CAIE Biology IGCSE

11: Gas Exchange in Humans

Notes

(Content in **bold** is for Extended students only)

Human respiratory system

Key structures:

- **Lungs** - The lungs are the main organs in the respiratory system, containing the surfaces where gas exchange takes place.
- **Ribs and intercostal muscles** - I**ntercostal muscles are found between the ribs. Internal and external intercostal muscles work antagonistically in pairs to expand and contract the rib cage during breathing.** The ribs also protect the lungs and heart from physical damage.
- **Larynx** - contains the vocal cords.
- **Trachea** - connects the throat to the bronchi. **C-shaped cartilage rings are present to provide structural strength, keeping the trachea open so that air can pass through it.**
- **Bronchi** - hollow tubes composed of cartilage rings that carry air from the trachea to the lungs. The bronchi splits into two tubes to enter the left and right lung, before branching further inside the lungs.
- **Bronchioles** - Smaller tubes which branch off from the bronchi in the lungs, leading to the alveoli.
- **Alveoli** - Where gas exchange occurs; comprising tiny air sacs with a capillary network. Oxygen from the air diffuses into the capillaries, whilst waste carbon dioxide diffuses out. Waste gases are then breathed out.

The respiratory system:

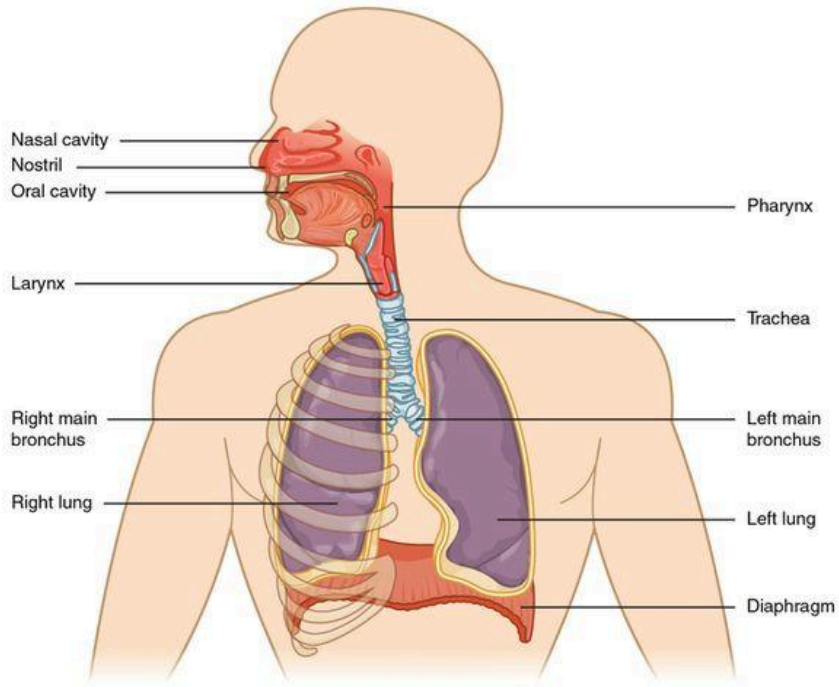


Diagram of the lungs:

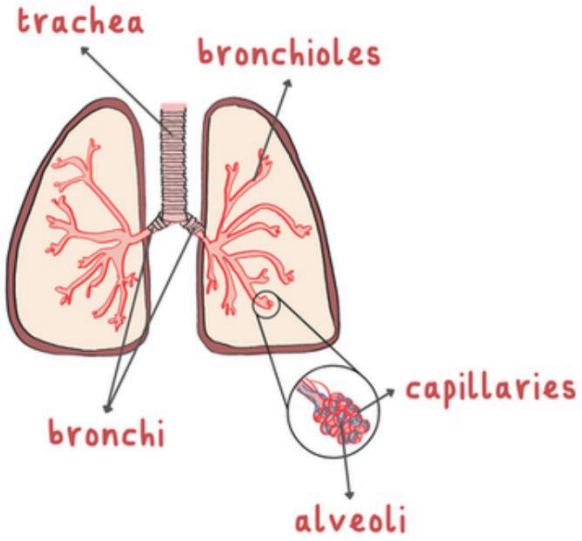
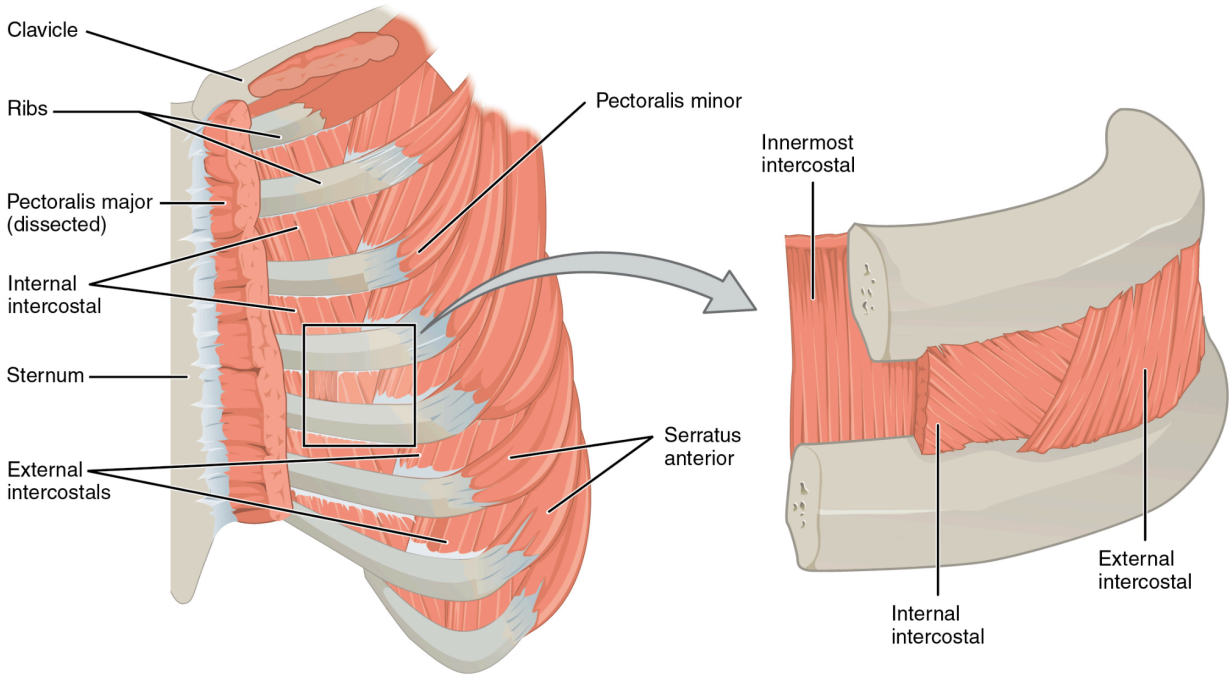


Diagram of internal and external intercostal muscles (extended students only):

(you only need to know the structure of internal and external intercostal muscles)



Ventilation:

Ventilation is the act of moving air into and out of the lungs to allow gas exchange to occur.

- **Breathing in - internal intercostal muscles relax whilst the external intercostal muscles contract, pulling the ribs up and out while the diaphragm flattens, pushing the abdominal muscles downwards. The volume in the thorax (chest cavity) increases, so air enters the lungs. Air diffuses into the lungs, rather than being 'sucked' in. This is because when the volume of the chest increases, there is a lower concentration of air inside the lungs compared to outside, thus air diffuses in.**

- **Breathing out - volume of thorax decreases, increasing pressure so that air is forced out. This is passive (does not require muscle contraction) except when forcibly breathing out, where the internal intercostal muscles contract.**

The majority of air in the atmosphere is composed of **nitrogen, oxygen and carbon dioxide**. Inhaled air is made up of **more oxygen** than exhaled air, **as oxygen is absorbed into the blood in the alveoli instead of being exhaled. Oxygen is used in cells for respiration, and carbon dioxide is produced as a waste product. This carbon dioxide is released from the blood at the alveoli and diffuses out into the lungs, before being exhaled**, thus there is **more carbon dioxide in exhaled air**. Exhaled air also contains **more water vapour** than inhaled air.

During physical activity, the rate and the depth of breathing increases. **When exercise is carried out, muscles increase the rate of respiration to produce energy for muscle contraction. Aerobic respiration requires oxygen; thus, a greater amount of oxygen is demanded. In addition, a greater amount of carbon dioxide is produced as a waste substance, which diffuses into the blood. This increase in carbon dioxide in the blood is detected by the brain, which causes the rate of breathing to speed up, allowing gas exchange to happen more rapidly, expelling the carbon dioxide whilst taking in more oxygen. The heart rate is also increased to pump substances around the body more quickly in the blood.**

Adaptations of exchange surfaces:

- **Large surface area** - allows more efficient diffusion. The alveoli allow the lungs to have a huge surface area of 80-100 square metres.
- **Thin surface** - this means that there is a short diffusion distance, thus exchange can occur more rapidly.
- **Good blood supply** - Maintains concentration gradient by carrying away substances which have diffused across already.
- **Good ventilation with air** - this means that waste gases can diffuse out of the blood into the air in the lungs whilst oxygen diffuses into the blood.
- **Moist** - Allows gases to dissolve before diffusing across the membrane.

The lungs are also adapted to protect from foreign pathogens and particles. Goblet cells, found in the trachea and bronchi, are adapted to secrete mucus into the respiratory tract. Foreign pathogens and particles stick to this mucus, which is then moved upwards towards the throat by cilia (hair-like projections from some cells). Mucus is then swallowed, and pathogens are destroyed in the acidic conditions in the stomach.