IGCSE BIOLOGY 0610 · CHAPTER 8 NOTES · ~12 MIN READ

Transport in animals

Single versus double circulation, a fully labelled heart, how the valves work, coronary heart disease, arteries vs veins vs capillaries, the liver and kidney vessels, blood cells and clotting.

Double circulation | Heart | Coronary heart disease | Blood vessels | Blood components

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No tag = **Core** (everyone) EXTENDED Extended only highlight = comes up again and again

Test yourself at the end

IN 30 SECONDS

- The **circulatory system** is a **pump (the heart)**, a network of **vessels** and **valves** that keep blood moving one way. **Arteries** carry blood **away** from the heart; **veins** carry it **back**; **capillaries** link them and exchange materials with cells.
- **Blood** = **plasma** (liquid) + **red cells** (carry oxygen) + **white cells** (fight disease) + **platelets** (help clotting).
- **Coronary heart disease** happens when **coronary arteries** are blocked, so heart muscle gets too little oxygen. Risk factors: **diet, stress, smoking, genes, age, gender**.

BY THE END YOU CAN

- Describe the circulatory system as a pump, vessels and valves giving one-way flow.
- Identify the parts of the heart and the main vessels to and from the heart, lungs, liver and kidney.
- Describe coronary heart disease, its risk factors and how diet and exercise reduce the risk.
- Describe how the heart rate is monitored and how exercise changes it.
- Describe the structure and function of arteries, veins and capillaries.
- Name the components of blood and state the function of each.
- Compare single and double circulation and explain the advantages of double. EXT
- Explain how the valves, septum and thick ventricle walls work. EXT
- Explain how blood clots, in terms of fibrinogen and fibrin. EXT

1 The circulatory system

Why animals need a circulatory system

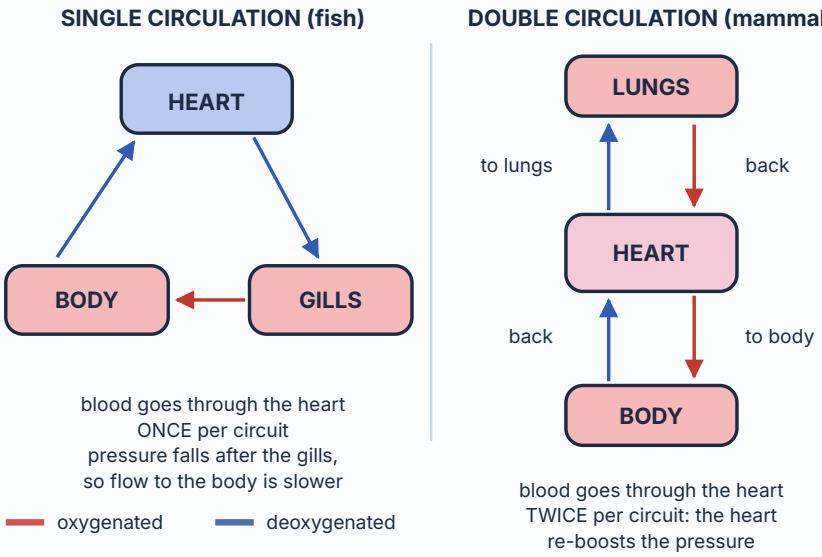
- Large animals have **too small a surface area to volume ratio** for diffusion alone to supply every cell. Blood **transports** oxygen, glucose, CO_2, urea, hormones and heat around the body (diffusion and surface area).
- It has **three parts**: a **pump** (the heart), **vessels** (arteries, veins, capillaries) and **valves** that make sure blood flows in **one direction**.

MEMORY TRICK

Arteries go **A**way from the heart. **V**eins **V**isit (go to) the heart.

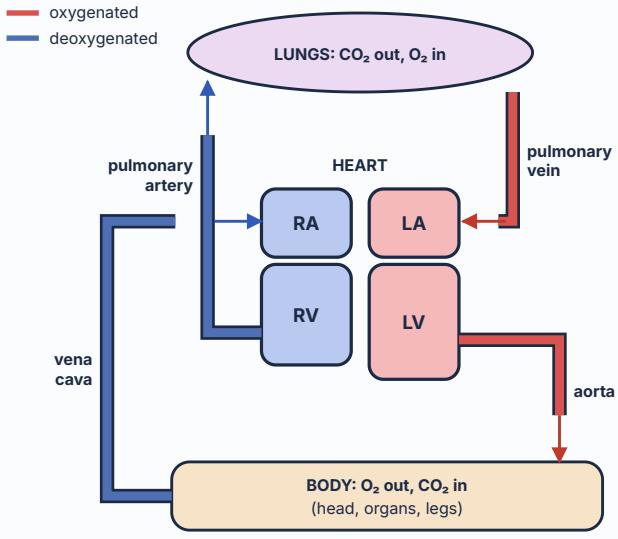
Single and double circulation

EXTENDED



EXT A fish heart pumps blood once per circuit. A mammal heart pumps it twice.

- EXT **Fish** have a **single circulation**: heart → gills → body → heart. Blood **loses pressure** in the narrow gill capillaries, so it reaches the body **slowly**.
- EXT **Mammals** have a **double circulation**: a **low-pressure** circuit to the **lungs** and a **high-pressure** circuit to the **body**. The blood **returns to the heart** to be pumped again, which **boosts the pressure**.
- EXT **Advantages of double circulation:** blood reaches the body at **high pressure** (so it delivers oxygen and glucose **faster**, which a warm-blooded animal needs); the **lung capillaries are not damaged** because pressure there is lower; **oxygenated and deoxygenated blood are kept separate**.



Follow one drop of blood round the whole circuit. It passes through the heart twice.

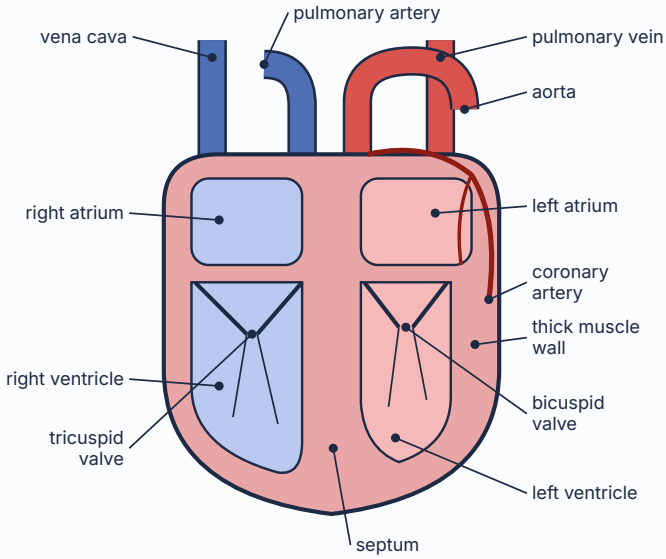
- **Pulmonary** circuit (right side of the heart): **right ventricle → pulmonary artery → lungs → pulmonary vein → left atrium**.
- **Body** circuit (left side of the heart): **left ventricle → aorta → body → vena cava → right atrium**.

COMMON MISTAKE

"Arteries always carry oxygenated blood and veins always deoxygenated." **The pulmonary artery carries deoxygenated blood** (to the lungs) and the **pulmonary vein carries oxygenated blood** (to the heart). The rule is **direction**, not colour.

2 The heart

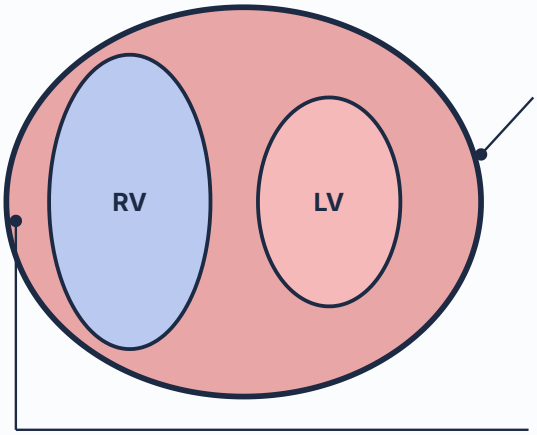
Structure



The heart seen from the front. The left side of the heart is on the right of the picture.

Part	Job
right atrium	receives **deoxygenated** blood from the body through the **vena cava**
right ventricle	pumps deoxygenated blood to the **lungs** through the **pulmonary artery**
left atrium	receives **oxygenated** blood from the lungs through the **pulmonary vein**
left ventricle	pumps oxygenated blood to the **body** through the **aorta**
septum	the muscular wall between the two sides; keeps the two kinds of blood **apart**
valves	make sure blood flows **one way only**
coronary arteries	supply the **heart muscle** with oxygen and glucose

- **Atria** (top chambers) receive blood. **Ventricles** (bottom chambers) pump it out.
- EXT **Why is the left ventricle wall thicker?** It must pump blood at **high pressure** all round the **body**. The right ventricle only sends blood to the **nearby lungs** at lower pressure.

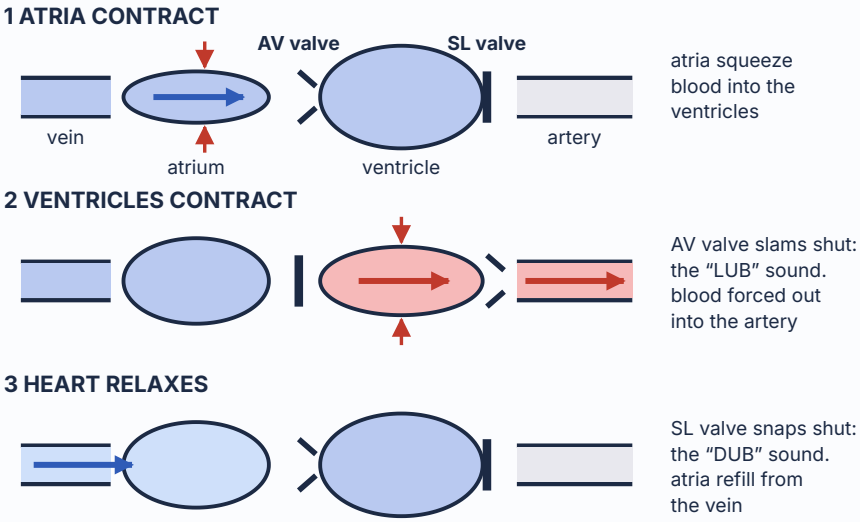


cross-section through the two ventricles

EXT Same heart, cut across: the left ventricle wall is much thicker.

How the valves work

EXTENDED

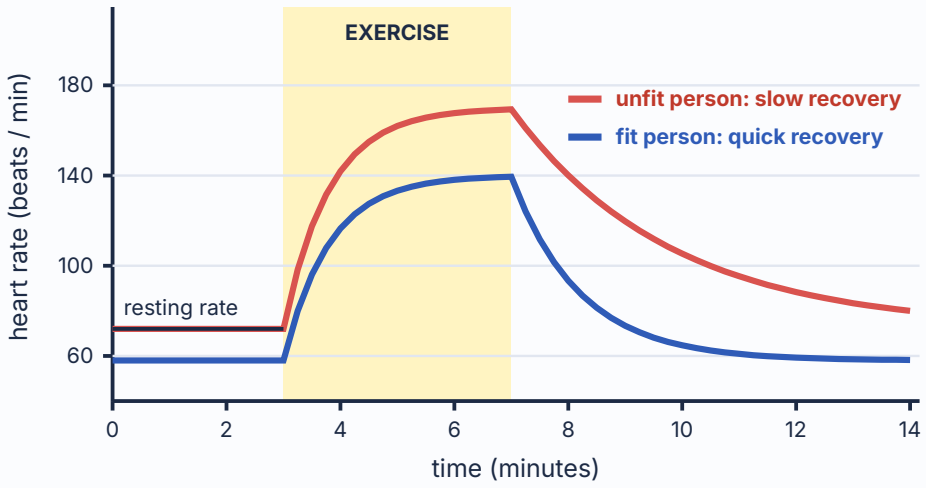


EXT The three stages of one heartbeat.

- EXT **Atrioventricular (AV) valves** sit between atria and ventricles. They **shut when the ventricles contract**, so blood cannot go back into the atria. This is the "**lub**" sound.
- EXT **Semilunar (SL) valves** sit at the start of the aorta and pulmonary artery. They **shut when the ventricles relax**, so blood cannot fall back into the ventricles. This is the "**dub**" sound.
- EXT Valves open because blood **pushes** them open and close because blood **pushes** them shut. They have **no muscle**.

Monitoring the heart

- **Pulse:** the pressure wave in an **artery** (felt at the wrist or neck). **Pulse rate = heart rate** in beats per minute.
- An **ECG** records the **electrical activity** of the heart. A **stethoscope** lets you hear the **valves closing**.



Heart rate before, during and after exercise for an unfit and a fit person.

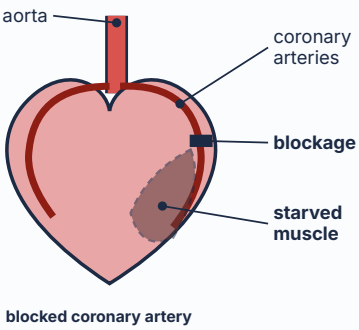
- During exercise the heart rate **rises** and breathing gets faster. After exercise it **falls slowly** back to the resting rate. The **fitter** you are, the **lower** your resting rate and the **faster** you recover.
- EXT **Why?** Exercising muscles **respire faster**. They need more **oxygen and glucose** and make more **CO_2**. The brain detects the higher CO_2 and the hormone **adrenaline** is released, so the heart beats **faster and harder** to deliver and remove materials more quickly.

WORKED EXAMPLE

A student counts 21 pulses in 15 seconds at rest and 38 pulses in 15 seconds after exercise. Find each heart rate and the percentage increase.

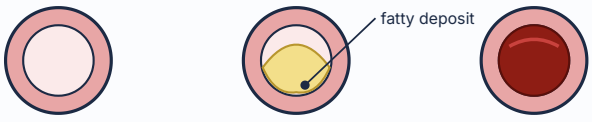
1. rest: 21 × 4 = **84 beats/min**
2. after: 38 × 4 = **152 beats/min**
3. increase = (152 − 84) ÷ 84 × 100 = **81%** (to the nearest whole number)
4. **because the muscles need more oxygen and glucose**

Coronary heart disease



blocked coronary artery

WHAT GOES WRONG
1 fat + cholesterol build up in the artery wall
2 the lumen becomes narrower
3 a clot can block it completely
4 muscle starved of oxygen: cells die = HEART ATTACK



HEALTHY
blood flows freely

NARROWED
less blood gets through

BLOCKED
no blood gets through

A blocked coronary artery starves part of the heart muscle of oxygen.

Coronary heart disease — a disease in which the **coronary arteries** are **blocked or narrowed** by fatty deposits, so the heart muscle gets **too little oxygen and glucose**.

- **Fatty deposits (cholesterol)** build up in the artery wall, narrowing it. A **blood clot** can then **block** it completely. The muscle cells beyond the blockage **cannot respire** and may die: a **heart attack**.

Risk factor	How it raises the risk
diet	too much **saturated fat** raises cholesterol; too much **salt** raises blood pressure
stress	raises blood pressure
smoking	nicotine raises heart rate and blood pressure; carbon monoxide carries less oxygen; chemicals damage artery walls
genetic predisposition	some people inherit a higher risk
age	risk **increases** as arteries age
gender	**males** are generally at greater risk

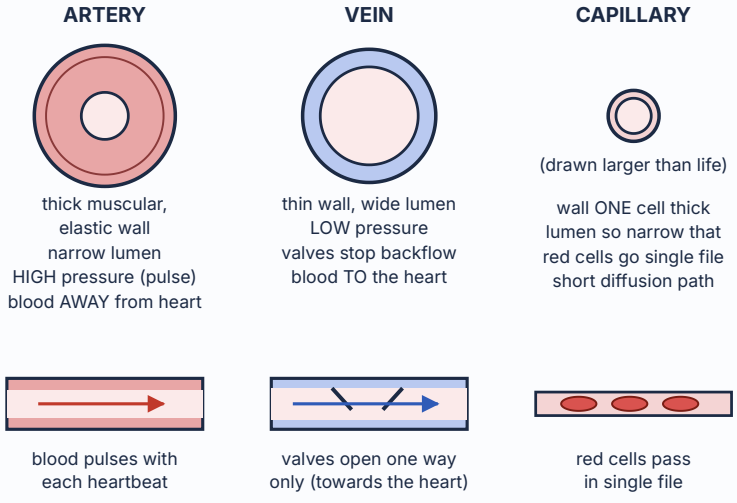
- **Lower your risk:** eat a **balanced diet** low in saturated fat and salt, take **regular exercise** (it strengthens the heart and helps control weight and blood pressure), **do not smoke** and manage stress.

EXAM TIP

You **cannot change** age, gender or genes. You **can change** diet, exercise, smoking and stress.

3 Blood vessels

Arteries, veins and capillaries

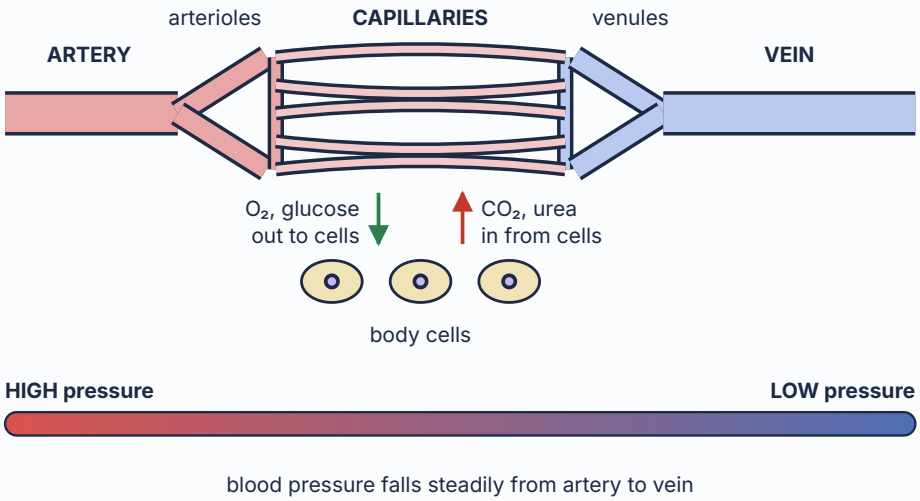


pressure: artery > capillary > vein

Three vessels, three jobs: cross-sections above, long sections below.

	Artery	Vein	Capillary
carries blood	**away** from the heart	**to** the heart	**between** arteries and veins
wall	**thick**, muscular and elastic	**thin**	**one cell thick**
lumen	**narrow**	**wide**	**very narrow**
pressure	**high** (a pulse)	**low**	falls as blood passes
valves	none (except at the heart)	**yes**	none

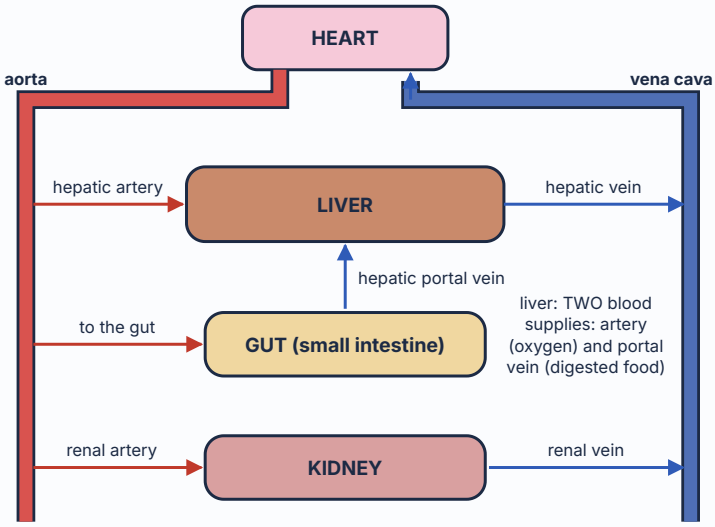
- EXT **Artery:** the **thick muscular and elastic wall** stretches as blood is forced in and recoils to **keep the pressure up**, so blood reaches the whole body.
- EXT **Vein:** the blood is at **low pressure**, so a **wide lumen** gives little resistance and **valves** stop **backflow**. Muscles squeezing the veins help to push blood along.
- **Capillary:** the **wall is one cell thick** and the lumen is just wide enough for one red cell, so oxygen, glucose, CO_2 and urea diffuse across a **very short distance**.



blood pressure falls steadily from artery to vein

Blood slows and loses pressure as it passes through the capillaries.

Vessels to and from the organs



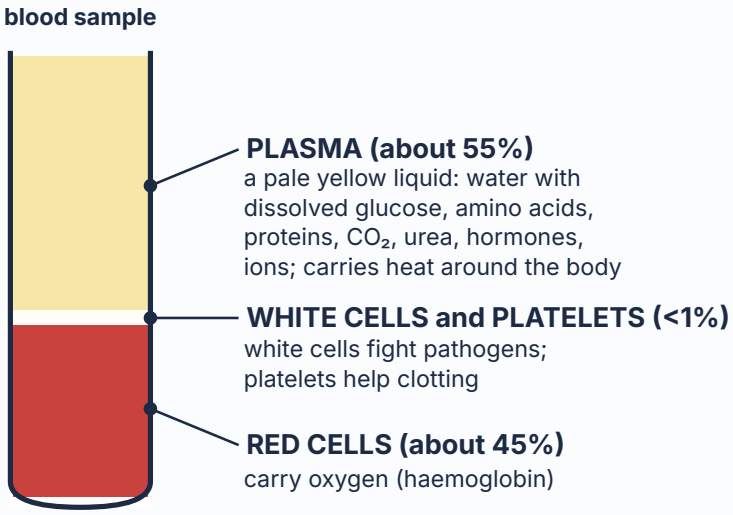
The main vessels linking the heart, liver, gut and kidney.

Organ	Vessel in	Vessel out
heart	**vena cava**, **pulmonary vein**	**aorta**, **pulmonary artery**
lungs	**pulmonary artery**	**pulmonary vein**
kidney	**renal artery**	**renal vein**
EXT **liver**	**hepatic artery**, **hepatic portal vein**	**hepatic vein**

- EXT The **hepatic portal vein** carries blood **from the gut to the liver**, rich in digested food such as glucose and amino acids. The liver then processes it (liver and excretion).

4 Blood

What blood is made of



A centrifuge spins blood into layers: plasma on top, then white cells and platelets, then red cells.

Component	What it does
plasma	liquid that **transports** blood cells, ions, glucose, amino acids, CO_2, urea, hormones and **heat**
red blood cells	carry **oxygen** using **haemoglobin**
white blood cells	**fight pathogens**
platelets	help the blood to **clot**



RED BLOOD CELL
biconcave disc
no nucleus
full of haemoglobin
carries oxygen

PHAGOCYTE
lobed nucleus
engulfs and digests pathogens

LYMPHOCYTE
large round nucleus
makes antibodies

PLATELETS
cell fragments
help the blood to clot

Remember the sizes: red cells are the most NUMEROUS (roughly 600 for every white cell), white cells are the LARGEST, platelets are the smallest and are not whole cells.

Red cells and platelets have NO nucleus. White cells do.

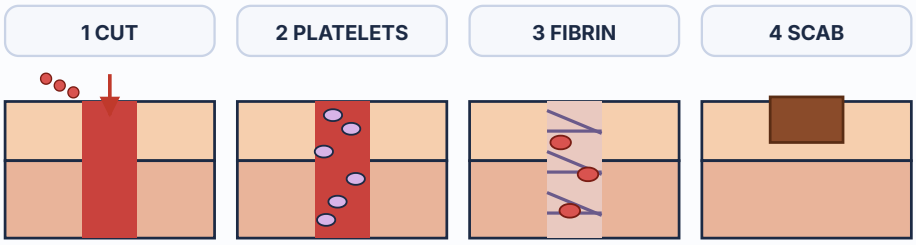
The four cell types in blood.

- **Red cells** have **no nucleus**, which leaves more room for **haemoglobin**. The **biconcave** shape gives a **large surface area** for taking up oxygen. **Haemoglobin + oxygen → oxyhaemoglobin** in the lungs; it releases the oxygen again in the tissues.
- **White cells** include **phagocytes**, which **engulf and digest** pathogens, and **lymphocytes**, which make **antibodies** (immunity).
- EXT **Platelets** are **fragments of cells**; they are not whole cells.

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Clotting

EXTENDED



soluble FIBRINOGEN (a plasma protein) → insoluble FIBRIN threads
a clot seals the wound: it stops blood loss and keeps pathogens out

(Extended) fibrinogen → fibrin is the key chemical step in clotting

EXT A clot forms when platelets and fibrin seal a wound.

- EXT When a vessel is cut, **platelets** stick to the damaged area and a soluble plasma protein, **fibrinogen**, is changed into **insoluble fibrin threads**. The threads form a **mesh** that traps red cells and forms a **clot**.
- EXT The clot **stops blood loss** and **keeps pathogens out** while the skin repairs. It dries into a **scab**.

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5 Test yourself

Test yourself — cover the answers first

QUICK CHECK

1. Which type of blood vessel carries blood away from the heart?
2. Name the vessel that carries oxygenated blood from the lungs to the heart.
3. Which chamber of the heart pumps blood to the whole body?
4. Name the vessels that supply the heart muscle with blood.
5. State two risk factors for coronary heart disease.
6. Which blood vessels have valves?
7. What do red blood cells carry?
8. What do platelets do?
9. Name the vessel that carries blood from the gut to the liver.
10. EXT Why is the wall of the left ventricle thicker than the right?
11. EXT Name the protein that forms the clot.

EXAM-STYLE

12. Describe the path of blood from the body to the lungs and back. [4]
13. Describe how a capillary is adapted for exchange. [3]
14. Explain why heart rate increases during exercise. [3]
15. EXT Explain two advantages of a double circulation. [2]
16. EXT Describe how a blood clot forms. [3]

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Show answers

1. artery
2. pulmonary vein
3. left ventricle
4. coronary arteries
5. e.g. smoking, diet high in saturated fat, stress, genes, age, gender
6. veins
7. oxygen (in haemoglobin)
8. help the blood to clot
9. hepatic portal vein
10. it pumps blood at high pressure to the whole body
11. fibrin (from fibrinogen)
12. vena cava into right atrium
    right ventricle
    pulmonary artery to lungs
    pulmonary vein to left atrium
13. wall one cell thick
    short diffusion distance
    very narrow so red cells pass slowly in single file
14. muscles respire faster
    need more oxygen and glucose and produce more CO_2
    faster heart rate delivers these and removes CO_2 more quickly
15. blood is pumped at high pressure to the body
    lung capillaries are not damaged because pressure there is lower
16. platelets stick to the damaged vessel
    fibrinogen is changed to insoluble fibrin
    fibrin threads form a mesh that traps red cells

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