Transport in humans

Circulation

The circulatory system

- (Most) animals circulatory systems consist of blood, some sort of pump and blood vessels
- Circulatory systems in animals transport useful substances such as oxygen and nutrients
- Circulatory systems also transport waste such as carbon dioxide

Blood circulation

- The heart is a pump that circulates blood through blood vessels
- Blood flows in **arteries** away from the heart to the different organs of the body
- Blood flows back to the heart in **veins**
- The smallest blood vessels that connect arteries to veins are **capillaries**
- The circulatory system allows one way flow of blood around the body
- The heart pumps blood giving it pressure so that it flows inside arteries and this helps maintain one way flow
- This is good for getting blood to capillaries
- High pressure blood will damage the delicate capillaries so small muscular blood vessels known as arterioles reduce the pressure before blood enters capillaries
- When blood leaves the capillaries the blood pressure is even lower
- There are semi-lunar valves in veins to make sure that blood does not flow backwards away from the heart
- If this happens veins swell and blood is not circulated properly
- Each valve has three of these pockets
- The valves open when the pressure of the blood pushes them, but they close when blood flows back to fill these pockets
- The semi-lunar valves in the heart are at places where blood leaves the heart chambers to enter arteries
- There are also valves between the chambers the heart

Single circulation (e.g. fish)

- Blood flows through the heart once during a complete circuit of the body
- Blood arriving to the heart via veins is deoxygenated
- The heart pups blood to an artery which takes it to the gills to be oxygenated
- The blood flows from gills to arteries and to body organs

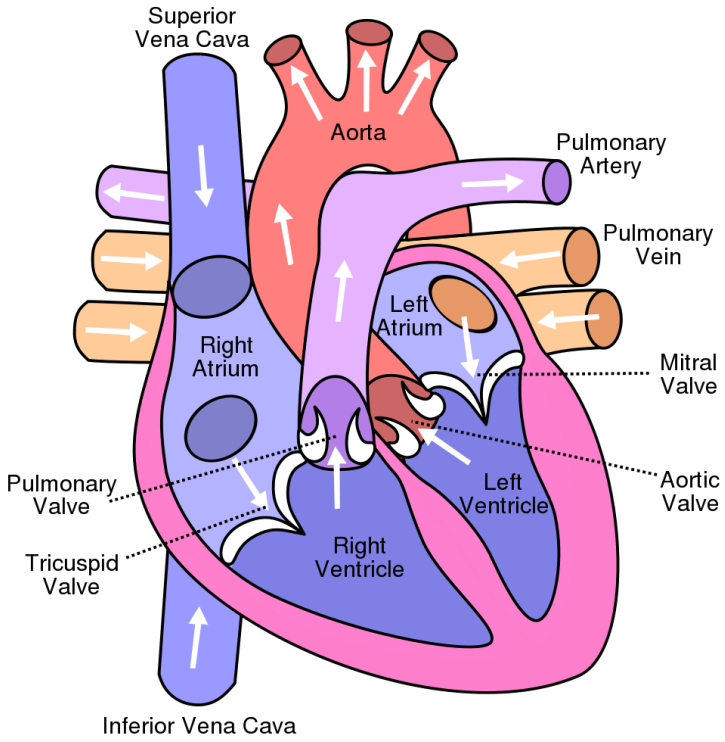
Double circulation

- Occurs in mammals
- Blood flows through the heart twice during one complete circuit around the body
- The mammalian heart is divided into two halves: left and right
- The septum is a thick wall of muscle that separates the two halves of the heart

- The right side of the heart pumps deoxygenated blood to the lungs and back to the heart again
- Pressure requirement is low as there is little resistance to flow in the lungs
- Oxygenated blood returns to heart via pulmonary vein
- Gas exchange takes place in lungs –oxygen enters the blood, carbon dioxide exits
- Oxygen blood is bright red in colour

- The left side of the heart pumps oxygenated blood to the rest of the body and back to the heart again
- Pressure is greater as there is more resistance to flow
- Gas exchange occurs in organs- oxygen leaves the blood, carbon dioxide enters
- Deoxygenated blood is dark red in colour

The heart



- Right atrium: collects deoxygenated blood via vena cava & pumps it to the right ventricle
- Right ventricle: pumps deoxygenated blood to lungs via pulmonary artery
- Pulmonary artery: carries deoxygenated blood from right ventricles to lungs
- Septum: separates left and right sides of the heart
- Left atrium: collect oxygenated blood via pulmonary veins and pumps it to left ventricle
- Left ventricle: pumps oxygenated blood to the body via the aorta
- Aorta: carries oxygenated blood from the left ventricle to the rest of the body
- Tricuspid & bicuspid valves: prevents the backflow of blood into the atria when ventricles contract
    - Pulmonary & aortic valves; prevent backflow of blood from the arteries into the ventricles

- Ventricles have more muscular walls than atria as they have to pump blood further than the atria
- The left ventricle has a more muscular wall than the right ventricle as it has to pump blood around the body and has to overcome resistance to flow

Heart action

- The heart pumps blood when its muscles contract
- When muscles contract, the chamber squeezes out blood
- After contraction, relaxation occurs, allowing blood to fill again
- The two sides of the heart work in sync
- The atria contract and relax at the same times
- The ventricles contract and relax at the same time

- During the relaxation phase, blood flows into the atria from the veins
- During contraction:
    i. Atria contract and force blood into the ventricles, valves between atria and ventricles open due to pressure of blood
    ii. The ventricles contract to force blood into the arteries. The valves close to prevent back flow

The electrocardiogram (ECG)

- The control of heartbeat depends on electrical activity
- Heart disorders can produce irregularities in this activity
- An ECG is used to detect these defects
- Electrode are taped to various positions on the body and the electrical activity

Heart Sounds

- The sound the heart makes when it beats is 'lub-dub'
- During contraction, the ventricle walls contract to force blood out of the pulmonary artery and aorta
- The pressure of the blood causes the atrioventricular valves to shut, preventing backflow
- This produces the sound 'lub'
- During the relaxation phase, the ventricles relax
- The pressure of the blood in arteries causes the semi-lunar valves to shut, preventing backflow
- This produces the sound 'dub'
- Irregularities in the heartbeat can be detected by listening to these heart sounds

The heart and exercise

- During exercise, your muscles need more energy from respiration to contract
- The heart beats faster and the artery dilate
- These changes increase the flow of blood of blood to muscles and result in:
    i. Increase in removal of carbon dioxide
    ii. Increase in supply of oxygen
- You can detect the flow of blood through your pulse
- The resting pulse rate is an indication of a person's fitness

The table below shows the correspondence between resting pulse rate and fitness

Pulse rate	Level of fitness
Less than 50	Outstanding
50-59	Excellent
60-69	Good
70-79	Fair
80 and over	Poor

Blood vessels

Vessel	Organs			
	heart	lungs	liver	kidney
Bring blood to organ	Vena cava to right atrium; pulmonary vein to left atrium	Pulmonary artery	Hepatic artery; hepatic portal vein	Renal artery
Taking blood away from organ	Pulmonary artery from right ventricle; aorta from left ventricle	Pulmonary vein	Hepatic vein	Renal vein

Structure and function of blood vessel

Vessel	Structure
Arteries	Narrow space in the centre Thick walls made of muscle Elastic fibre High pressure
Veins	Wide space in centre Less muscular than arteries Less elastic than arteries Lower pressure Have semi-lunar valves to prevent backflow
Capillaries	Very narrow Single layer of very thin cells No muscle tissue

How blood vessels are adapted to their functions

- Elastic fibres in arteries stretch and recoil
- The recoil of elastic fibres help to push blood along so maintaining pressure
- Capillaries provide a huge surface area for exchange between blood and cells
- Blood moves slowly giving adequate time for exchange
- As the walls are one cell wall thick, it is easy for substances to diffuse
- Pressure of blood in veins is low
- It gets moved along by the contraction of muscles and organs that surround veins

Arterioles

- Small subdivisions of arteries that carry blood to capillary networks
- Have muscle in their walls
- Function; blood transport and regulating blood pressure
- Receive nerve impulses that trigger hormones to regulate diameter

Venules

- Small blood vessels that collect blood from capillary beds
- Thin walled vessels that unite to form veins
- Transport deoxygenated blood

Shunt vessels

- Vessel that links an artery directly to a vein
- Allows blood to bypass capillaries in certain areas
- Control blood flow by constriction and dilation
- Endotherms- constrict in response to cold, reducing heat loss

Coronary heart disease (CHD)

- Coronary heart disease is caused by blockage of the coronary arteries that supply the heart with glucose and oxygen

Risk factors of CHD

i. Eating a diet with too much saturated animal fat
ii. Being overweight
iii. Smoking
iv. Taking little or no exercise
v. Stress
vi. Genes inherited
vii. Age – risk increases with age
viii. Sex – men are more likely to get CHD than women

Treatment of CHD

- Coronary artery bypass- this is done by grafting a blood vessel from another part of the body, above or below the narrowed or blocked area.
- Coronary angioplasty-this is whereby a small balloon is inflated inside the artery to widen it. A small metal tube is then inserted to help keep the artery open. This tube is called a stent
- Antiplatelet medicines (e.g. aspirin) – prevent blood clots from forming in the arteries. Low dosage of daily aspirin is used for people with CHD, angina, heart attack patients, coronary stent and bypass surgery

Other conditions

- Atherosclerosis- cholesterol sticks to the walls of the artery, effectively narrowing them
- Thrombosis- artery walls become rough which can cause blood to clot and block the vessel
- Angina- chest pains caused by not enough oxygen getting to the heart muscle
- Angina acts as a warning for a heart attack
- Total blockage or thrombosis can cause a heart attack
- When this happens supply of oxygen is cut off
- Causes severe pain and the heart is damaged
- The heart may stop beating altogether – cardiac arrest

Blood Composition

Plasma (accounts for 55% of the blood volume)
Consists of water with chemicals dissolved in it:

i. Nutrients (glucose, amino acids, lipids, vitamins, mineral ions such as sodium and chloride ions)
ii. Wastes, such as urea and carbon dioxide
iii. Blood proteins, such as albumen and antibodies
iv. Hormones. such as insulin, glucagon and adrenaline

Blood cells

Red blood cells have no nuclei, and have cytoplasm full of haemoglobin for transporting oxygen. They are disc shaped with the middle pushed in, they have a large surface area to volume ration that aids with their function.

White blood cells have nuclei. They may appear white when spun around in a centrifuge, but with closer observation- they are colourless and have no pigment that gives them colour. We have to stain them in order for them to be visible

Platelets are tiny fragments of cells that cause blood to clot when you cut yourself.

Blood in defence

White blood cells defend us against diseases, there are two types: lymphocytes and phagocytes.

Phagocytes

They surround pathogens, ingest them and take them into food vacuoles.
Then they digest them by using enzymes that kill the pathogens, this is called phagocytosis

Lymphocytes

They make proteins called antibodies that have a particular binding site, much like an enzyme, each antibody's binding site combines with one particular type of pathogen.
Antibodies attack pathogens in the following ways:

i. They make them sick (agglutinate)
ii. They dissolve their cell membranes
iii. They neutralise toxins produced by pathogens

After a person has had a disease, the lymphocytes remain to produce more antibodies for that pathogen if the disease is encountered again. This is called immunity.

Blood clotting

- When you cut yourself – you bleed
- Platelets helps the blood thicken and the bleeding stops
- The thickened blood forms a clot
- This is a barrier against infection
- Platelets release a substance that converts the soluble protein fibrinogen to the insoluble fibrin
- Fibrin forms a meshwork of fibres
- Red blood cells get trapped in these threads and clot
- The clot hardens to form a scab
- The skin heals and the scab falls off

Lymph and tissue fluid

Tissue fluid

- Some constituents of plasma move out the capillary walls to form tissue fluid surrounding cells
- Tissue fluid bathes the cell providing a stable environment
- Tissue fluid helps substances diffuse in and out of cells
- Useful substance such as oxygen and glucose diffuse in from the tissue fluids and waste products diffuse out
- Most fluid tissue re-enters the capillary
- Fluid flows from plasma back into plasma but some drains into our lymphatic system

The lymphatic system

- The remaining plasma enter the lymph capillaries, it is now called lymph
- Lymph consist of plasma and white blood cells, but has no red blood cells or large plasma proteins
- Lymph capillaries have tiny valves allowing entry but no exit
- They join up to form lymph vessels
- Similar structure to veins: thin walls and semi lunar valves
- Has no pump so it dependent on the contraction of muscles
- Lymph flows from tissues to heart
- Substances empty into subelavian veins, mixes with blood and enters the heart via the vena cava
- They are many lymph nodes throughout the lymph vessels
- Lymphocytes are in the lymph nodes where they multiply during an infection and produce antibodies