Human Transport

The double circulatory system, the structure and action of the heart, coronary heart disease, the blood vessels, and the components and functions of blood.

9.1 Circulatory systems

The circulatory system is a system of blood vessels with a pump (the heart) and valves to ensure one-way flow of blood.

Humans have a double circulation: the blood passes through the heart twice for each complete circuit of the body.

- The **pulmonary circulation** takes blood from the heart to the **lungs** and back. It is a **low-pressure** circulation, so that the delicate capillaries in the lungs are not damaged and the blood flows slowly enough to pick up oxygen.
- The **systemic circulation** takes blood from the heart to the **body tissues** and back. It is a **high-pressure** circulation, so that the blood is delivered quickly to all parts of the body.

9.2 Heart

Structure of the heart

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Structure	Function
muscular wall (cardiac muscle)	contracts to pump the blood
septum	separates the left and right sides, so oxygenated and deoxygenated blood do not mix
right atrium	receives deoxygenated blood from the body (vena cava)
right ventricle	pumps deoxygenated blood to the lungs (pulmonary artery)
left atrium	receives oxygenated blood from the lungs (pulmonary vein)
left ventricle	pumps oxygenated blood to the body (aorta)
atrioventricular valves	between each atrium and ventricle; prevent blood flowing back into the atria
semilunar valves	at the base of the aorta and pulmonary artery; prevent blood flowing back into the ventricles
coronary arteries	supply the heart muscle with oxygen and glucose

Why the walls differ in thickness.

- The **left ventricle** has a **thicker muscle wall** than the right ventricle, because it pumps blood at **high pressure** around the whole body, while the right ventricle only pumps blood a short distance to the lungs.
- The **atria** have **thinner walls** than the ventricles, because they only pump blood into the ventricles next to them, while the ventricles pump it out of the heart.

A heartbeat

1. Blood flows into the **atria**.
2. The **atria contract**, pushing blood through the **atrioventricular valves** into the ventricles.
3. The **ventricles contract**; the atrioventricular valves **close** (making the "lub" sound), and blood is forced out through the **semilunar valves** into the arteries.
4. The semilunar valves **close** (the "dub" sound) to stop blood going back.
5. The heart muscle relaxes, and the cycle repeats.

Blood is pumped **away** from the heart in **arteries** and **returns** to the heart in **veins**.

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Monitoring the heart

The activity of the heart can be monitored by an **electrocardiogram (ECG)** (which records the heart's electrical activity), by the **pulse rate** (felt at the wrist or neck) and by **listening to the sounds of the valves closing** with a stethoscope.

Heart rate and exercise

During exercise, the muscles need more oxygen and glucose, and have to get rid of more carbon dioxide, so the **heart rate increases** (and so does the stroke volume), to deliver blood faster. After exercise it takes time to return to the resting rate. The effect can be investigated by measuring the pulse at rest and after exercise.

Coronary heart disease

> **Coronary heart disease is caused by blockage of the coronary arteries (by a build-up of fatty deposits). The heart muscle then does not get enough oxygen, which can cause chest pain or a heart attack.**

Risk factors: diet (high in saturated fat and salt), a **sedentary lifestyle** (lack of exercise), **stress**, **smoking**, **genetic predisposition** (a family history), **age** (higher risk with age) and **gender** (higher in men).

Reducing the risk. A diet low in saturated fat and salt and high in fibre, fruit and vegetables lowers the build-up of fatty deposits and blood pressure. **Regular exercise** strengthens the heart, helps control weight and lowers blood pressure. Not smoking also reduces the risk.

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9.3 Blood vessels

The main blood vessels

Vessel	Carries blood
aorta	from the left ventricle to the body
vena cava	from the body to the right atrium
pulmonary artery	from the right ventricle to the lungs
pulmonary vein	from the lungs to the left atrium
hepatic artery	to the liver
hepatic vein	from the liver
hepatic portal vein	from the small intestine to the liver
renal artery	to the kidneys
renal vein	from the kidneys

Arteries, veins and capillaries

	Artery	Vein	Capillary
direction	away from the heart	towards the heart	between arteries and veins
blood pressure	high	low	falling
wall	thick, with **muscle and elastic tissue**	thin, with little muscle or elastic tissue	**one cell thick**
lumen	narrow	wide	very narrow
valves	no (except at the heart)	**yes**, to prevent backflow	no

- **Arteries** carry blood at **high pressure**, so they have thick, strong walls. The elastic tissue lets the wall stretch and spring back, which helps to smooth out the pulse and maintain the pressure.
- **Veins** carry blood at **low pressure**, so they need **valves** to stop the blood flowing backwards, and a wide lumen to reduce resistance.

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- **Capillaries** have walls **one cell thick**, which lets substances **diffuse** quickly between the blood and the cells.

9.4 Blood

Components of blood

Component	Function
red blood cells	carry **oxygen** (as oxyhaemoglobin)
white blood cells	defend against disease: **lymphocytes** make **antibodies**; **phagocytes engulf pathogens**
platelets	help blood to **clot**: they cause **soluble fibrinogen** to be changed into **insoluble fibrin**, which forms a mesh and **prevents blood loss and the entry of pathogens**
plasma	the liquid part, which **transports** blood cells, ions, glucose, amino acids, hormones, carbon dioxide, urea, vitamins and plasma proteins

Identifying cells. Red blood cells are small, round and have **no nucleus** (they appear as pink discs). **Phagocytes** have a large, **lobed** nucleus and granular cytoplasm. **Lymphocytes** have a large, **round nucleus** that takes up most of the cell.

Tissue fluid

Blood at the **capillaries** is under pressure, so some **plasma** is forced out through the thin capillary walls. This forms **tissue fluid**, which surrounds the body cells. Oxygen and glucose **diffuse** from the tissue fluid into the cells, and carbon dioxide and urea diffuse out of the cells into the tissue fluid and then back into the blood. Red blood cells and the large plasma proteins stay inside the capillaries.

> **TRY IT**
>
> Describe how a blood clot helps to protect the body after a cut.

Platelets cause **soluble fibrinogen** to be changed into **insoluble fibrin** threads, which form a mesh that traps blood cells and seals the wound. This **stops blood loss** and prevents **pathogens** from entering.

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