Transport in Animals

Circulatory system of fish (single circulation):

- Fish have the simplest circulatory system.
- The heart has 2 chambers: blood collecting atrium and blood ejecting ventricle
- Blood is pumped to gills for oxygenation
- Oxygenated blood flows from gills to the rest of the body before returning to the heart.
- Single circulation is ineffective since blood pressure is lost during circulation.

Circulatory system of mammals:

- Double circulation- blood passes through the heart twice during one complete circuit.
- <u>Pulmonary circulation</u>:
  Right ventricle→lungs→left atrium
- <u>Systemic circulation:</u>
  Left ventricle→rest of the body→right atrium
- Double circulation is advantageous as blood pressure is maintained during circulation.
- The drop in blood pressure during pulmonary or systemic circulation is made up as the blood re-enters the heart.

Heart structure:

- 4 chambers- 2 atria and 2 ventricles.
- Atria- upper 2 chambers having thin walls
- Ventricles- lower 2 chambers having thick muscular walls.

- Left side of the heart deals with oxygenated blood, the right side deals with deoxygenated blood.
- Left and right side of the heart are separated by septum whose function is to prevent mixing of oxygenated and deoxygenated blood.

Pathway of blood:

Deoxygenated blood from the lower half of the body enters the right atrium from the inferior vena cava. Blood from the upper half of the body enters the right atrium from the superior vena cava.

↓

Blood flows through tricuspid valve into the relaxed right ventricle (state of relaxation is called diastole).Right atrium contracts (contraction is called systole),

↓

Ventricle contracts, blood enters the pulmonary artery and is taken to the lungs for oxygenation.

↓

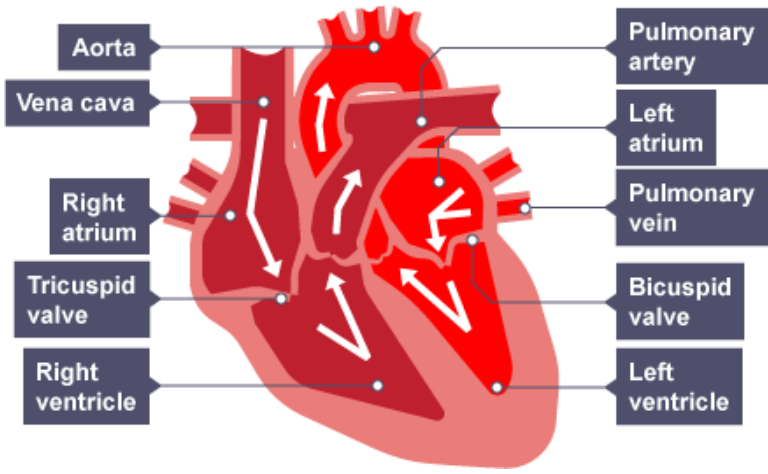
Oxygenated blood returns through the pulmonary vein to the left atrium.

↓

Blood passes through the bicuspid/mitral valve from the atrium to the ventricle.

↓

Left ventricle contracts, blood enters the aorta and oxygenated blood is distributed throughout the body.



Transport in Animals

Control of blood flow:

- Valves prevent the backflow of blood
- The atria and ventricles are separated by atrioventricular valves shaped like parachutes
- right side- tricuspid valve
- Left side- bicuspid valve
- Valves have tendons or cords to prevent turning them inside out.
- Semilunar valves- in pulmonary artery and aorta. Half moon shaped. Consists of 'pockets' which fill up and close when blood tries to flow the other way.
- Ventricles contract- pressure closes bicuspid and tricuspid valves.
- Ventricles relax- blood pressure in arteries closes semilunar valves
- When the atria are contracted, the ventricles are relaxed.
- However, during every heartbeat there is a brief rest period when atria and ventricles are relaxed. During the rest period, blood flows from the atria to the ventricles due to low pressure in ventricles. When the atria contract, they do so to squeeze out whatever blood is remaining.
- The left ventricle has the thickest walls as the contraction of the left ventricle has to generate enough pressure for blood to circulate around the whole body.

Monitoring the heart:

<u>Heart sounds:</u>

- Can be heard using stethoscope.
- Regular 'lub-dub' sound as a result of closing of atrioventricular valves ('lub) and semilunar valves ('dub')
- Unclear sounds indicate faulty valves.

<u>ECGs (Electrocardiogram)</u>

- Monitors electrical activity associated with heartbeat.
- Electrodes are stuck on arms, legs and chest, connecting to an ECG recording machine

<u>Pulse rate:</u>

- No continuous blood flow in arteries. Blood travels in discrete batches hence pressure in arteries is not constant.
- The wave of pressure passing through arteries due to this is known as pulse.
- Pulse can be observed using digital pulse rate monitors or by pressing the carotid artery in the neck or radial artery in the wrist using fingers (except thumb which has its own pulse)
- Normal resting heart rate- 70 bpm, slightly higher for younger people, females.

Exercise and heart rate:

- Muscle respires faster during exercise and hence increased blood flow is needed to provide more oxygen, glucose, take away more carbon dioxide
- Inadequate oxygen- cells respire anaerobically, producing lactic acid which causes a cramp.
- Pulse rate can reach 200 bpm during exercise and reduces to resting state when exercise stops.
- Fitter people have lower resting heart rate and it takes less time for pulse rate to return to normal after exercise.

Coronary heart disease

- Coronary arteries supply blood to heart muscles.
- Atheroma- patches of fatty deposits form in arteries, restricting blood flow.
- Atheroma gets more numerous with age.
- Patches can join up to form a continuous layer, reducing diameter of the artery.
- Atheroma causes protein fibrinogen to deposit fibrin forming blood clot (thrombus)

- Coronary thrombosis- blocked coronary arteries prevent heart muscles from getting oxygenated blood, heart may stop beating
- Angina- chest pain caused by partial blockage of coronary artery (warning sign)

Causes of coronary heart disease:

- Diet- high cholesterol diet. Obesity also puts strain on heart, makes exercise difficult.
- Stress- high blood pressure increases atheroma formation rate.
- Smoking- Smokers are 2-3 times more likely to die of heart attack. There is a correlation between smoking and heart attacks but the cause is not known.
- Genetic predisposition- Passed on from one generation to the next. Care should be taken to reduce risk of other factors.
- Age and gender- Risk of coronary heart disease increases with age. Affects males more than females.
- Lack of exercise- Heart is less efficient, slower blood flow, more atheroma formation.

Prevention of coronary heart disease:

- Healthy balanced diet- less chance of obesity.
- Low intake of saturated fats- less atheroma forms
- Exercise- improves muscle tone, heart requires less effort to keep pumping

Treatment of coronary heart disease:

<u>Blood thinners:</u>

- Patient is given regular dose of aspirin
- Prevents clot formation.
- Long term use reduces risk of coronary heart disease.

<u>Angioplasty:</u>

- Tube called catheter is passed through artery.
- Wire with balloon attached passed through catheter
- Balloon is inflated causing artery to expand and remove blockage
- Artery is propped open with a stent.
- Stent- mesh tube that acts as scaffolding

<u>By-pass surgery:</u>

- Saphenous vein is taken from calf muscle and is attached around the blocked artery.
- Blood by-passes the blocked artery by going through the saphenous vein
- Invasive procedure- open heart surgery

Blood Vessels:

Arteries	**Veins**
Carry blood away from heart	Carry blood towards heart
Carry oxygenated blood (except pulmonary artery)	Carry deoxygenated blood (except pulmonary vein)
Carry blood at high pressure in discrete batches	Carry blood at low pressure in a continuous stream
Thick walls made of elastic tissue and muscle fibres to maintain pressure and prevent bursting.	Thin walls with lesser elastic tissue and muscle fibres as blood is carried at low pressure.
Narrow lumen which increases slightly as a pulse of blood passes to maintain blood pressure.	Wide lumen to allow blood to flow through easily.
Do not have valves as y high pressure prevents backflow of blood.	Valves are present
Arteries divide to form arterioles	Venules join to form veins

Blood from the legs is able to travel to the heart despite there being low blood pressure in veins due to contractions in leg muscles which force blood

upwards and valves which prevent blood flowing back down

Capillaries:

- Only one cell thick
- Thin walls- diffusion of gases, food, etc.
- Dense capillary network ensures no cell is far from oxygen/food supply
- Arterioles greatly reduce blood pressure to ensure capillaries don't burst.

Arterioles and shunt vessels:

- Arterioles have less elastic tissue, more muscle fibres.
- Vasoconstriction- muscle fibres contract, restricting blood flow.
- Vasodilation- muscle fibres expand, increasing blood flow.
- Vasoconstriction and vasodilation allow regulation of blood flow.
- Shunt vessels connect arterioles and venules and can dilate to bypass capillaries, eg: in the skin in low temperatures to reduce heat loss.

Important blood vessels:

- Vena cava- Largest vein. Brings blood to right side of heart.
- Pulmonary arteries and veins- 2 of each since there are 2 lungs. Bring blood to and from lungs respectively.
- Aorta- Largest artery. Sends blood to the rest of the body.
- Renal artery and renal vein- Brings blood to and from the kidney respectively.
- Hepatic portal vein-Transports blood from small intestine to liver.
- Hepatic artery and hepatic vein- Brings blood to and from the liver respectively.

Lymphatic system:

- Due to high pressure at the arterial end, blood plasma is forced out from the capillary walls.
- Amount of nutrients leaving capillaries depends on blood concentration.
- The fluid surrounds cells and tissues and is known as tissue fluid (same as blood plasma, but with fewer proteins which are too big to diffuse out).
- 90% of tissue fluid re-enters the capillaries.
- The rest enters vessels known as lymph vessels
- The lymphatic system acts as a parallel circulatory system.
- Tissue fluid in the lymph vessels is known as lymph.
- Lymph vessels are similar in structure to veins (thin walls, valves, etc)
- Lymph nodes- swellings in the lymph vessels where lymphocytes (WBCs) are stored.
- Lymph nodes filter lymph before it is returned to blood.
- The lymph re-enters the circulatory system as the right lymphatic duct opens into the subclavian vein near the collarbone.

Functions of lymphatic system:

- Immunity due to lymphocytes present in lymph vessels.
- Return fluids back to circulatory system
- Drain excess fluids from tissues
- Transport fats after digestion as in the villi, lipids are absorbed into the lacteal which is part of the lymphatic system.

Blood

Blood plasma:

- Pale yellow liquid.
- It forms over half of the blood.
- It is mostly water with other substances such as ions, glucose, proteins, etc.
- Ions- sodium, potassium, chloride, etc

- Proteins- albumin, globulin, fibrinogen, antibodies, hormones, etc.
- Nutrients- glucose, amino acids, lipids
- Excretory products- urea, carbon dioxide.

Red Blood Cells:

- Biconcave shape-flexible.
- Contains red pigment haemoglobin in the cytoplasm which is a protein combined with iron.
- Haemoglobin combines with oxygen forming oxyhaemoglobin.
- Oxygenated blood- mostly oxyhaemoglobin
- Deoxygenated blood- Little oxyhaemoglobin.
- After RBC breaks down, haemoglobin changes to yellow pigment bilirubin and the iron is stored in the liver.
- RBCs don't have nucleus, mitochondria or endoplasmic reticulum.

White blood cells:

- Larger than RBCs, have a nucleus.
- 2 types- phagocytes and lymphocytes
- Phagocytes- can squeeze through capillary walls and escape from capillaries.
- Phagocytes perform phagocytosis- ingesting pathogens and degenerating them
- Lymphocytes- produce antibodies

Clotting of blood:

Platelets accumulate near site of wound, clump together and block smaller arteries

↓

Platelets release a clotting factor (prothrombin activator. The name is not required for IGCSE), which, through a series of enzymes, splits the blood protein fibrinogen to form insoluble fibrin.

↓

Fibrin deposits form a fine mesh over the wound, preventing proteins and blood cells from leaving and bacteria from entering the body.