# OCR (A) Biology A-level

## Topic 3.2: Transport in animals

Notes

# Circulatory systems

Circulatory systems can either be **open**, for instance in insects or **closed**, like in fish and mammals where the blood is confined to blood vessels only. **Closed circulatory systems** come in two forms, either a single form which consists of a heart with **two chambers** meaning the blood passes through the heart once for every circuit of the body or double, where the heart has **four chambers** and blood passes through the heart twice for every circuit of the body.

## Important structures and their functions

- **Arteries** – adapted to carrying blood away from the heart to the rest of the body, **thick walled** to withstand **high blood pressure**, contain **elastic tissue** which allows them to **stretch and recoil** thus smoothing blood flow, contain **smooth muscle** which enables them to vary blood flow, lined with **smooth endothelium** to reduce friction and ease flow of blood

- **Arterioles** – branch off arteries, have **thinner** and **less muscular walls**, their role is to feed blood into capillaries

- **Capillaries** – smallest blood vessels, site of **metabolic exchange**, only **one cell thick** for fast **exchange** of substances

- **Venules** – larger than capillaries but smaller than veins

- **Veins** – carry blood from the body to the heart, contain **a wide lumen** to maximise volume of blood carried to the heart, **thin walled** as blood is under **low pressure**, contain **valves** to **prevent backflow** of blood, no pulse of blood meaning there's little elastic tissue or smooth muscle as there is no need for stretching and recoiling

**Tissue fluid** is a liquid containing dissolved **oxygen** and **nutrients** which serves as a means of supplying the tissues with the essential **solutes** in exchange for **waste products** such as **carbon dioxide**. Therefore, it enables **exchange** of substances between **blood** and **cells**.

**Hydrostatic pressure** is created when blood is pumped along the **arteries**, into **arterioles** and then **capillaries**. This **pressure** forces blood fluid out of the capillaries. Only substances which are small enough to escape through the gaps in the **capillary** wall are components of the **tissue fluid** – this includes dissolved **nutrients** and **oxygen**. The fluid is referred to as **tissue fluid**, as described above.
The fluid is also acted on by **osmotic pressure** which pushes some of the fluid back into the **capillaries**. As both the tissue fluid and blood contain **solutes**, they have a negative **water potential**. Although the **potential** of the tissue fluid is negative, it is less negative in comparison to the blood (the blood contains more **solutes**). Therefore, the **tissue fluid** is

positive in comparison to the blood. This causes water to move down the **water potential gradient** from the tissue fluid to the blood by **osmosis**.

The remaining tissue fluid which is not pushed back into the capillaries is carried back via the **lymphatic system**. The lymphatic system contains **lymph fluid**, similar in content to **tissue fluid**. However, lymph fluid contains less **oxygen** and **nutrients** compared to tissue fluid, as its main purpose is to carry **waste products**. The lymph system also contains **lymph nodes** which filter out **bacteria** and **foreign material** from the fluid with the help of **lymphocytes** which destroy the invaders as part of the immune system defences.

# Mammalian heart and cardiac cycle

Due to the heart's ability to initiate its own contraction, it is referred to as **myogenic**. In the wall of the right **atrium** there is a region of specialised fibres called the **sinoatrial node** which is the pacemaker of the heart, as it initiates a wave of electrical stimulation which causes the **atria to contract at roughly the same time**. The **ventricles** do not start contracting until the **atria** have finished due to the presence of tissue at the base of the atria which is **unable to conduct the wave of excitation**. The electrical wave eventually reaches the **atrioventricular node** located between the two atria which passes on the excitation to ventricles, down the **bundle of His** to the apex of the heart. The bundle of His branches into **Purkyne fibres** which carry the wave upwards. This causes the ventricles to **contract**, thus emptying them.

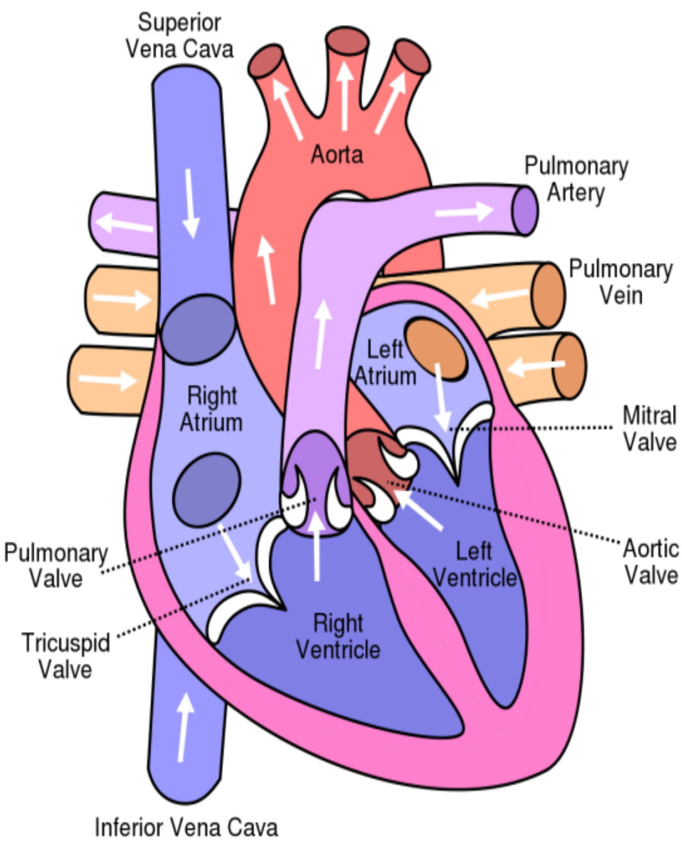


*Figure 1 Wikipedia*

**There are 3 stages of the cardiac cycle:**

1) **Atrial systole** – during atrial systole the **atria contract** and this forces the atrio-ventricular **valves open** and blood flows into the ventricles.

2) **Ventricular systole** – contraction of the ventricles causes the **atrio-ventricular valves** to **close** and **semi-lunar valves to open** thus allowing **blood to leave the left** ventricle through the **aorta** and right ventricle through the **pulmonary artery**.

3) **Cardiac diastole** – atria and ventricles relax, **elastic recoil** of the heart **lowers the pressure inside the heart chambers** and **blood is drawn from the arteries and veins** thus causing **semilunar valves** in the aorta and pulmonary arteries to close, preventing backflow of blood.

# Haemoglobin

Haemoglobin is a water soluble globular protein which consists of twoalpha and two beta polypeptide chains each containing a haem group. It carries oxygen in the blood as oxygen can bind to the haem ($Fe^{2+}$) group and oxygen is then released when required. Each molecule can carry four oxygen molecules.

The affinity of oxygen for haemoglobin varies depending on the partial pressure of oxygen which is a measure of oxygen concentration. The greater the concentration of dissolved oxygen in cells the greater the partial pressure. Therefore, as partial pressure increases, the affinity of haemoglobin for oxygen increases, that is oxygen binds to haemoglobin tightly. This occurs in the lungs in the process known as loading. During respiration, oxygen is used up therefore the partial pressure decreases, thus decreasing the affinity of oxygen for haemoglobin. As a result of that, oxygen is released in respiring tissues where it is needed. After the unloading process, the haemoglobin returns to the lungs where it binds to oxygen again.

Dissociation curves illustrate the change in haemoglobin saturation as partial pressure changes. The saturation of haemoglobin is affected by its affinity for oxygen, therefore in the case where partial pressure is high, haemoglobin has high affinity for oxygen and is therefore highly saturated, and vice versa.

Saturation can also have an effect on affinity, as after binding to the first oxygen molecule, the affinity of haemoglobin for oxygen increases due to a change in shape, thus making it easier for the other oxygen molecules to bind.

Fetal haemoglobin has a different affinity for oxygen compared to adult haemoglobin, as in needs to be better at absorbing oxygen because by the time oxygen reaches the placenta, the oxygen saturation of the blood has decreased. Therefore, fetal haemoglobin must have a higher affinity for oxygen in order for the foetus to survive at low partial pressure.

The affinity of haemoglobin for oxygen is also affected by the partial pressure of carbon dioxide. Carbon dioxide is released by respiring cells which require oxygen for the process to occur. Therefore, in the presence of carbon dioxide, the affinity of haemoglobin for oxygen decreases, thus causingoxygen to be released. This is known as the Bohr effect.