CIE Biology GCSE

Transport in animals

Notes

The **circulatory system** acts as the main transport system in animals. It is made up of **blood vessels** such as **arteries, veins and capillaries**, in which blood travels around the body, carrying nutrients and waste products.

Fish have a **single circulatory system**. This means that their heart only has **two chambers**, and blood passes through it only **once** on its circuit around the body. Oxygen is absorbed as blood passes the gills, thus fish do not have lungs. Mammals, in contrast, have a **double circulatory system**, meaning that blood passes through the heart **twice** each circuit of the body. This means that the mammalian heart must have **four chambers** to keep oxygenated and deoxygenated blood separate. Mammals require double circulatory systems as they are larger and have a **greater need for oxygen** to use in respiration for **warmth**, as oppose to fish which are cold blooded. Double circulatory systems are also more **efficient** at supplying oxygen and can maintain a **high blood pressure**.

The heart

Heart function:

1. Deoxygenated blood enters the heart through the **vena cava** (vein) into the right atrium.
2. The right atrium contracts and blood moves through the **tricuspid valve** to the right ventricle.
3. The ventricle contracts and blood exits the heart through the **semilunar valve** to the **lungs** via the **pulmonary artery**.
4. Blood becomes oxygenated in the lungs and then returns to the heart via the **pulmonary vein**, entering the left atrium.
5. The left atrium contracts and blood moves through the **bicuspid valve** into the left ventricle.
6. The left ventricle contracts and oxygenated blood exits the heart past the **semilunar valve** through the **aorta** (artery) and travels around the body, becoming deoxygenated. The wall of the left ventricle is much **thicker** than the right side, as it must be able to pump blood at **high pressure** around the entire body, rather than just to the lungs. The walls of **both ventricles** are thicker than the atria walls.
7. The left and right sides of the heart are separated by the **septum,** which makes sure that oxygenated and deoxygenated blood **remain separate.**

Valves are present in the heart and veins to **prevent backflow** of blood. The bicuspid and tricuspid valves are known as the **atrioventricular valves** as they prevent backflow of blood between the ventricles and atria. They are **not present in arteries** as the pressure is high enough that backflow does not occur.

Usually, **deoxygenated blood travels in veins to the heart** and **oxygenated blood travels in arteries away from the heart**. The only exception to this is the **pulmonary artery**, which carries **deoxygenated blood** from the heart to the lungs, and the **pulmonary vein** which carries **oxygenated blood** from the lungs to the heart.

Heart monitoring:
The heart can be monitored using an **electrocardiogram (ECG),** which records the electrical signals in the heart that cause contractions of the atria and ventricles. It can also be monitored by listening to the **pulse rate** and **valve activity.**

Pulse rate is affected by a variety of factors. **Physical activity** is a factor that can influence **short-term** heart rate changes. When physical activity is carried out, **muscles respire** to produce energy for movement. **Aerobic respiration requires oxygen**, thus the **heart rate speeds up** so that blood is pumped around the body more quickly, allowing **more oxygen to be delivered to respiring tissues**. **Long-term** influencers of heart rate are **diet and fitness**. Exercising regularly and eating healthily will result in a **lower resting heart rate.** Diets high in salt and caffeine raise heart rate.

Coronary heart disease:
Coronary heart disease is caused by a **buildup of cholesterol in the coronary artery** which **narrows the artery** thus limiting **blood flow to the heart**. Cholesterol is a result of too much saturated fat in the diet, thus eating a healthy diet can reduce the risk of coronary heart disease. Regular exercise can also decrease the risk of coronary heart disease by **lowering blood pressure**. Other risk factors include stress, smoking, genetic predisposition, age and gender.

Treatments:

- **Drug treatment** - **Aspirin** can be used to reduce the risk of heart disease. Aspirin thins the blood and makes platelets less likely to clump together to block the artery. It also helps to reduce high blood pressure.

- **Surgery** - There are a variety of treatments which involve surgery.
  - **Stent** - which is a small tube that can be inserted into the artery to keep it open, allowing blood to flow.
  - **Angioplasty** - also helps widen the artery by inserting a deflated balloon into the artery, before inflating it, causing the artery to widen. The balloon is then removed, and the artery remains widened. A stent can also be inserted at the same time to remain after the balloon has gone.

- Coronary bypass - This is a more invasive method, where an artery from the patient's leg or arm is grafted onto the damaged artery to divert the blood flow around the damaged section.

Blood and lymphatic vessels

Adaptations of blood vessels:

- Arteries carry oxygenated blood at high pressure to the tissues. They have a thick elastic layer and wall to maintain high pressure without bursting. They also have a thick muscle layer to control the volume of blood by dilating and constricting the artery. At tissues, arteries branch into arterioles, which enter the tissues and become capillaries.

- Veins, by comparison, have a thin elastic and muscle layer as the blood travels at low pressure back to the heart so there is no need to control blood flow. They are also adapted to prevent backflow of blood by containing valves. Venules are small veins which are formed by groups of capillary vessels. Venules eventually become veins.

- Capillaries are thin blood vessels which are used to exchange substances with tissues, such as oxygen, carbon dioxide and other nutrients. Therefore, they must be adapted for efficient exchange. They have a large surface area and are branched. They also have a narrow diameter and lumen to decrease diffusion distance, and a slow rate of blood flow to allow time for exchange.

- Shunt vessels connect arteries to veins without the blood travelling through capillaries. They can dilate and constrict like arteries to control blood flow and dilate in cold conditions to limit blood flow to extremities to reduce heat loss.

Lymphatic system and tissue fluid:
The lymphatic system is made up of lymph vessels and lymph nodes.

Capillaries exchange substances with cells by producing tissue fluid. This forms at the arteriole end of the capillary when nutrients are forced out of capillaries due to the high pressure in the narrower blood vessel. Tissue fluid bathes the cells and allows nutrients to diffuse into cells, and waste substances to diffuse out into the tissue fluid. Most of the tissue fluid is reabsorbed into the capillary at the venous end. Some larger molecules, such as lipids and large proteins,

cannot re-enter the capillary, thus must be carried away by the lymph system. These molecules enter the lymph vessels and travel as a fluid called lymph. Lymph passes through lymph vessels and drains into the blood system in the chest cavity.
Lymph nodes are present along the lymph vessels, predominantly located in the neck, armpits and groin. Their function is to filter the lymph fluid, removing bacteria and foreign particles from it. They therefore help protect the body from infection.

Components of the Blood

- Red blood cells - contain haemoglobin (protein) which binds to oxygen, allowing it to be transported around the body to cells.

- White blood cells - play a major role in fighting off infection. A lymphocyte is a type of white blood cell which produces antibodies. Antigens are proteins found on the cell membrane of pathogens. Each antibody is specific to one type of antigen, and they bind to these antigens, causing the foreign cells to clump together. This makes them harmless as they can no longer enter cells to cause damage. White blood cells also carry out phagocytosis (below).

- Platelets - involved in blood clotting (below).

- Plasma - the liquid in blood vessels in which contains blood cells, ions, soluble nutrients, hormones and carbon dioxide.

Phagocytosis:

1. Phagocyte recognizes and attaches to foreign pathogen
2. The membrane of the phagocyte envelops the pathogen and folds inwards, trapping it inside the phagocyte.
3. The phagocyte releases enzymes which break down the pathogen, killing it.

Blood clotting:
Blood clotting occurs when a blood vessel breaks due to an injury. Platelets stick to the broken vessel wall and clump together, blocking the cut. Fibrinogen is then converted to a protein called fibrin, which forms a mesh of fibrin fibers across the wound. More platelets stick to this mesh. This forms a scab and prevents bleeding by blocking the cut. This prevents blood loss and allows the vessel to heal, as well as preventing pathogens from entering the blood vessel.

CIE Biology GCSE

Gas exchange in humans

Notes

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** - Intercostal 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; comprised of 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.

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.

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 meters.
- **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.

Respiration is a chemical reaction which happens in almost all cells in the body to produce energy from nutrient molecules. This energy can be used in a variety of processes including:

- Muscle contraction
- Protein synthesis
- Cell division
- Active transport
- Growth
- Nerve impulses
- Maintaining body temperature

Respiration usually occurs with the presence of oxygen (aerobic respiration), although it can occur in the absence of oxygen (anaerobic respiration). Anaerobic respiration is less efficient and leads to fatigue in humans. Both types of respiration are catalysed by enzymes. This means that the rate of respiration can be influenced by factors such as temperature and pH.

Aerobic Respiration:

Aerobic respiration occurs in the presence of oxygen. Glucose is broken down into carbon dioxide, water and energy with the help of oxygen. This occurs in the cell mitochondria. Cells which require lots of energy, such as muscle cells, therefore have high amounts of mitochondria.

Equations for aerobic respiration:

- glucose + oxygen → carbon dioxide + water
- $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

Anaerobic respiration:

Anaerobic respiration occurs when oxygen is not present. It is less efficient than aerobic respiration and produces less energy per glucose molecule. It occurs in the cell cytoplasm and thus does not require mitochondria.

Animal cells undergo anaerobic respiration during vigorous exercise as not enough oxygen is delivered to muscles. In this reaction, glucose is broken down to produce lactic acid, as well as releasing energy. This lactic acid builds up in muscles and causes muscle fatigue. Anaerobic respiration also produces an 'oxygen debt'. To repay this, the lactic acid must be transported to the liver where it is broken down into carbon dioxide and water using oxygen. This is the reason why the breathing and heart rates remain high after exercise.

Microorganisms, such as **yeast**, also undergo anaerobic respiration. Yeast breaks down anaerobically to form **alcohol and carbon dioxide** instead of lactic acid.

Equations for anaerobic respiration in yeast:

- glucose → alcohol + carbon dioxide
- $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

Equation for anaerobic respiration in animal cells:

- glucose → lactic acid