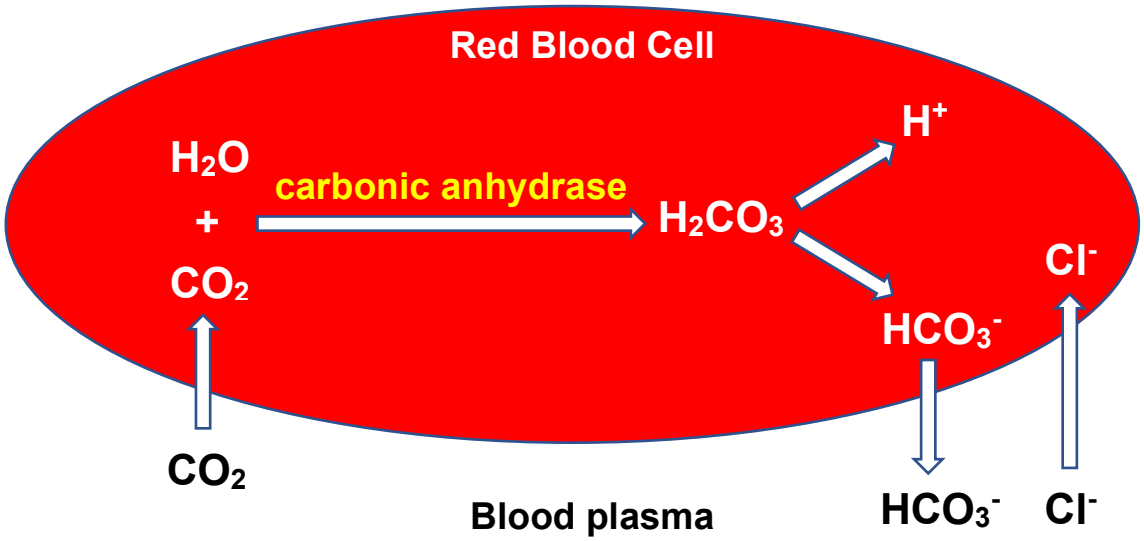
1. THREE WAYS OF TRANSPORTING CARBON DIOXIDE TO THE LUNGS

1. A small amount is carried in **solution**, dissolved in blood **plasma**.
2. More is carried **attached** to **haemoglobin**. This is known as **carbaminohemoglobin**.
3. More still is transformed into **hydrogencarbonate ions** (HCO_3^-) in **red blood cells**.

This is how the last of these occurs at **respiring tissues**:



- CO_2 **diffuses** into red blood cells and **combines** with **water** to form **carbonic acid** (H_2CO_3).
- This reaction is **catalysed** by the enzyme **carbonic anhydrase**.
- **Carbonic acid** quickly **dissociates** into **hydrogencarbonate ions** and **hydrogen ions**.
- The **hydrogencarbonate ions** move **out** of red blood cells by **facilitated diffusion**.
- A **carrier protein** is used that **simultaneously** moves a **chloride ion** into the red blood cell.
- This is called the **chloride shift** and it **prevents** the **balance** of **charges** across the **membrane** from **changing** – it **maintains electroneutrality**.
- When red blood cells **reach** the **lungs**, the same enzyme helps to **convert** the **hydrogencarbonate** back to **carbon dioxide** (which we **breathe out**) and **water**.

2. CONTROLLING THE VENTILATION RATE

CHEMORECEPTORS

- in **walls** of **aorta** and **carotid arteries**
- detect **changes** in **blood pH**
- **normal range** is **7.35 – 7.45**

During **vigorous exercise**:

Increase in CO_2 entering **blood** from **respiring** cells

Electrical **impulses** are sent to the:

RESPIRATORY CONTROL CENTRE

(IN MEDULLA OBLANGATA)

Electrical **impulses** are sent to the:

DIAPHRAGM MUSCLE

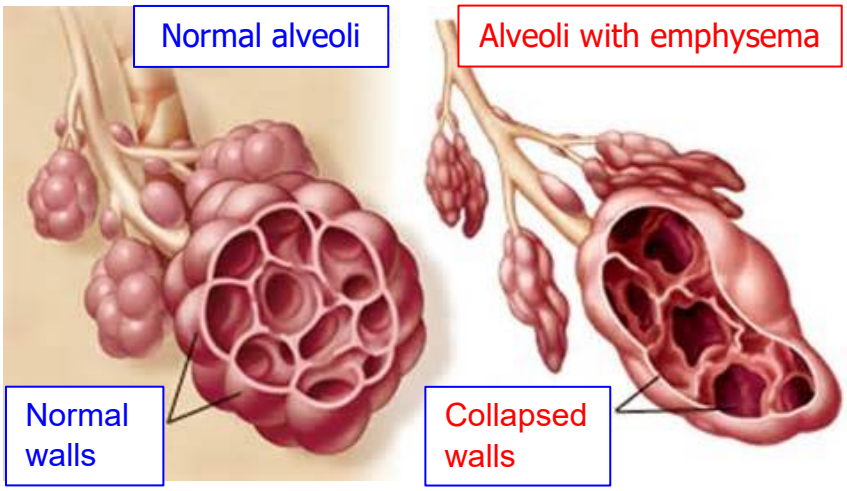
INTERCOSTAL MUSCLES

- Increased **rate** of **contraction** and **relaxation**
- Increased **ventilation rate**
- (So) CO_2 is **removed faster** from **blood** by the lungs
- (So) **blood pH rises** and **remains** in the **normal range**
- (So) **aerobic respiration** continues
- (For) increased **energy demand** of **muscles**
- (So) helps to **repay** the O_2 **debt** after **anaerobic** respiration

DURING VIGOROUS EXERCISE	AFTER EXERCISE
Increased **energy demand** of the body	Decreased **energy demand** of the body
Increased **rate** of **aerobic respiration** by **muscles**	Decreased **rate** of **aerobic respiration** by **muscles**
Increased CO_2 enters the **blood**	Decreased CO_2 in the **blood**
Decreased **blood pH** but still **remains** in the **normal** range	Increased **blood pH** but still **remains** in the **normal** range
Due to increased **ventilation rate**	Due to decreased **ventilation rate**

3. TREATMENTS FOR EMPHYSEMA

- The **causes** and **consequences** of this **lung** disease are in the **Topic 6** revision notes.



Alveoli **walls break down**

Reduces the **surface area** of the **lungs**

Loss of **elasticity** of **lung tissue**

More difficult to **exhale** air

- **Treatments** for emphysema are:
  - providing a supply of **oxygen-enriched air**, to **increase** the **oxygen concentration gradient** between mouth and lungs
  - training in **breathing techniques** to reduce breathlessness
  - surgery to **remove damaged lung tissue**
  - **bronchodilators** and **inhaled steroids**
  - lung **transplants**

4. PUBLIC ATTITUDES TO SMOKING

Due to a wealth of scientific and statistical evidence, linking smoking to lung diseases, politicians have had enough evidence to allow them to:

RAISE TAXES ON TOBACCO

BAN SMOKING IN PUBLIC PLACES, WITH FINES

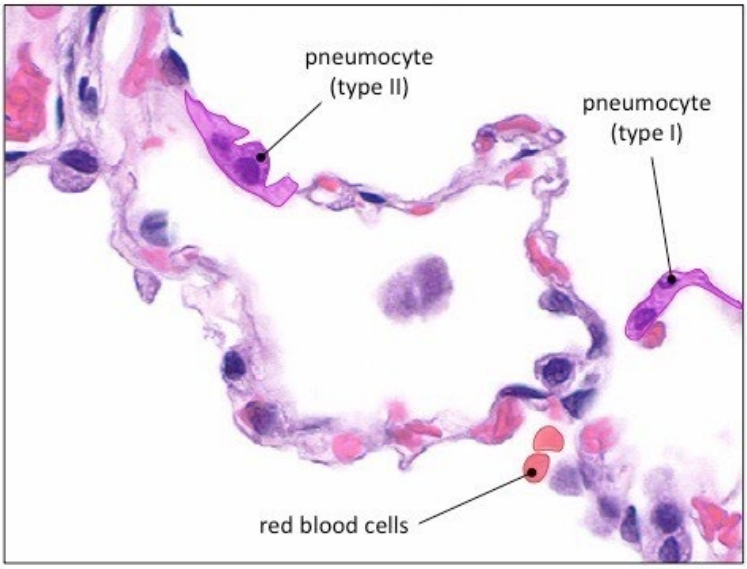
This evidence has included:

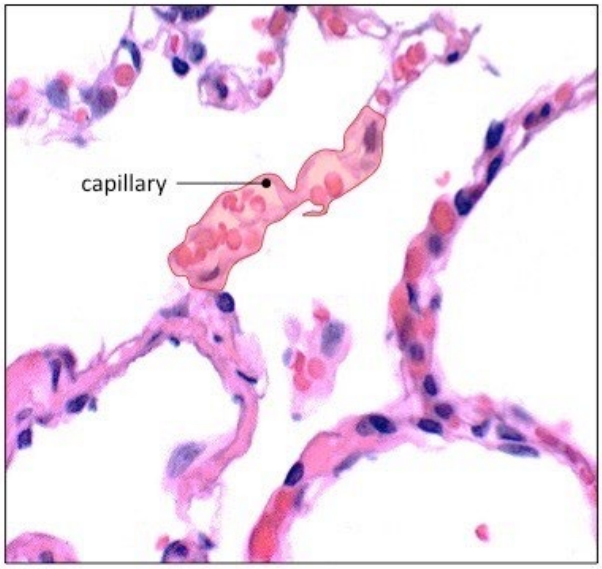
- **Incidence** of **many different** lung diseases is **higher** in **smokers** than non-smokers
- **Physical appearance** and **impaired function** in **lungs** of **smokers** compared to non-smokers
- Tobacco is known to contain several different **carcinogens** that can cause **mutations**
- **Mutations** in certain genes can cause **cancer**

5. LUNG TISSUE IN MICROGRAPHS

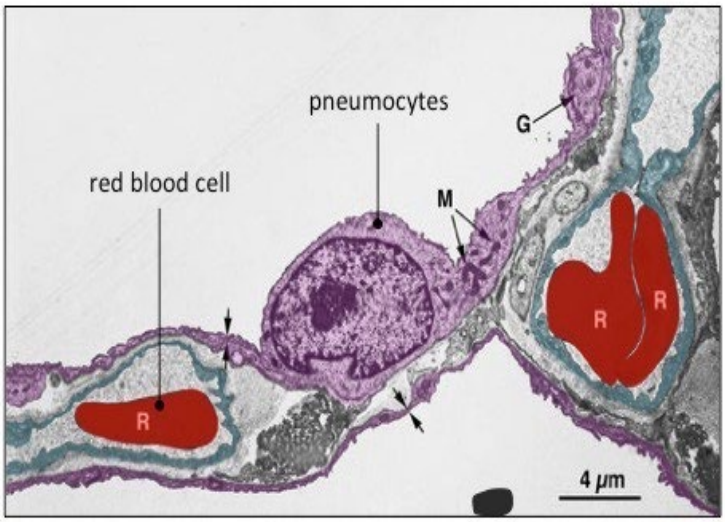
- The **structure** of **alveoli** is **discussed** in the **Topic 6** revision notes.
- Alveoli **walls** consist of **one** layer of **pneumocytes**:
    - Type **I** pneumocytes are **very thin** in order to allow **gas exchange** with the bloodstream (via diffusion)
    - Type **II** pneumocytes secrete a pulmonary **surfactant** in order to **reduce** the **surface tension** within the alveoli to **prevent** their **walls** from **sticking together**
- Capillaries **between** the walls of **pairs** of **alveoli** are only **wide enough** for **red blood cells** to pass in **single file**.
- You need to be able to **identify** pneumocytes, capillary endothelium cells and blood cells in light micrographs and electron micrographs of lung tissue

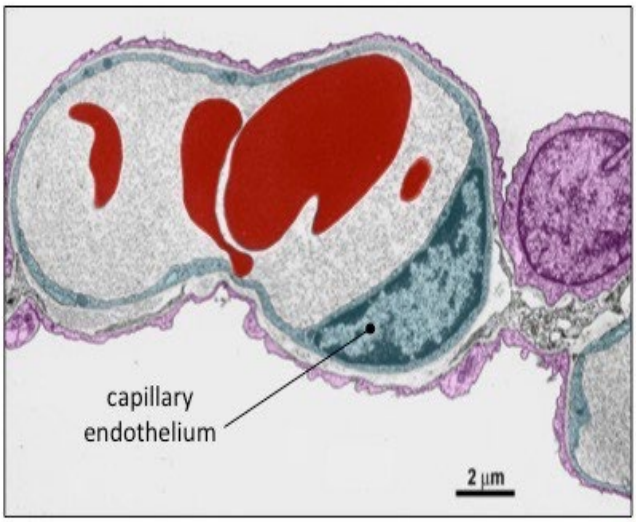
Light micrograph of lung tissue





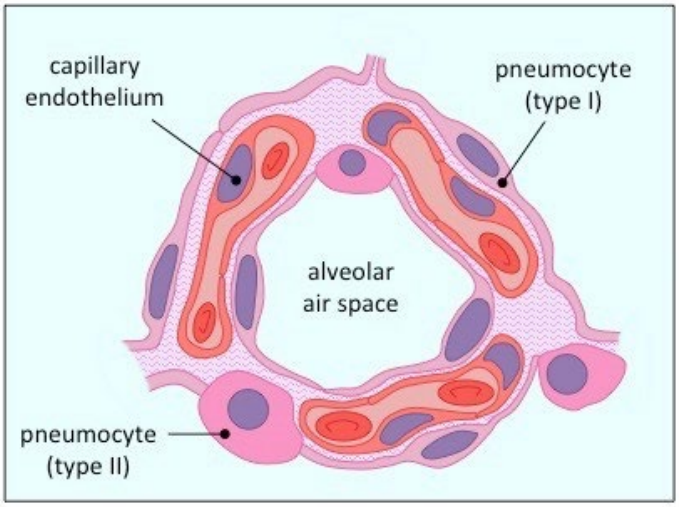
Electron micrograph of lung tissue

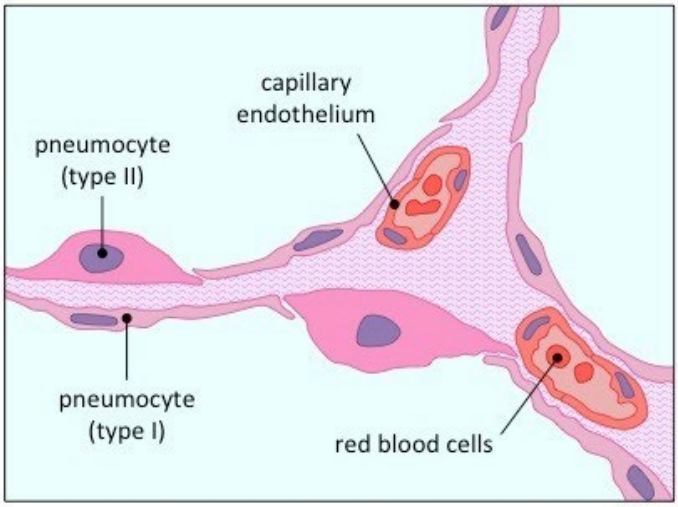




Just for comparison:

Diagrammatic representation of lung tissue





- Separating the air in the **alveoli** from haemoglobin in the **red blood cells** are just **two** layers:
    - the **epithelium** (epithelial cells = on walls of the alveolus)
    - the **endothelium** (endothelial cells = on walls of the capillary)