

Transport in animals revision notes

Transport in animals looks at how blood is pumped around the body and what it carries. You study the heart, the blood vessels and the components of blood, and compare the single circulation of a fish with the double circulation of a mammal. You also look at how exercise affects the heart and the causes of coronary heart disease.

For Cambridge IGCSE Biology 0610 (and 0970, which has the same content). **Supplement** is Extended content, only examined on Papers 2 and 4.

1 Circulatory systems Spec 9.1

Single and double circulation Spec 9.1.1, 9.1.2, 9.1.3, 9.1.4

The **circulatory system** is a system of blood vessels with a pump and valves to ensure **one-way flow of blood**. The pump is the heart. The vessels are arteries, veins and capillaries. Valves stop blood flowing backwards.

Supplement

Single circulation of a fish

Supplement

In a fish the blood passes through the heart only once during each complete circuit of the body.

Supplement

1. The heart pumps deoxygenated blood to the gills.
2. In the gill capillaries the blood picks up oxygen. Blood pressure falls because the capillaries are so narrow.
3. The oxygenated blood flows on to the organs and muscles of the body, but at lower pressure.
4. The blood returns to the heart.

Supplement

Double circulation of a mammal

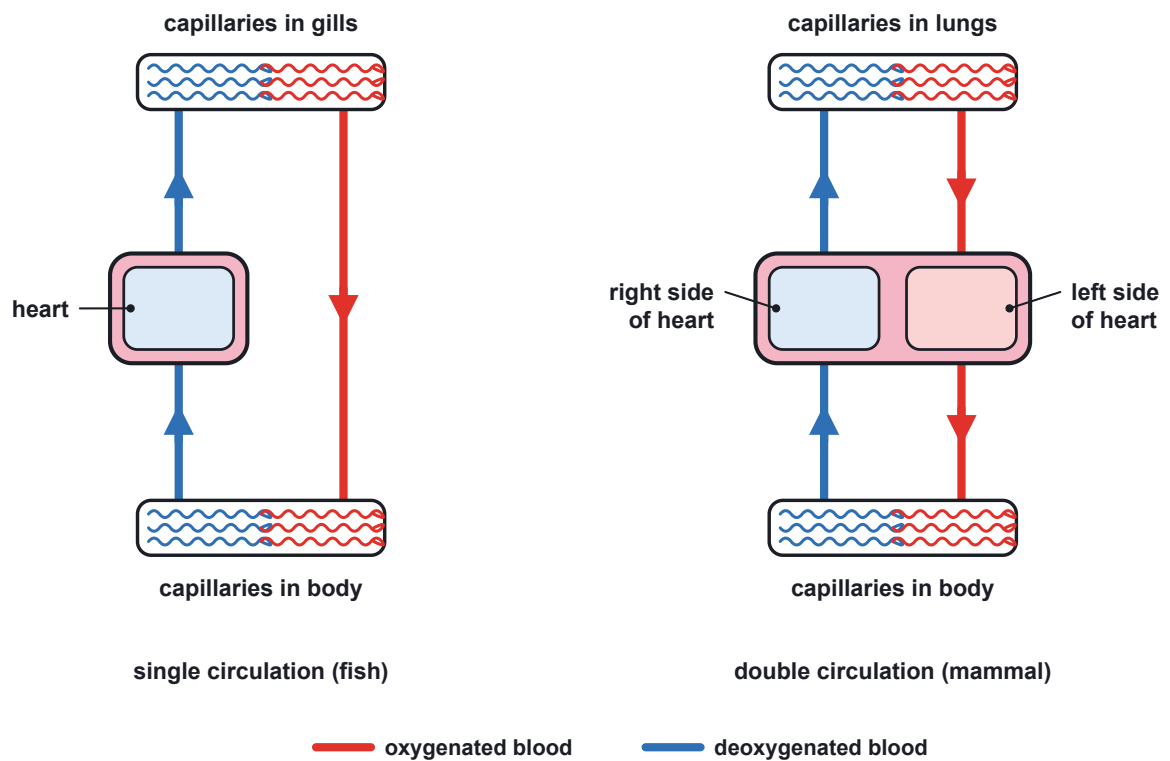
Supplement

In a mammal the blood passes through the heart twice during each complete circuit of the body. There are two separate circuits.

Supplement

- **Pulmonary circulation**: right side of the heart, then the lungs, then back to the left side of the heart.
- **Systemic circulation**: left side of the heart, then the rest of the body, then back to the right side of the heart.

Supplement



In a fish the blood passes through the heart **once** in each circuit. In a mammal it passes through **twice**.

Supplement

Advantages of a double circulation

Supplement

After blood has passed through the lung capillaries its pressure is low. In a double circulation it returns to the heart to be pumped again.

Supplement

- Blood is pumped at **high pressure** to the body, so oxygen and glucose reach the tissues quickly.
- Blood pressure in the lungs can be kept lower, so the delicate lung capillaries are not damaged.
- Mammals have a high rate of respiration (for example, to keep their body temperature constant), so they need this fast supply of oxygen and glucose.

Supplement

Single and double circulation compared

Feature	Fish (single)	Mammal (double)
Times blood passes through the heart in one circuit	Once	Twice
Pressure of blood reaching the body organs	Low, as it has just passed through the gill capillaries	High, as it is pumped again after the lungs

Supplement

Exam tip: Always say the blood returns to the heart before going to the body in a double circulation. That is the idea that earns the marks for the advantage.

Quick check

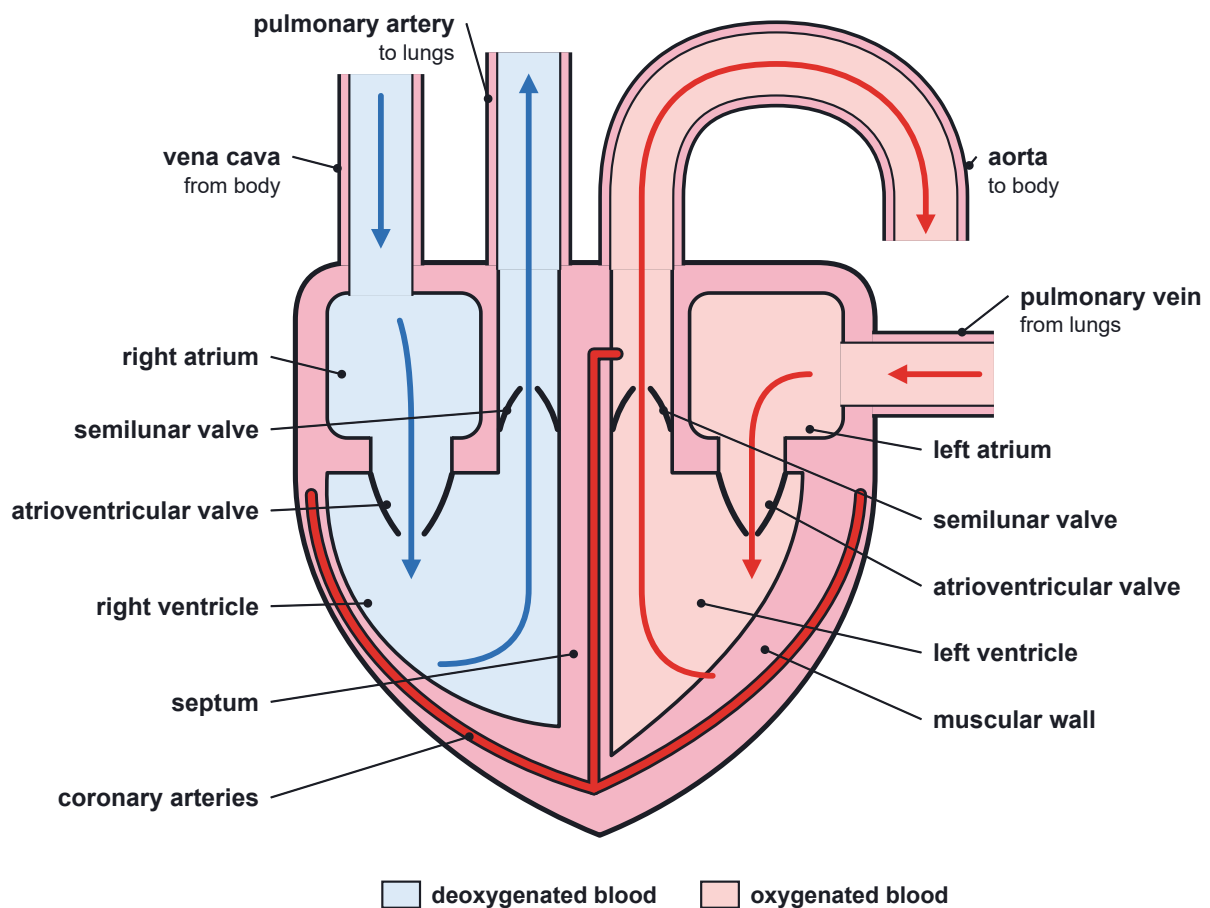
1. What is the circulatory system?
2. **Supplement** How many times does blood pass through the heart in one circuit of a fish?
3. **Supplement** Name the two circuits of a mammal's double circulation.
4. **Supplement** Give one advantage of a double circulation.

2 The heart Spec 9.2

Structure of the heart Spec 9.2.1, 9.2.2, 9.2.7, 9.2.9

The mammalian heart is a pump made of cardiac muscle. You need to identify these structures in diagrams and images.

Structures of the heart	
Structure	What it is or does
Muscular wall	Contracts to squeeze blood out of the chambers
Right atrium and left atrium	Upper chambers that receive blood from veins
Right ventricle and left ventricle	Lower chambers that pump blood out into arteries
Septum	Wall of muscle between the left and right sides of the heart
One-way valves	Stop blood flowing backwards
Coronary arteries	Run over the surface of the heart and supply the heart muscle with oxygenated blood (oxygen and glucose)



The heart is drawn as if you are facing the person, so the **left side** of the heart is on the right of the page.

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

Supplement

Valves

Supplement

- The **atrioventricular valves** are between the atria and the ventricles.
- The **semilunar valves** are at the start of the aorta and the pulmonary artery, where blood leaves the ventricles.

Supplement

The septum

Supplement

The **septum** separates the left side of the heart from the right side. The right side holds deoxygenated blood and the left side holds oxygenated blood. The septum stops the two mixing, so blood sent to the body is fully oxygenated.

Common mistake: The heart is drawn as if you are facing the person. The left side of the heart is on the right of the page. The coronary arteries supply the heart itself, not the lungs.

How the heart pumps blood Spec 9.2.8, 9.2.10 Supplement

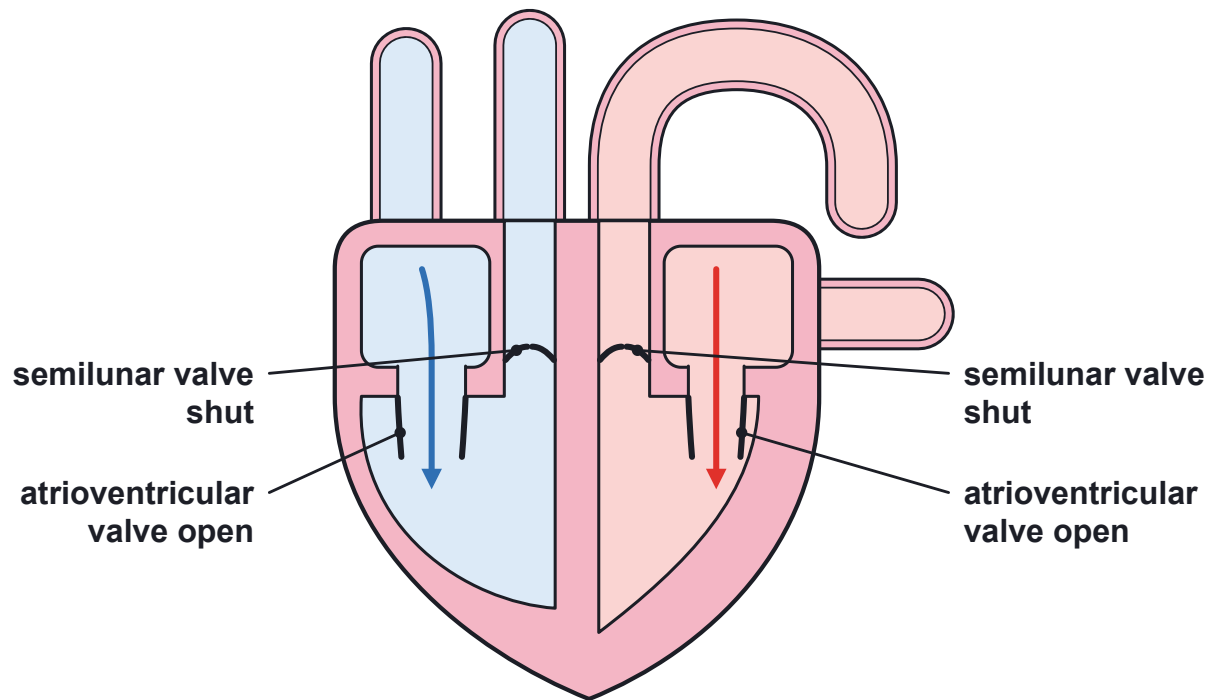
Thickness of the muscle walls

Wall thickness and function	
Comparison	Explanation
Left ventricle wall is thicker than right ventricle wall	The left ventricle pumps blood all around the body, so it must produce a high pressure . The right ventricle pumps blood only to the nearby lungs, at lower pressure that does not damage the lung capillaries
Atria walls are thinner than ventricle walls	The atria only push blood a short distance into the ventricles. The ventricles must push blood out of the heart and to the lungs or body

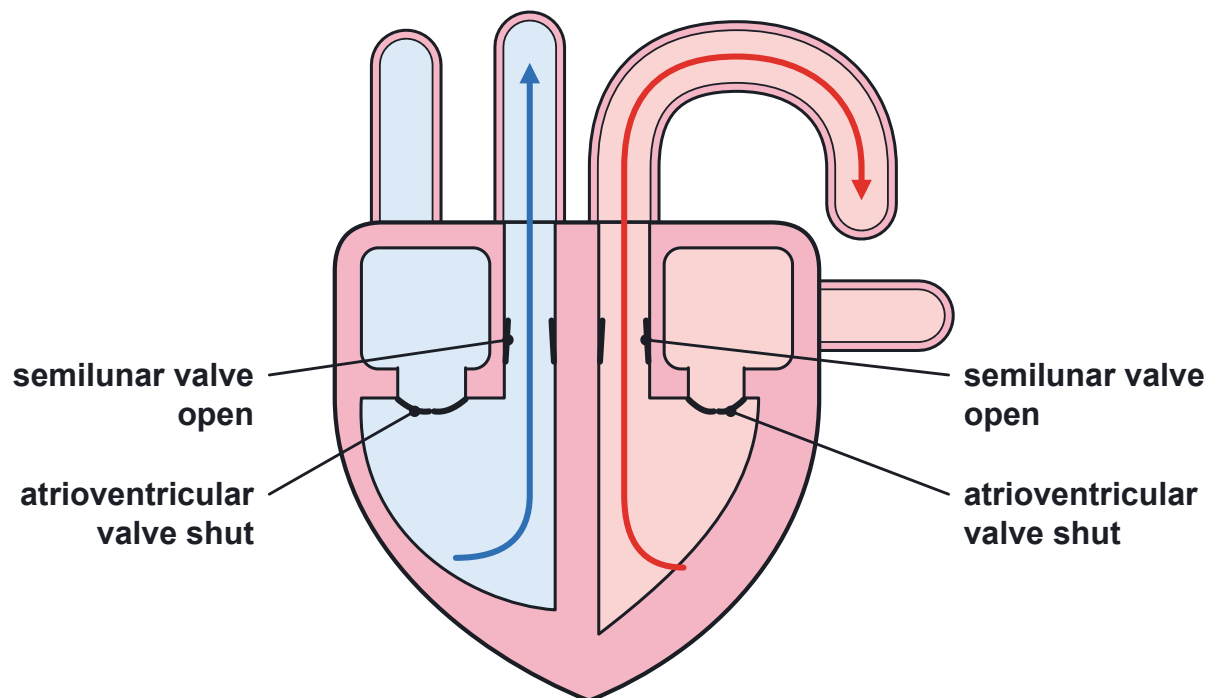
The pumping action

1. Blood flows into the atria from the veins. The atria contract and push blood through the open **atrioventricular valves** into the ventricles.
2. The ventricles contract. Pressure rises, the atrioventricular valves shut (stopping blood flowing back into the atria) and the **semilunar valves** open.
3. Blood is forced out of the ventricles into the aorta and pulmonary artery.
4. The ventricles relax. The semilunar valves shut, which stops blood flowing back into the ventricles. The atria fill again.

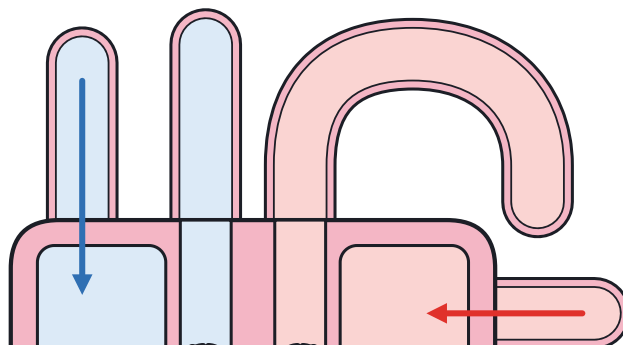
1 The atria contract

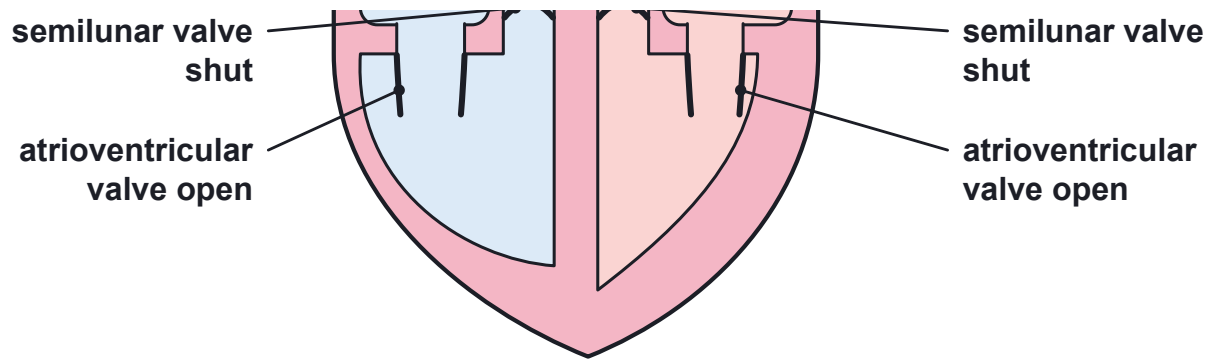


2 The ventricles contract



3 The heart relaxes and the atria fill





The valves open and shut because of **blood pressure**, so blood flows only one way.

Exam tip: The valves open and shut because of the pressure of the blood, not because the valves can contract. Say which valve and which way the blood is pushed.

Monitoring the heart and the effect of exercise Spec 9.2.3, 9.2.4, 9.2.11

The activity of the heart may be monitored in three ways.

- An **ECG** (electrocardiogram), which records the electrical activity of the heart.
- **Pulse rate**, felt at the wrist or neck, which is the number of beats per minute.
- **Listening to the sounds of the valves closing**, using a stethoscope.

Practical skill: Investigating the effect of physical activity on heart rate. Independent variable: the activity (for example, minutes of step-ups or jogging on the spot). Dependent variable: heart rate in beats per minute. Control: the same person, same time of day, same length of rest. Repeat and calculate a mean. Safety: stop if you feel dizzy or unwell, and do not take part if you have a heart or breathing condition.

1. Sit still for several minutes, then measure the resting pulse rate by counting beats for 15 seconds and multiplying by 4.
2. Do a set exercise for a fixed time, for example 2 minutes of step-ups.
3. Measure the pulse rate immediately after exercise.
4. Keep measuring every minute until the pulse returns to the resting rate. Record the recovery time.
5. Repeat with a different level of exercise and compare.

Calculating heart rate from a pulse count

A student counts 19 beats in 15 seconds. Calculate the heart rate in beats per minute.

1. 15 seconds is one quarter of a minute
2. heart rate = 19×4

Answer: 76 beats per minute

Typical results: heart rate rises during exercise and returns to the resting rate during recovery. The harder the exercise, the higher the rate and the longer the recovery.

Supplement

Explaining the effect of exercise

Supplement

During physical activity the muscles respire faster, so they need more oxygen and glucose and produce more carbon dioxide. Heart rate increases so that blood flows faster and:

Supplement

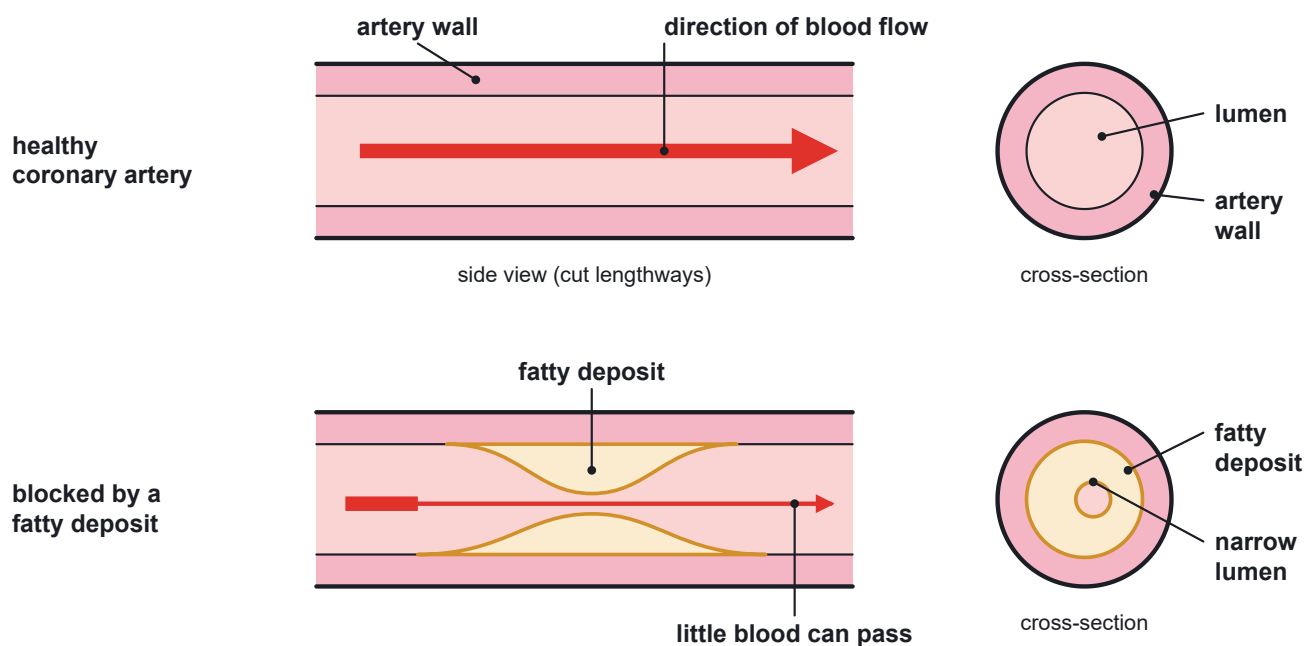
- more oxygen and glucose are delivered to the muscles for aerobic respiration
- carbon dioxide is removed more quickly, and lactic acid is carried away from the muscles if anaerobic respiration has happened

Supplement

Common mistake: Heart rate does not rise to 'give the muscles energy'. It rises to deliver oxygen and glucose faster and to remove carbon dioxide.

Coronary heart disease Spec 9.2.5, 9.2.6

In **coronary heart disease** (CHD) the **coronary arteries are blocked** by fatty deposits. Less blood reaches the heart muscle, so it receives less oxygen and glucose. If an artery is completely blocked, part of the heart muscle cannot get enough oxygen to respire, and a heart attack results.



A **fatty deposit** narrows the lumen, so less blood reaches the heart muscle.

Risk factors

- Diet, especially one high in saturated fat
- Lack of exercise
- Stress
- Smoking
- Genetic predisposition (family history)
- Age (risk increases with age)
- Sex (men are more at risk than women of the same age)

The roles of diet and exercise

Reducing the risk of CHD

Factor	How it reduces the risk
Diet	Eating less saturated fat reduces the fatty deposits in the arteries. Eating less salt and more fruit, vegetables and fibre helps keep the arteries and blood pressure healthy
Exercise	Regular exercise strengthens the heart muscle, helps to control body mass and lowers blood pressure, so the risk of blockage is lower

Exam tip: 'Discuss' means give both sides. For diet and exercise, say what each does, and also that other risk factors such as age and genes cannot be changed.

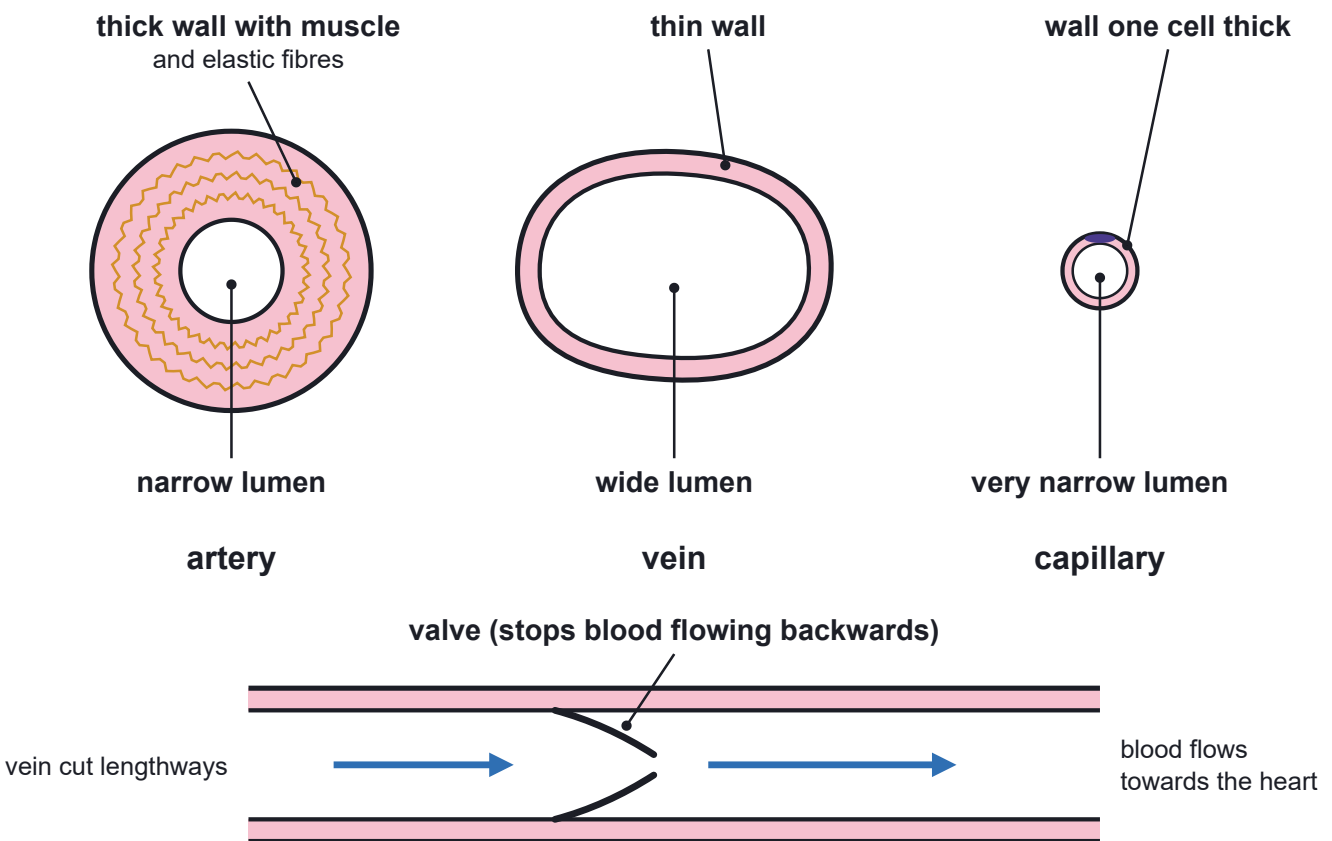
Quick check

1. **Supplement** What is the septum?
2. Name the vessels that supply the heart muscle with blood.
3. **Supplement** Why is the wall of the left ventricle thicker than that of the right ventricle?
4. State three ways of monitoring the activity of the heart.
5. State two risk factors for coronary heart disease.

3 Blood vessels Spec 9.3

Arteries, veins and capillaries Spec 9.3.1, 9.3.2, 9.3.4, 9.3.5

Structure of blood vessels			
Vessel	Wall	Lumen	Valves
Artery	Thick	Narrow	No
Vein	Thin	Wide	Yes
Capillary	One cell thick	Very narrow	No



Arteries have thick walls, veins have a wide lumen and valves, capillaries have walls one cell thick. (The capillary is drawn much larger than its real size.)

Capillaries are the site of exchange. They allow substances such as oxygen, glucose and carbon dioxide to pass between the blood and the cells of the body tissues.

Supplement

Structure related to pressure

- Supplement**
- Arteries** carry blood away from the heart at high pressure. Their thick walls, containing muscle and elastic fibres, withstand the pressure and stretch and recoil with each beat. The narrow lumen helps to maintain the pressure.
 - Veins** carry blood back to the heart at low pressure. They need only thin walls, and the wide lumen gives little resistance to flow. Valves stop the blood flowing backwards.

Supplement

Structure of capillaries related to function

Supplement

- Walls are **one cell thick**, giving a short distance for diffusion.
- Walls are **permeable**, so substances in the blood plasma can leak out and pass in.
- They are very narrow and form a large network (large surface area) close to every cell, and the slow flow gives time for exchange.

Supplement

Exam tip: Do not say that veins have 'no muscle'. Say their walls are thinner because the blood is at lower pressure.

The main blood vessels Spec 9.3.3, 9.3.6

Main blood vessels

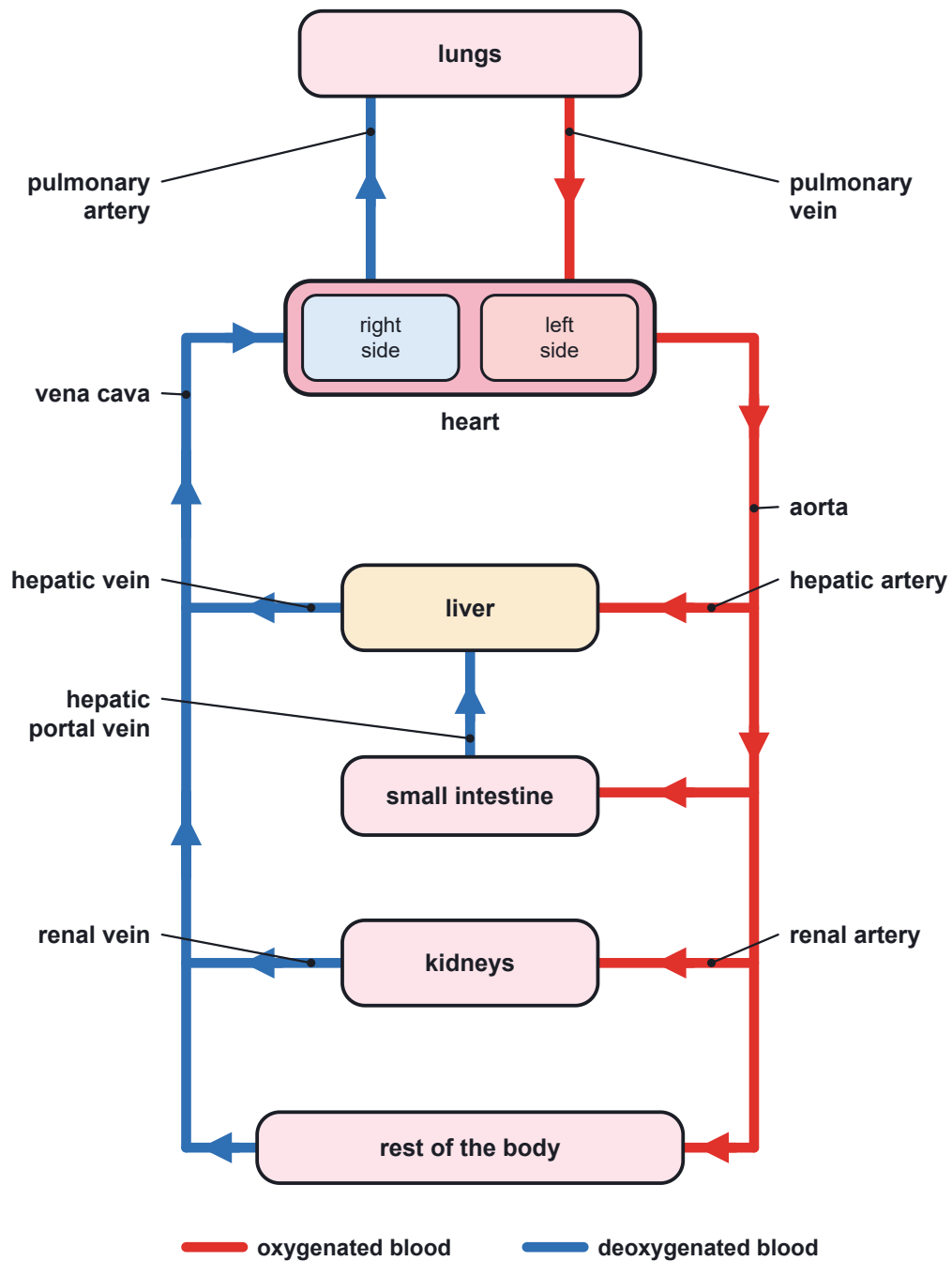
Vessel	Carries blood	Oxygen content
Vena cava	From the body to the right atrium	Deoxygenated
Pulmonary artery	From the right ventricle to the lungs	Deoxygenated
Pulmonary vein	From the lungs to the left atrium	Oxygenated
Aorta	From the left ventricle to the body	Oxygenated
Renal artery	From the aorta to the kidney	Oxygenated
Renal vein	From the kidney to the vena cava	Deoxygenated; contains less urea than the blood in the renal artery

Supplement

Blood vessels of the liver

Supplement

- **Hepatic artery**: brings oxygenated blood to the liver.
- **Hepatic portal vein**: brings blood from the small intestine, carrying absorbed nutrients, to the liver.
- **Hepatic veins**: take blood away from the liver to the vena cava.



The main blood vessels. The hepatic artery, hepatic portal vein and hepatic vein are Supplement content.

Common mistake: Arteries do not always carry oxygenated blood. The pulmonary artery carries deoxygenated blood and the pulmonary vein carries oxygenated blood. Artery or vein depends on the direction relative to the heart.

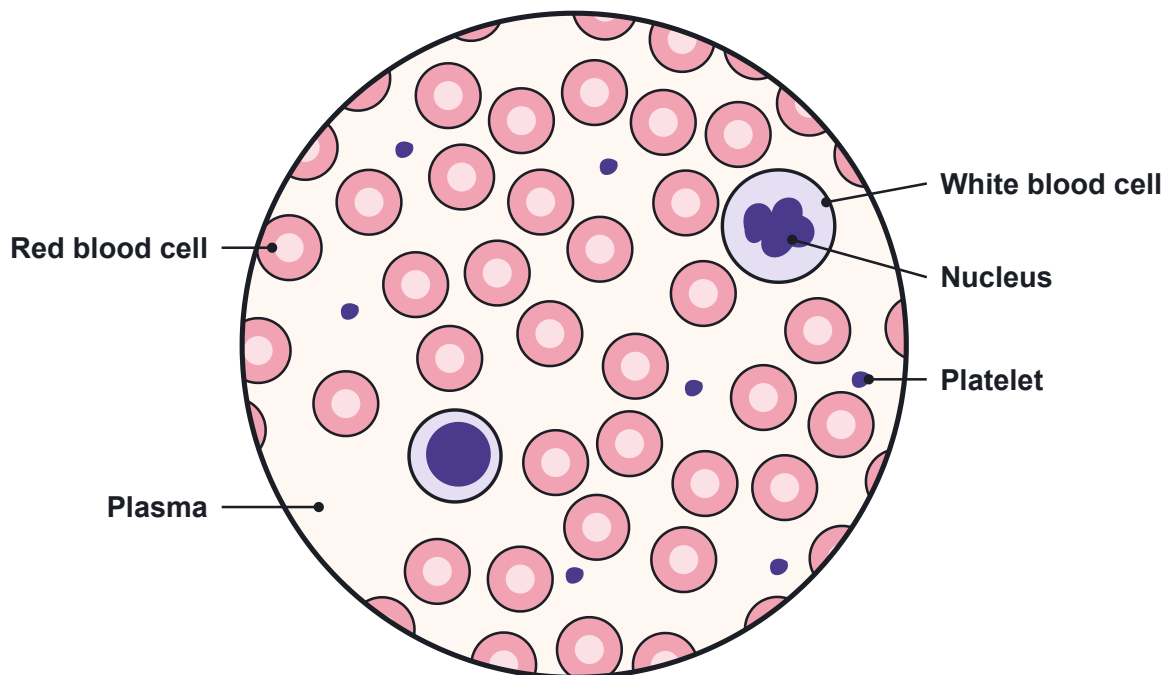
Quick check

1. Which blood vessels have valves?
2. State the function of capillaries.
3. **Supplement** Why do arteries have thick walls?
4. Name the blood vessel that carries blood from the lungs to the heart.
5. **Supplement** Which vessel carries blood from the small intestine to the liver?

4 Blood Spec 9.4

Components of blood Spec 9.4.1, 9.4.2, 9.4.3

Blood is made of red blood cells, white blood cells, platelets and plasma. Plasma is the liquid part.



Red blood cells are the most numerous. White blood cells have a **nucleus**. Platelets are tiny fragments.

- Red blood cells are small, round and pale in the middle, with **no nucleus**.
- White blood cells are larger and have a **nucleus**, usually stained dark.
- Platelets are tiny fragments of cells.

Functions of the components of blood

Component	Function
Red blood cells	Transport oxygen. They contain the red pigment haemoglobin , which combines with oxygen
White blood cells	Defend against pathogens by phagocytosis and antibody production
Platelets	Help blood to clot
Plasma	Transports blood cells, ions, nutrients, urea, hormones and carbon dioxide

Exam tip: Name the pigment. 'Red blood cells carry oxygen' is not enough: say the oxygen is carried by haemoglobin. Clotting details are not required for platelets.

White blood cells and blood clotting Spec 9.4.4, 9.4.5, 9.4.6, 9.4.7

Roles of blood clotting

When the skin is cut, blood clots to **prevent blood loss** and to **prevent the entry of pathogens** into the body. The clot dries to form a scab.

Supplement

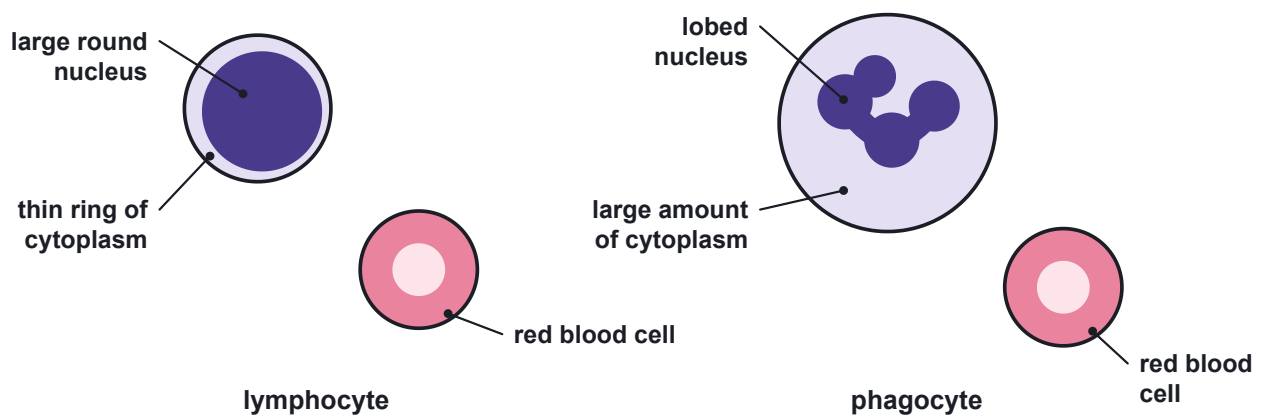
Two types of white blood cell

Supplement

Lymphocytes and phagocytes

Type	How to identify	Function
Lymphocyte	Large round nucleus filling most of the cell, with little cytoplasm	Antibody production
Phagocyte	Lobed or bean-shaped nucleus and a larger amount of cytoplasm	Engulfing pathogens by phagocytosis

Supplement



A **lymphocyte** has a large round nucleus. A **phagocyte** has a lobed nucleus and more cytoplasm.

Supplement

The clotting process

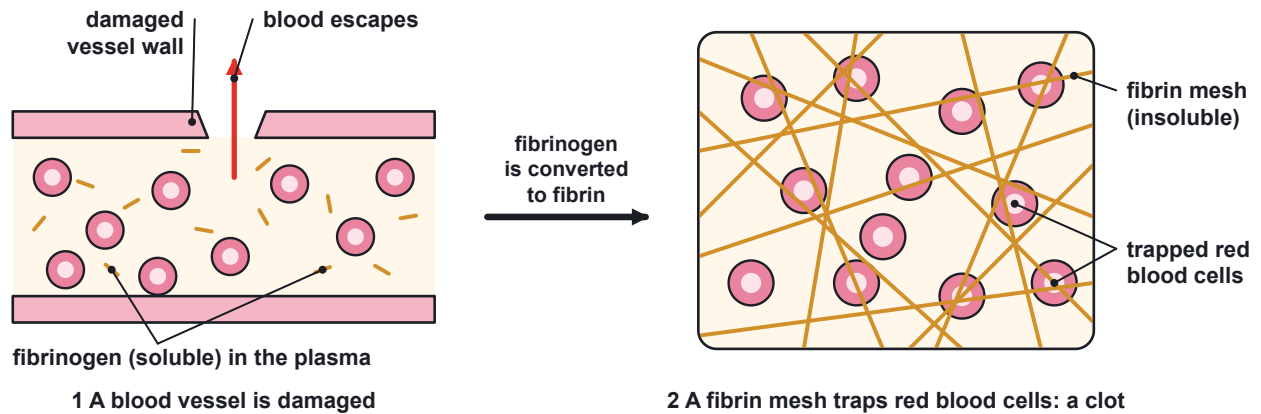
Supplement

Clotting is the conversion of soluble **fibrinogen** to insoluble **fibrin** to form a mesh.

Supplement

1. A blood vessel is damaged and blood escapes.
2. Fibrinogen (a soluble protein in the plasma) is converted to fibrin (insoluble).
3. Fibrin forms a mesh of fibres across the wound.
4. The mesh traps red blood cells and forms a clot, which dries into a scab.

Supplement



Soluble **fibrinogen** is converted to insoluble **fibrin**, which forms a mesh that traps red blood cells.

Supplement

Common mistake: Fibrin is the insoluble mesh. Fibrinogen is the soluble form in the plasma. Do not swap them.

Quick check

1. List the four components of blood.
2. What is the function of haemoglobin?
3. State two roles of blood clotting.
4. **Supplement** What does a phagocyte do?
5. **Supplement** Name the protein converted to fibrin during clotting.

Quick check answers

Circulatory systems

1. A system of blood vessels with a pump and valves to ensure one-way flow of blood.
2. Once (single circulation).
3. Pulmonary (heart to lungs and back) and systemic (heart to body and back).
4. Blood is returned to the heart and pumped to the body at high pressure, so substances are delivered faster.

The heart

1. The wall of muscle separating the left and right sides of the heart.
2. The coronary arteries.
3. It pumps blood to the whole body at higher pressure; the right pumps only to the lungs.
4. ECG, pulse rate, listening to the sounds of the valves closing.
5. Any two of: diet, lack of exercise, stress, smoking, genetic predisposition, age, sex.

Blood vessels

1. Veins.
2. Exchange of substances between the blood and the cells of the body tissues.
3. They carry blood at high pressure, so the walls must withstand it.
4. Pulmonary vein.
5. The hepatic portal vein.

Blood

1. Red blood cells, white blood cells, platelets and plasma.
2. To transport oxygen in the red blood cells.
3. Prevents blood loss and prevents entry of pathogens.
4. Engulfs pathogens by phagocytosis.
5. Fibrinogen.