Respiratory System Notes

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The respiratory system enables **breathing** (or ventilation), which gets oxygen into our bodies. This oxygen is then transported to our cells where **aerobic respiration** takes place.

The respiratory system: the group of organs in the body responsible for gas exchange. It allows oxygen to enter the blood and carbon dioxide to be removed, through the process of breathing (ventilation) and diffusion in the lungs.

Why do we need a respiratory system? To bring oxygen to the cells for aerobic respiration and to remove carbon dioxide as a waste product.

Aerobic respiration: the process of transferring energy from glucose in the presence of oxygen. Mitochondria are the site of aerobic respiration inside cells.

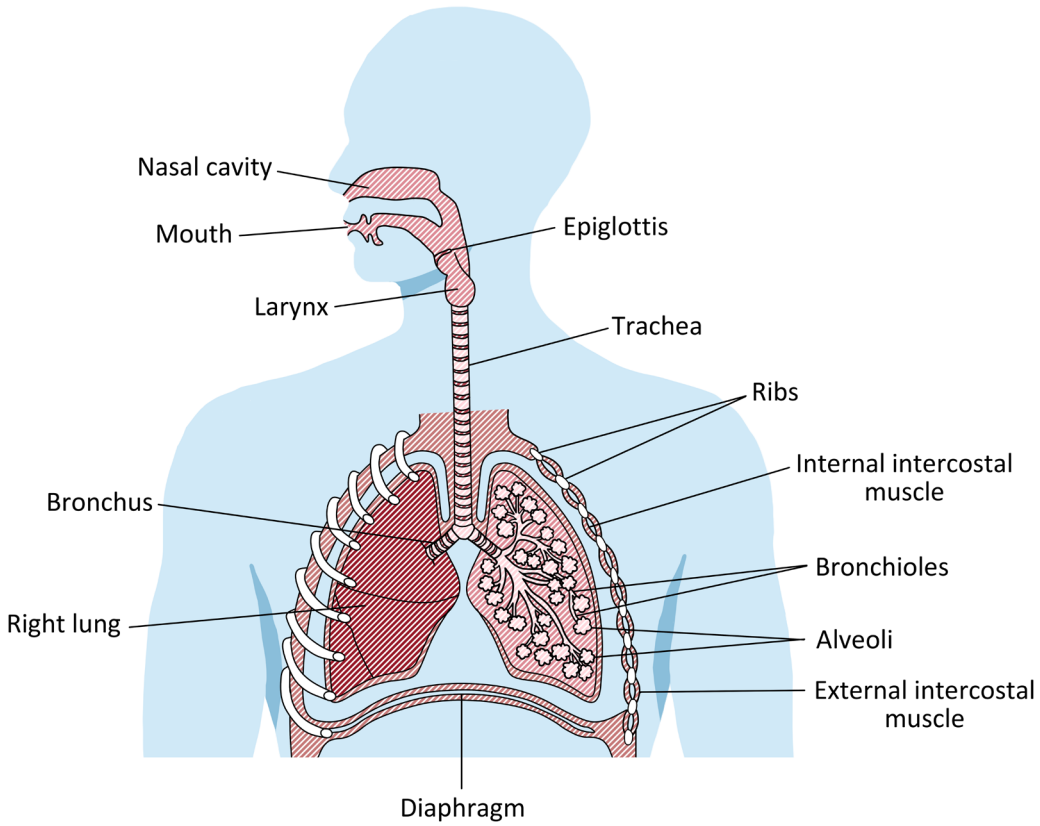
OXYGEN MUST BE PRESENT for aerobic respiration to take place 😊

The **word** equation: Glucose + oxygen → carbon dioxide + water

The **balanced chemical** equation: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

The Respiratory System

The figure below shows the respiratory system of a human.



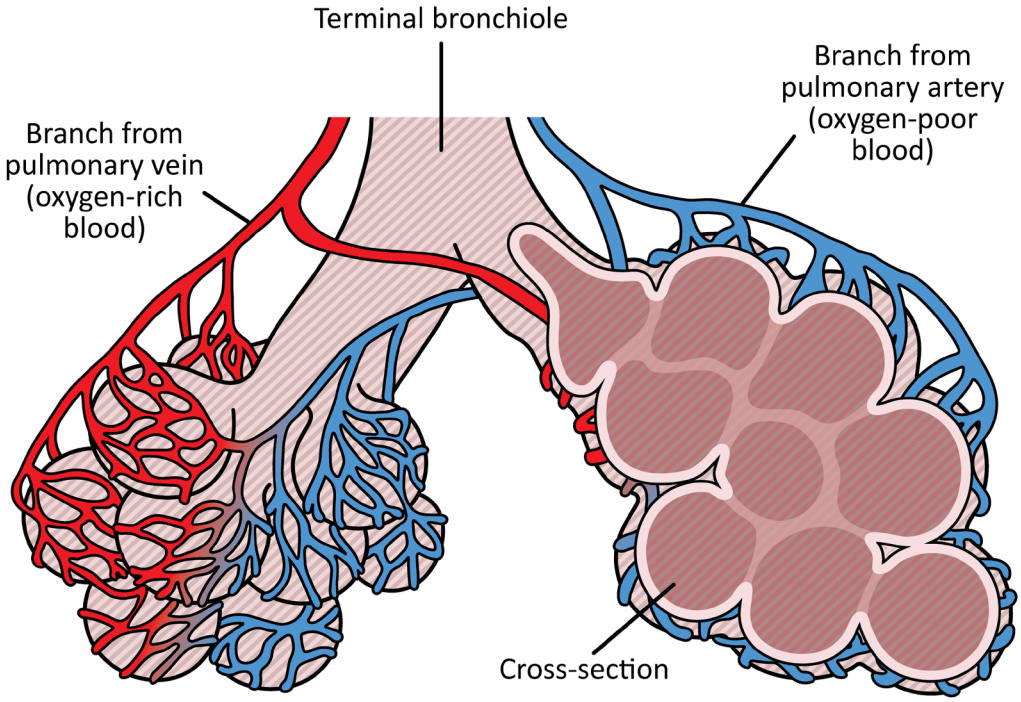
Structure	Function
Nasal cavity/mouth	Air enters the body here. The air is warmed, moistened, and filtered.
Trachea	Carries air from the mouth/nose to the lungs. Contains rings of cartilage to keep it open.
Bronchi	Two tubes that branch from the trachea and lead to each lung. One is called a Bronchus.
Bronchioles	Are smaller tubes that branch off the bronchi inside each of the lungs.
Alveoli	Tiny air sacs where gas exchange takes place. They are surrounded by capillaries.
Diaphragm	A sheet of muscle under the lungs that helps control breathing.
Intercostal muscles	Muscles between the ribs that also help with breathing by moving the ribcage.

The Alveoli

The alveoli are the sites of gas exchange, and a single air sac is called an alveolus. Gas exchange occurs via diffusion. But before we continue let's have a quick reminder of diffusion.

Diffusion: the net movement of a substance from an area of high concentration to an area of low concentration moving down its concentration gradient. It is a passive process meaning we don't need to put in any energy.

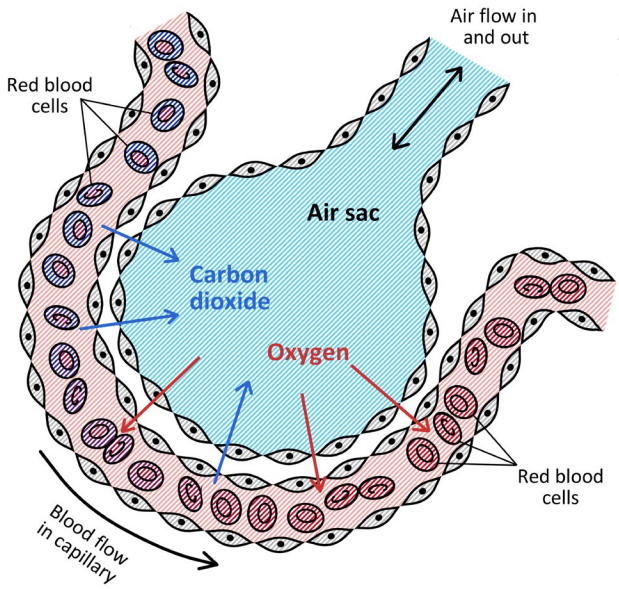
The figure below shows a pair of alveoli of the lungs.



What gases are being exchanged?

1. **Oxygen (O_2)** – diffuses from the air in the lungs where it is in higher concentration, into the blood capillaries where it is in lower concentration.

2. **Carbon dioxide (CO_2)** diffuses from the blood where it is in higher concentration, into the air in the lungs where it is in lower concentration. The figure below shows gas exchange occurring in an alveolus.



A common question that is asked is "*How are the alveoli of the lungs adapted for gas exchange?*"

Please find below the ideal answer to this type of question. 😊

1. **Thin structure** – diffusion occurs faster when a layer is one cell thick compared to a layer that is three cells thick. The thinner it is the faster the substance can move through.

2. **Large surface area** – this increases the rate of diffusion that can occur per second.

3. **Network of capillaries** – capillaries ensure that there is a steep concentration gradient.

   Note to explain this: as soon as some oxygen diffuses into the capillary from the lung it is carried away. This means that there is always less oxygen in the capillaries surrounding the lungs and more oxygen in the lungs.

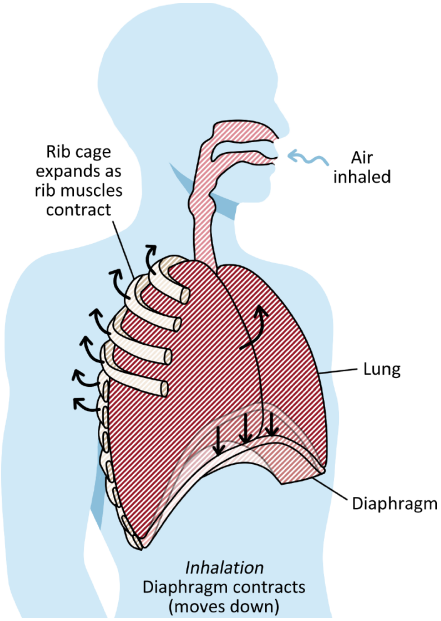
4. **Moist surface** – gases dissolve easily into the layer of moisture covering the alveoli. After this the gases can diffuse through membranes of the alveoli more easily.

Ventilation – the Mechanism of Breathing

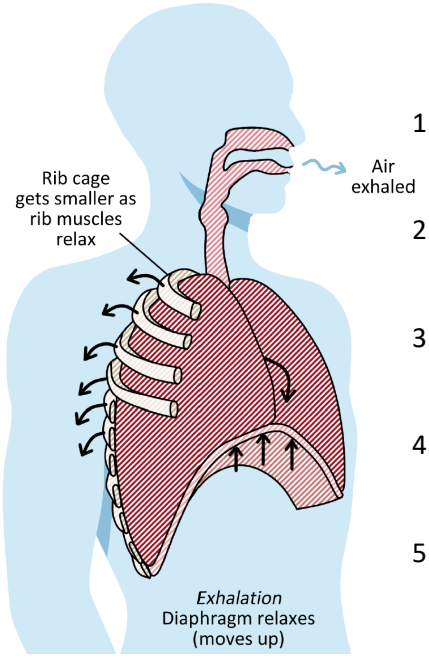
Ventilation: the movement of air into and out of the lungs. It includes inhalation (breathing in) and exhalation (breathing out), which helps maintain a concentration gradient for gas exchange in the alveoli.

Let's look at **inhalation** first 😊 for ease we can think of this as a step by step process.

1. **Diaphragm contracts** – it moves downwards and flattens, increasing the volume of the chest cavity. This decreases the pressure in the chest.
2. **Intercostal muscles contract** – these pull the ribcage up and out. This also increases the volume and decreases the pressure of the chest cavity.
3. **Pressure inside the lungs decreases** – the pressure in the lungs is now lower than the pressure outside the body.
4. **Air is drawn into the lungs** – from an area of high pressure (outside) to low pressure (inside).
5. **Lungs inflate** – air travels through the trachea to the bronchi then to the bronchioles then to the alveoli, where gas exchange happens.



Next let's look at **exhalation**, again we think of this as a step by step process.



1. **Diaphragm relaxes** – It moves upwards into a dome shape, reducing the volume and increasing the pressure within the chest cavity.
2. **Intercostal muscles relax** – The ribcage moves down and in. This also reduces the volume and increases the pressure of the chest cavity.
3. **Pressure inside the lungs increases** – the pressure in the lungs is now higher than the pressure outside the body.
4. **Air is pushed out of the lungs** – from an area of high pressure (inside) to lower pressure (outside).
5. **Lungs deflate** – air is exhaled out of the lungs.