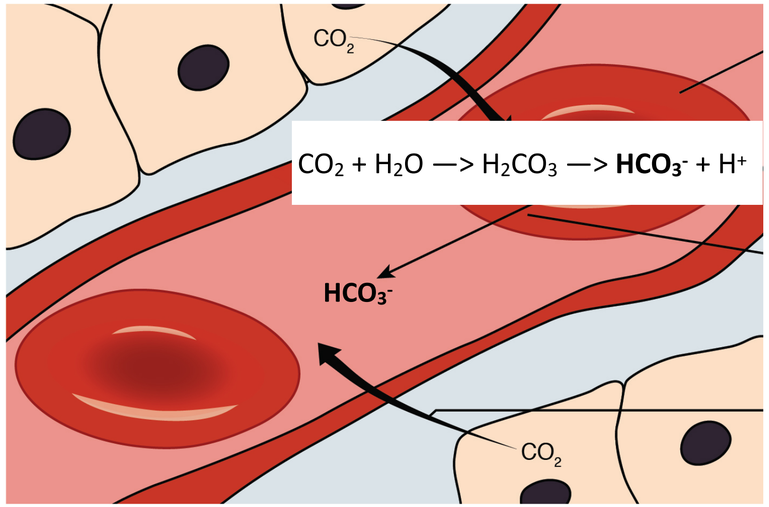
absorption of oxygen



1. The alveolar air contains a higher concentration of oxygen than the blood, **oxygen dissolves in the moisture lining the alveolar walls** and then diffuses into the blood capillaries.
2. Oxygen combines with the **haemoglobin** in red blood cells to form **oxyhaemoglobin**.
3. This reaction is **reversible** depending on the amount of oxygen in the surroundings.
4. When the blood passes through oxygen-poor tissues, the **oxyhaemoglobin releases oxygen**, which will then diffuse through the walls of the blood capillaries into the cells of the tissues.

oxygen + haemoglobin —> oxyhaemoglobin
oxyhaemoglobin —> oxygen + haemoglobin (surrounding has low oxygen)

removal of carbon dioxide



AT TISSUE CELLS

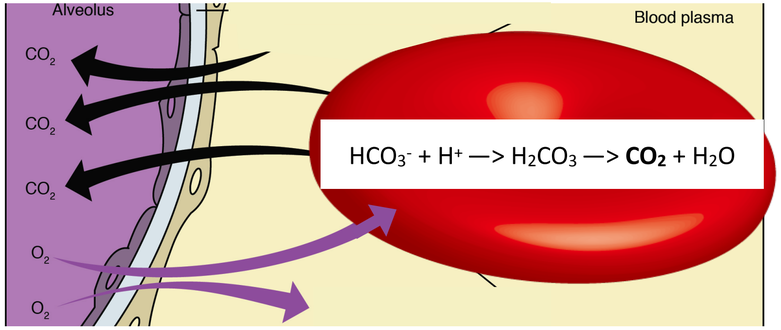
(a) Carbon dioxide produced by tissue cells due to respiration diffuses into **blood plasma** and then enters **into red blood cells**.

(b) In RBC, **carbon dioxide** reacts with **water** to give **carbonic acid**, catalysed by **carbonic anhydrase.**

(c) Carbonic acid then dissociates into **hydrogen carbonate ions**/bicarbonate ions and **hydrogen ions**.

(d) The hydrogen carbonate ions diffuse **out of red blood cells, into the plasma**

- Carbon dioxide is mainly transported in the blood plasma
- A small amount of carbon dioxide is also carried and dissolved in the red blood cells.



IN THE LUNGS

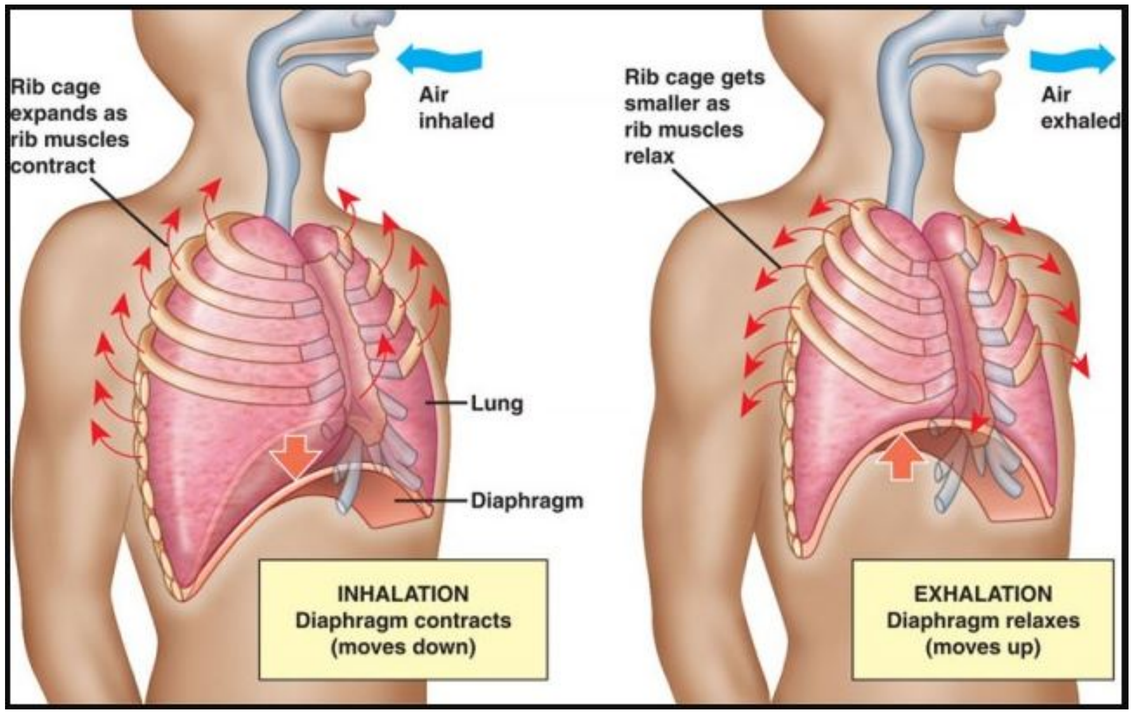
(e) **Hydrogen carbonate ions diffuse back into red blood cells** where they combine with hydrogen ions to form carbonic acid, then into water and carbon dioxide.

(f) The **carbon dioxide diffuses out of the blood into the alveolar space** where it is expelled during exhalation.

Key Concept

Inhalation and Exhalation Smoking

Breathing



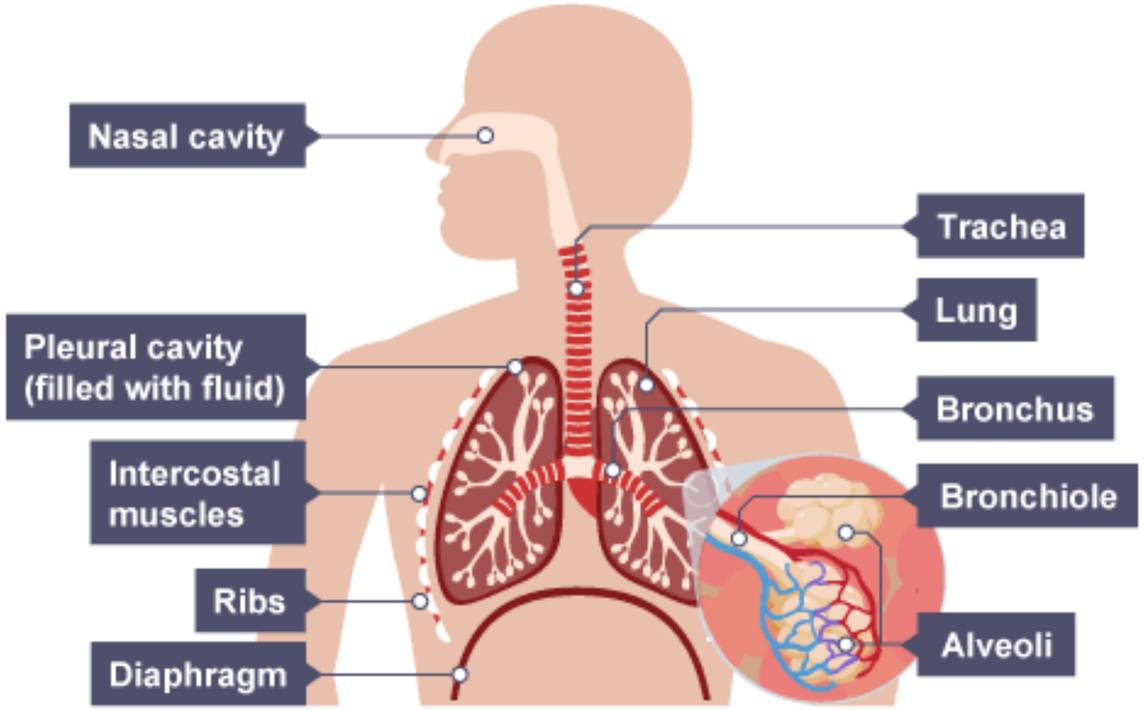
Inhalation/Inspiration

1. During inhalation, the **diaphragm contracts, flattens and moves downwards.**
2. The e**xternal intercostal muscles contract** while the **internal intercostal muscles relax**, causing the **ribs to move upwards and outwards.**
3. **Sternum** moves up and forward.
4. The **thoracic cavity increases in volume**, causing the **air pressure of the lungs to fall below** that of the atmosphere.
5. Air rushes into the lungs.

Exhalation/Expiration

1. During exhalation, the **diaphragm relaxes and arches upwards.**
2. The **internal intercostal muscles contract** while the **external intercostal muscles relax**, moving the **ribs downwards and inwards**
3. **Sternum** returns to its original position.
4. The thoracic cavity **decreases in volume**, causing the **air pressure in the lungs to be higher** than that of the atmosphere.
5. Air flows out of the lungs

pathway of air

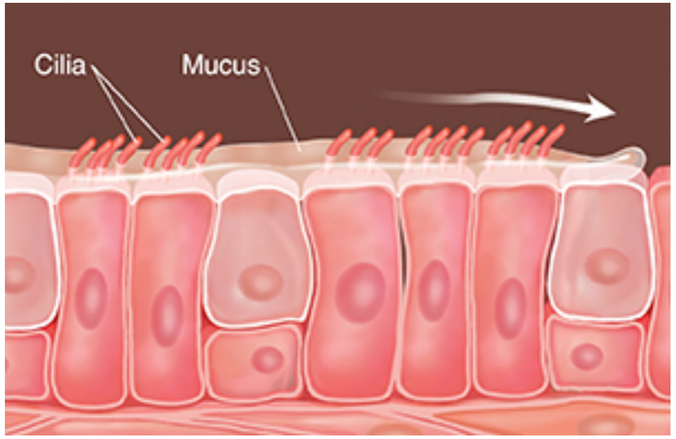


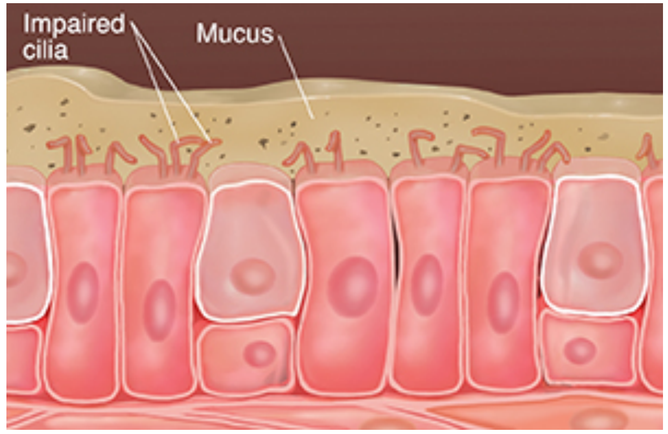
Pathway that the air travels during inhalation

Nostrils → Nasal Passages → Pharynx → Larynx → Trachea → Bronchi → Bronchioles → Alveoli

Exhalation is the reverse

component of cigarette

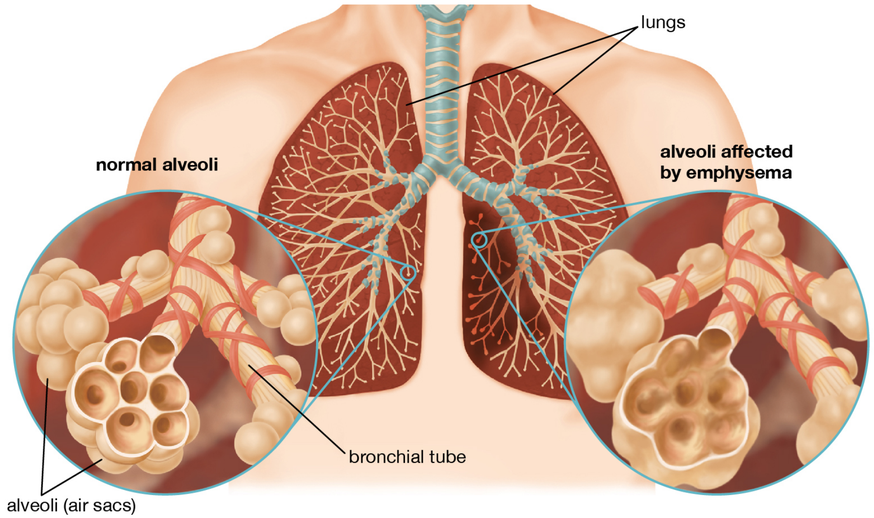




Nicotine	• **Addictive** substance that stimulates adrenaline release
	• Increases **heart rate** and **blood pressure**
	• Increase the risk of **blood clot**
	  • Blood clots in arteries leads to increased risk of heart attack
	  • Blood clots in blood capillaries in the brain increases risk of stroke

Tar	• **Carcinogenic** substances that increases risk of cancer • **Paralyses cilia** lining air passages. Dust and irritant are trapped in the mucus which cannot be removed, increasing risks of chronic bronchitis and emphysema.
Carbon Monoxide	• Combines **irreversibly with haemoglobin** to form carboxyhaemoglobin, which reduces efficiency of blood to transport oxygen • Increases the **rate of fatty deposits** on the inner arterial wall, increasing risk of atherosclerosis
Irritants	• **Paralyses cilia** lining air passages, dust and irritant are trapped in the mucus which cannot be removed, increasing risks of chronic bronchitis and emphysema.

effect of smoking on health



CHRONIC BROCHITIS

- Chronic bronchitis is the inflammation of respiratory lining of the airways, caused by irritation
- Prolonged exposure to **tar and irritant particles** leads to **excessive mucus is secreted** by the epithelium.
- The **cilia on the epithelium are paralysed** thus **mucus and dust particles cannot be removed.**
- The **air passages become blocked**, making breathing difficult.
- **Persistent coughing** is needed to clear air passages, in order to breathe. This increases the risk of getting lung infections.

EMPHYSEMA

- **Persistent and violent coughing** due to bronchitis may lead to emphysema.
- **alveolar walls break down** due to persistent and violent coughing.
- This **decreased surface area** for gaseous exchange.
- Lungs lose their elasticity and reduce ability to expel air, causing severe breathlessness result.

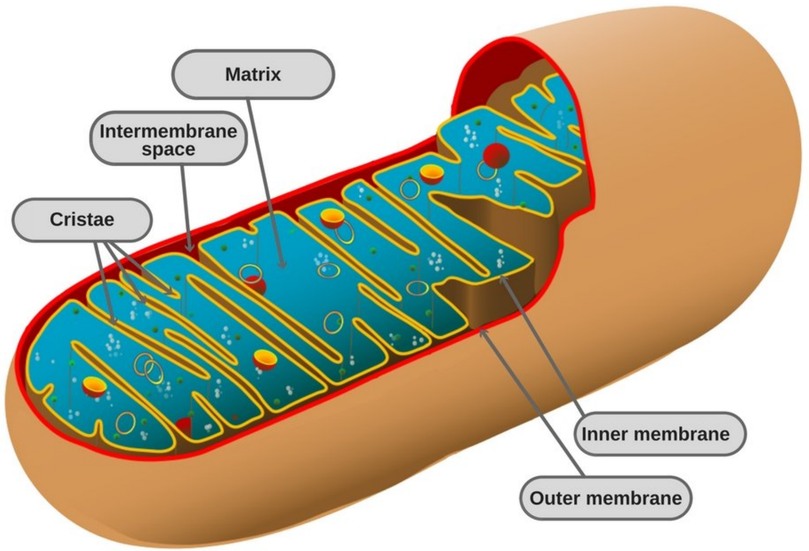
LUNG CANCER

- Risk of lung cancer increases when a person smokes tobacco due to **carcinogens (tar) present**
- Cancer is the uncontrolled division of cells producing tumour.

Key Concept

Aerobic Respiration
Anaerobic Respiration

aerobic respiration



Word equation

$$Glucose + Oxygen \longrightarrow CarbonDioxide + Water + Energy$$

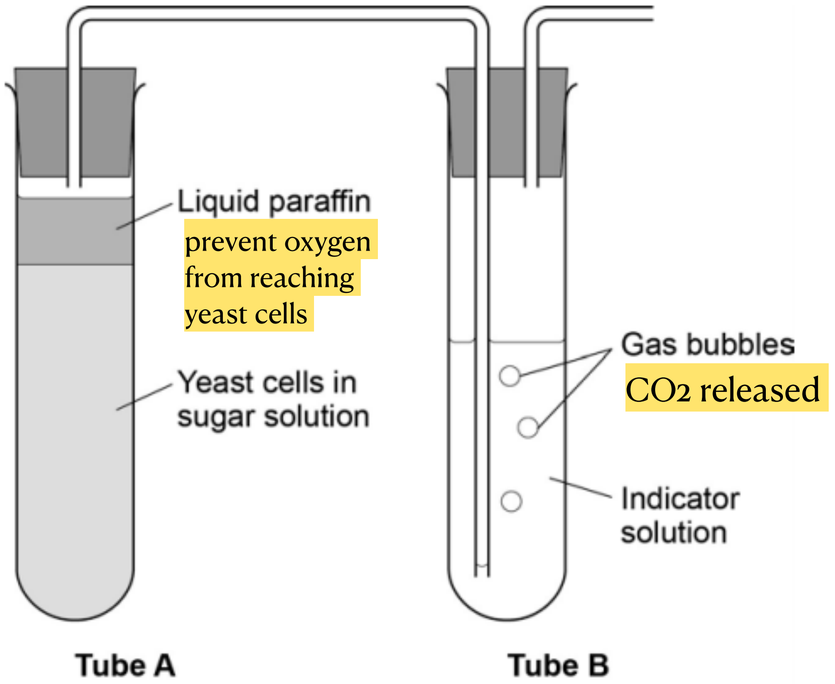
Chemical equation

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + Energy$$

- **in the presence of oxygen,** aerobic respiration can produce a large amount of energy
- Site of aerobic respiration is **mitochondria**
- Energy is needed
  - Synthesising complex molecules from simpler molecules i.e. proteins from amino acids
  - Synthesis of new protoplasm and genetic material for cell growth and division
  - Muscular contraction
  - Active transport
  - Transmission of nerve impulses
  - Maintenance of constant body temperature as heat is released during respiration

anaerobic respiration

in yeast



In yeast

$$Glucose \longrightarrow Ethanol + CarbonDioxide + Energy\ (small\ amount)$$

$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2 + Energy\ (small\ amount)$$

- in contrast to aerobic respiration, anaerobic respiration occurs in the **absence of oxygen** and can only **produce a small amount of energy**
- does not require mitochondria

anaerobic respiration in muscles

in mammals

In muscle cells

$$Glucose \longrightarrow LacticAcid + Energy\ (small\ amount)$$

$$C_6H_{12}O_6 \longrightarrow 2C_3H_6O_3 + Energy\ (small\ amount)$$

- During vigorous muscular contractions, the muscle cells **primarily respire aerobically.**
- However, during strenuous exercise, there is a limit to the rate of breathing and heart rate, there **may not be sufficient oxygen** supplied to muscle cells to sustain aerobic respiration.
- Therefore, muscle cells also **respire anaerobically** for short durations in order **to meet the energy demands of the activity**.
- The **extra energy** released by anaerobic respiration supplements the energy released by aerobic respiration to **allow continuous muscle contraction**
- When anaerobic respiration occurs, there is a **buildup of lactic acid** in the muscle cells.
- The muscles are **incur an oxygen debt** and lactic acid build up causes **fatigue and muscular pains**.

Recovery period

- The body requires rest and the **breathing rate continues to be fast** for some time.
- This is to **take in more oxygen to repay the oxygen debt.**
- **Lactic acid** is removed from the muscles and **transported to the liver**.
- In the liver, oxygen is also used to **oxidised some of the lactic acid to release energy**. This energy is used to **convert the remaining lactic acid back into glucose**.
- When **all the lactic acid has been converted to glucose**, the **oxygen debt is repaid.**

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