

CIE Biology GCSE

9: 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.