Gas Exchange in Humans

The Gas Exchange System

Structure

- The lungs are spongy organs found inside the chest (thorax) and are surrounded and protected by the sternum (breastbone).
- The diaphragm is a sheet of fibrous tissue and muscle that separates the thorax from the abdomen
- The movement of the diaphragm changes the volume of the lungs to move air when you breathe in and out
- The intercostal muscles between the ribs move the ribs during breathing, especially during deep breathing
- Air enters the nose or mouth and passes through the throat to the larynx (voice-box).
- It then enters the trachea (windpipe), which connects the throat to the lungs
- It branches to form two bronchi which enter each lung
- These continue to divide to form many bronchioles, which end in tiny air sacs called alveoli.
- It is here that gas exchange takes place
- The tubes through which air moves are often called airways
- The larynx contains vocal chords, when air passes over these you make sounds
- You cannot breather and swallow at the same time, this is because as you swallow a flap called the epiglottis moves to cover the opening of the larynx, this stops food from going down your trachea
- The trachea is kept open by C shaped rings of cartilage. The arms of the cartilage are joined by muscles at the back of the trachea
- The cartilage prevents the trachea from collapsing as you breathe in when the air pressure decreases

Composition of air

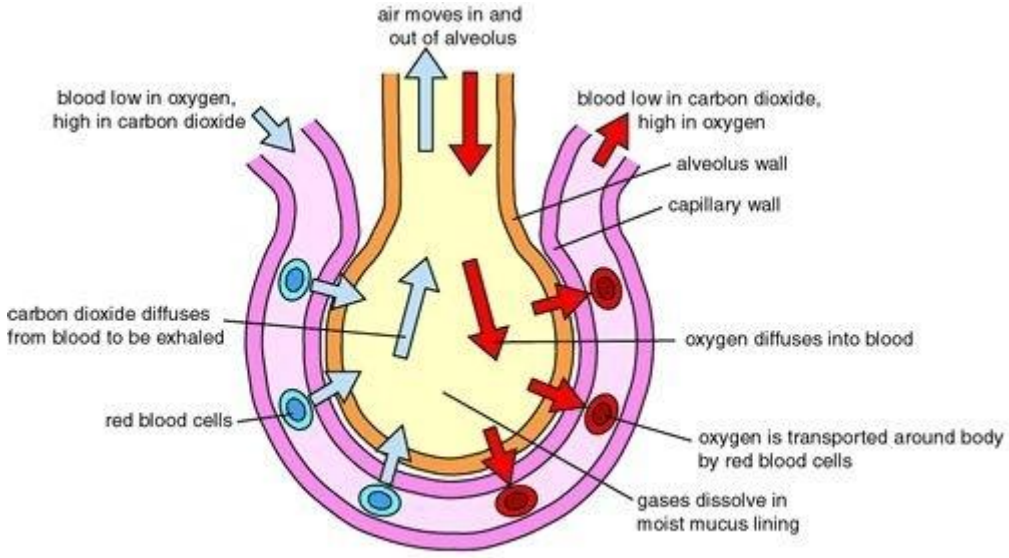
Gas	Composition/ %	
	Inspired air Breathing in	Expired air Breathing out
Oxygen	21	16
Carbon Dioxide	0.04	4
Nitrogen	78	78
Water vapour	Variable	Saturated

Gas Exchange Surfaces

- Have a very large surface area for diffusion of gases
- Moist surfaces so that gases can dissolve before diffusion
- A thin surface (only one cell thick in each alveolus) so the gases do not have to diffuse very far
- A good supply so that lots of carbon dioxide is removed quickly and lots of oxygen is supplied quickly, maintaining concentration gradients
- Ventilation of the lungs ensures that the air in the air passages is changed; this helps maintain the gas concentration gradients between air in the alveoli and that in the blood

Gas exchange at the alveolus

- Oxygen molecules from the alveolus diffuse into the red blood cells and combine with haemoglobin. The red blood cells can then transport oxygen to the body tissues
- There is a lot of carbon dioxide in the capillary, carried from respiring tissues to the blood plasma. It diffuses in the opposite direction, through the capillary wall across the alveolar wall into the space insid the alveolus, from here it is breathed out
- Alveoli are surrounded by elastic tissue. This stretches whilst breathing and recoils when breathing out to helps remove air from the lungs
- The air we breathe out is saturated with water vapour that has evaporated from the moist walls of the alveoli



Breathing

- Diaphragm and ribcage movements create changes in overall chest volume
- This change in volume then causes a pressure change in the chest cavity

Inspiration	Expiration
External intercostal muscles contract, internal intercostal muscles relax, ribs move upwards and outwards	Internal intercostal muscles contract and external relaxes, ribs move downwards and inwards
At the same time: muscle in diaphragm contracts and flattens	Muscles in diaphragm relaxes, bulges outwards (organs press up from below)
This increases the volume inside the thorax: decrease in overall pressure	This decreases the volume inside the thorax, so therefore increases the pressure
Atmospheric pressure is greater than thoracic pressure so air moves into the lungs	Air is forced out of the lungs and alveoli (elastic recoils)

Cleaning the Air

- Air is warmed and moistened when inhaled by the nose
- Hairs filter the air- removing particles and some pathogens
- In the trachea, bronchi and bronchioles:
  - → Goblet cells secrete mucus which traps pathogens
  - → Ciliated epithelial cells have cilia which beat to carry mucus and trapped pathogens to the throat, where it is swallowed

Rate and depth of breathing

Breathing and exercise

- Normal breathing rate at rest: 12-16 breaths per minute
- Rate and depth increases with exercise because:
  - → Muscles need more oxygen

- Breathing is deeper and faster in order to get more oxygen in the blood and get rid of more carbon dioxide
- Rapid rate of respiration in muscles continues after exercise
- Pulse rate remains high after exercise as the heart is still beating fast to keep up with the oxygen demand

Depth of Breathing

- An adult can take in 5l of air on their deepest breath
- The vital capacity of a person is the maximum volume of air breathed out after breathing in as much air as possible
- At rest 0.5l of air is breathed in and out
- During exercise 4.5l of air is breathed in and out

Controlling of breathing

- The medulla, the part of the brain located nearest to the spinal cord, directs the signal to the spinal chord to maintain breathing
- Breathing is an involuntary action
- During exercise carbon dioxide builds up in the blood, causing pH levels to drop (blood becomes acidic)
- pH change is detected by the brain which sends impulses to the diaphragm and intercostal muscles to contract faster, leading to an increase in rate and depth of breathing
- This lowers the carbon dioxide concentration in the blood and the pH returns to normal
- This is an example of homeostasis