CAIE Biology A-level

Topic 9: Gas exchange and smoking

Notes

The need for specialised exchange surfaces arises as the size of the organism, and its **surface area to volume ratio,** increases. In the case of **single celled organisms**, the substances can easily enter the cell as the distance that needs to be crossed over is short. However, in **multicellular organisms** that distance is much larger due to a higher surface area to volume ratio. As a result of this, multicellular organisms require **specialised exchange surfaces** for efficient gas exchange of **carbon dioxide and oxygen**.

Features of an efficient exchange surface include **large surface area**, for instance the **root hair cells** or **folded membranes**, such as those of the mitochondria. An efficient exchange surface should also be **thin** to ensure that the distance that needs to be crossed by the substance is short. The exchange surface also requires a **good blood supply/ventilation** to maintain a steep gradient, for example that of the alveoli.

Mammalian gaseous exchange system

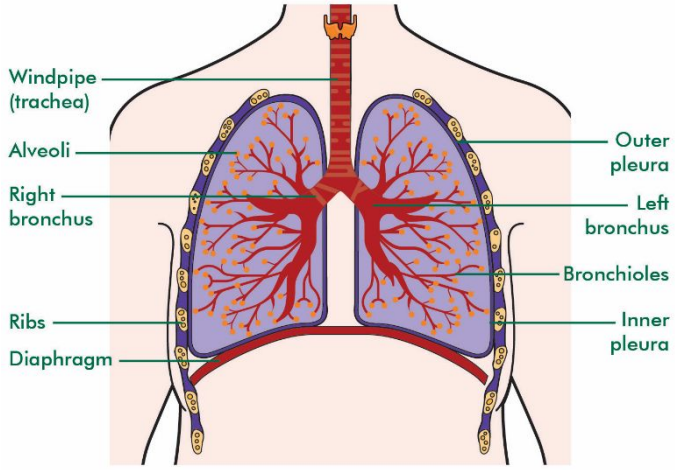

Figure Macmillan – The Lungs

The **lungs** are a pair of structures with a **large surface area** located in the **chest cavity** with the ability to **inflate**. The lungs are surrounded by the **rib cage** which serves to protect them. A lubricating substance is secreted to prevent the friction between rib cage and lungs during inflation and deflation. **External and internal intercostal muscles** between the ribs work antagonistically to raise and lower the ribcage. A structure called the **diaphragm** separates the lungs from abdomen area.

The air enters through the nose and passes along the **trachea, bronchi and bronchioles**, which are structures well adapted to their role in enabling passage of air into the lungs. The airways are held open with the help of rings **of cartilage**, incomplete in the trachea to allow passage of food down **the oesophagus** behind the **trachea.**

The gaseous exchange takes place in the walls of **alveoli**, which are tiny sacs filled with air and surrounded by **capillaries**. Capillaries have a constant flow of blood which moves oxygenated blood away from the area of diffusion to maintain the **concentration gradient**. The oxygen that is inhaled moves from the alveoli into the blood. At the same time carbon dioxide is also removed from the capillaries to the alveoli which again maintains a steep concentration gradient. The alveoli also have a thin layer of surfactant which keeps them from collapsing - keeping them inflated.

Trachea and bronchi are similar in structure, with the exception of size (bronchi are narrower). They are composed of **several layers** which together make up a thick wall. The wall is mostly composed of cartilage, in the form of incomplete C rings. Inside the surface of

the cartilage is a layer of **glandular and connective tissue, elastic fibres, smooth muscle and blood vessels.** This is referred to as the '**loose tissue**'. The inner lining is an epithelial layer composed of **ciliated epithelium and goblet cells.**

The **bronchioles** are narrower than the bronchi. Only the larger bronchioles contain cartilage. Their wall is made out of smooth muscle and elastic fibres. The smallest of bronchioles have alveoli clusters at the ends.

Structures and functions of mammalian gaseous exchange system include:

- **Cartilage** – involved in supporting the trachea and bronchi, plays an important role in preventing the lungs from collapsing in the event of pressure drop during exhalation
- **Ciliated epithelium** – present in bronchi, bronchioles and trachea, involved in moving mucus along to prevent lung infection by moving it towards the throat
- **Squamous epithelium** – Line the alveoli and allow gas exchange to take place between the capillaries and the air in the lungs. They are thin with a large surface area for quick diffusion.
- **Goblet cells** – cells present in the trachea, bronchi and bronchioles involved in mucus secretion to trap bacteria and dust to reduce the risk of infection with the help of lysozyme which digests bacteria
- **Smooth muscle** – their ability to contract enables them to play a role in constricting the airway, thus controlling its diameter as a result and thus controlling the flow of air to and from alveoli
- **Elastic fibres** – stretch when we exhale and recoil when we inhale thus controlling the flow of air