

The heart and circulation

Revision notes · Heart structure and function, heart rate and adrenaline, coronary heart disease, blood vessels and the circulation of blood around the body.

For Pearson Edexcel International GCSE Biology 4BI1 and Science (Double Award) 4SD0. **Biology only** is not in the Double Award and is only examined on Paper 2.

The heart and circulation Spec 2.65-2.69

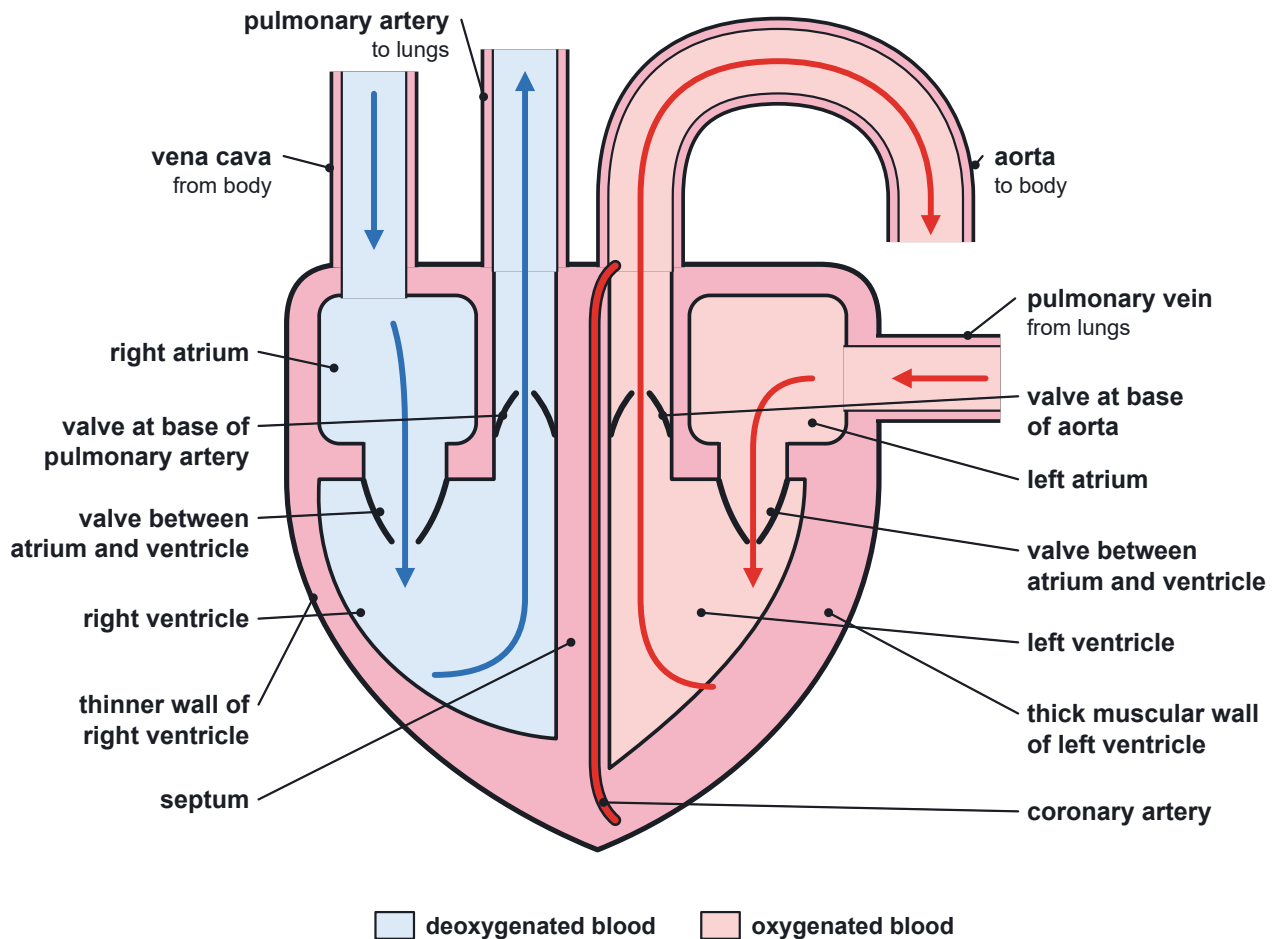
Structure and function of the heart Spec 2.65

The heart is a muscular pump. It has four chambers: two **atria** at the top, which receive blood, and two **ventricles** below, which pump blood out. A wall of muscle called the **septum** separates the left side from the right side, so oxygenated and deoxygenated blood do not mix.

1. Deoxygenated blood from the body enters the right atrium through the vena cava.
2. The right atrium contracts and pushes blood into the right ventricle.
3. The right ventricle contracts and pumps blood to the lungs through the pulmonary artery.
4. Oxygenated blood returns from the lungs through the pulmonary vein into the left atrium.
5. The left atrium contracts and pushes blood into the left ventricle.
6. The left ventricle contracts and pumps blood around the body through the aorta.

Blood vessels connected to the heart

Blood vessel	Carries blood	Between
Vena cava	Deoxygenated	Body to right atrium
Pulmonary artery	Deoxygenated	Right ventricle to lungs
Pulmonary vein	Oxygenated	Lungs to left atrium
Aorta	Oxygenated	Left ventricle to body



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

Valves

The heart has valves between the atria and ventricles, and at the bases of the aorta and pulmonary artery. They open to let blood flow forwards and close to **prevent backflow**.

Wall thickness

- The ventricles have thicker, more muscular walls than the atria, because they pump blood out of the heart.
- The **left ventricle** has a thicker wall than the right. It pumps blood all the way around the body, which needs a higher pressure. The right ventricle pumps blood only to the nearby lungs.

The heart muscle needs its own supply of oxygen and glucose. This is brought by the coronary arteries, which run over the surface of the heart.

Common mistake: 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. Check which side is which before you answer.

Heart rate, exercise and adrenaline Spec 2.66

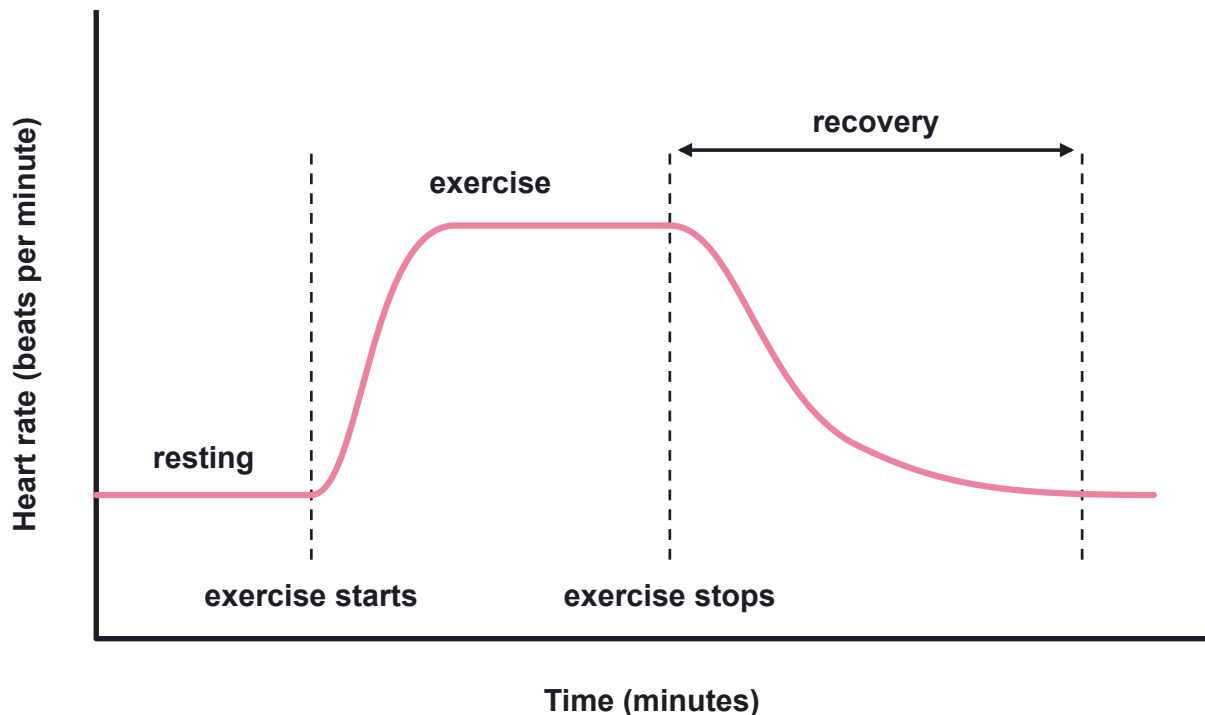
The heart rate is the number of heartbeats per minute. At rest it is steady, but it changes to match what the body needs.

Exercise

1. During exercise the muscles respire faster to release more energy.
2. They need more **oxygen and glucose**, and they produce more **carbon dioxide**.
3. The heart rate increases, so blood flows to the muscles faster.

4. More oxygen and glucose are delivered, and carbon dioxide is carried away more quickly.

After exercise, the heart rate stays high for a while and then gradually returns to its resting rate.



Heart rate **rises** during exercise, then falls gradually back to the resting rate during **recovery**.

Adrenaline

Adrenaline is a hormone released by the adrenal glands when you are frightened or excited. It prepares the body for 'fight or flight'. It makes the **heart rate increase**, so more blood, with more oxygen and glucose, reaches the muscles and they can release more energy quickly.

Heart rate from a pulse count

A student counts 18 pulses in 15 seconds at rest and 36 pulses in 15 seconds straight after exercise. Calculate the increase in heart rate in beats per minute.

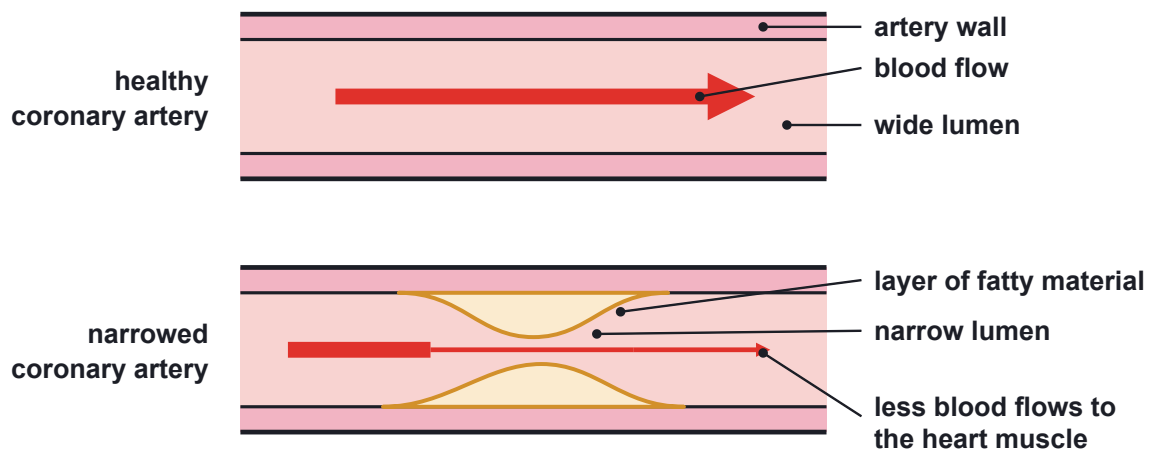
1. There are 4 lots of 15 seconds in a minute.
2. Resting rate = $18 \times 4 = 72$ beats per minute.
3. Rate after exercise = $36 \times 4 = 144$ beats per minute.
4. Increase = $144 - 72$.

Answer: 72 beats per minute

Exam tip: In an 'explain' answer, link the steps: exercise, so more respiration, so more oxygen and glucose needed and more carbon dioxide made, so higher heart rate.

Coronary heart disease and its risk factors Spec 2.67

The **coronary arteries** supply the heart muscle with oxygen and glucose. In **coronary heart disease** (CHD), layers of fatty material build up inside these arteries and narrow them. Less blood flows through, so the heart muscle gets less oxygen and may not be able to respire enough. This can cause chest pain and a heart attack.



Fatty material **narrows the lumen**, so less blood (and oxygen) reaches the heart muscle.

Risk factors

A **risk factor** is something that increases the chance of developing a disease. It does not mean that the disease is certain.

Risk factors for CHD	
Risk factor	How it increases the risk
Diet high in saturated fat and cholesterol	Fatty material builds up in the artery walls
Smoking	Damages the artery lining, raises blood pressure and reduces the oxygen carried by the blood
High blood pressure	Damages the artery walls, making fatty deposits more likely
Lack of exercise	Linked to obesity and high blood pressure
Obesity	Linked to high blood pressure and a diet high in fat
Stress	Linked to raised blood pressure
Genetic factors (family history)	Some people inherit a greater risk
Age	The risk increases as people get older

Exam tip: When asked how a factor increases the risk, state the factor and its effect, for example 'a diet high in saturated fat raises blood cholesterol, so more fatty material builds up in the coronary arteries'.

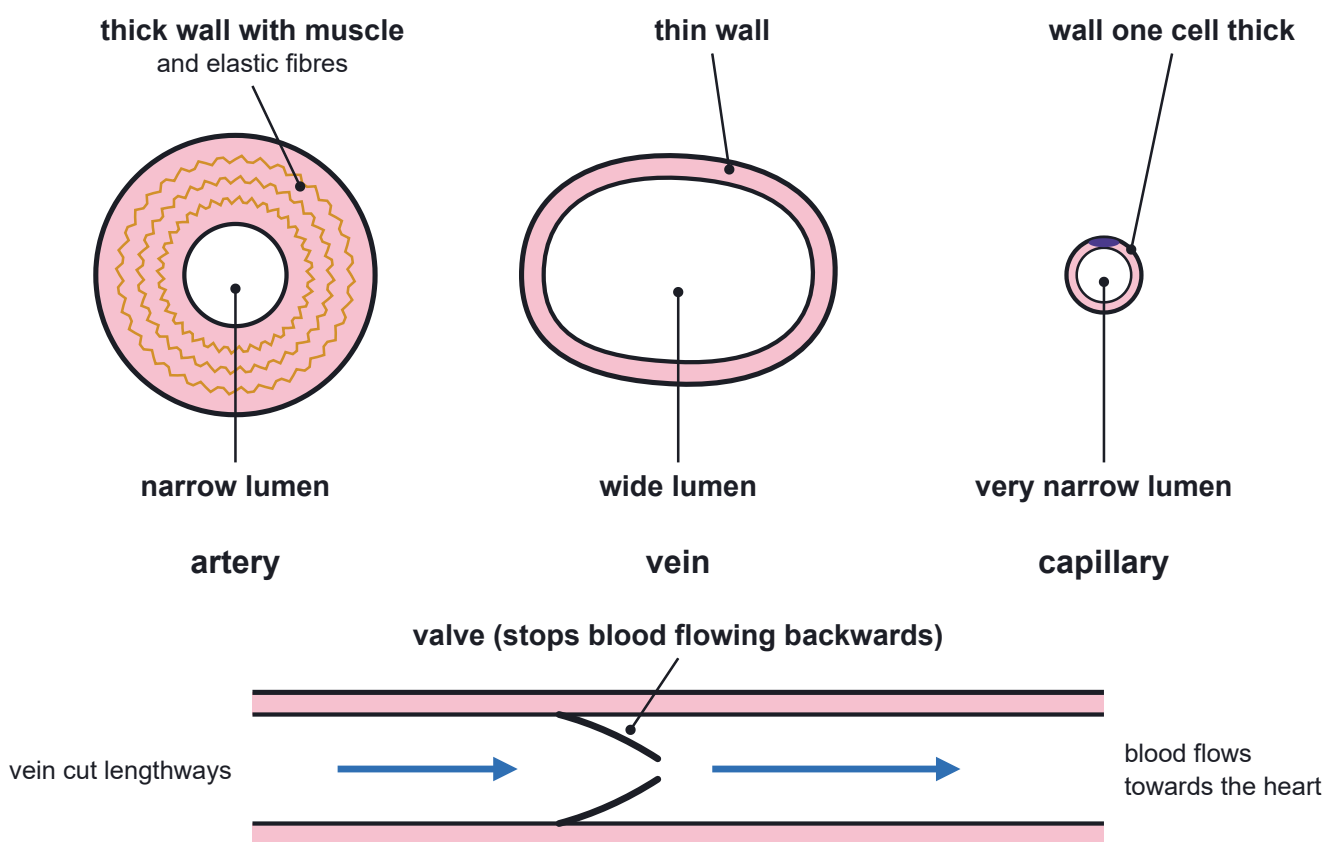
Arteries, veins and capillaries Spec 2.68

There are three types of blood vessel. Each has a structure that suits its function.

Arteries, veins and capillaries

	Artery	Vein	Capillary
Direction of blood	Away from the heart	Towards the heart	Between arteries and veins, through the tissues
Blood pressure	High	Low	Falls as blood passes through
Wall	Thick, muscular, with elastic fibres	Thinner wall	One cell thick
Lumen	Narrow	Wide	Very narrow
Valves	No	Yes	No
Function	Carry blood at high pressure to the organs	Carry blood back to the heart	Exchange substances with cells

- **Arteries** have thick, muscular walls with elastic fibres. The wall can stand the high pressure, and it stretches and springs back with each heartbeat.
- **Veins** carry blood at low pressure. They have a wide lumen, which lets blood flow easily, and **valves** to stop the blood flowing backwards.
- **Capillaries** have walls only one cell thick, so there is a short diffusion distance. They are very narrow and form a huge network, so they reach every cell and give a large surface area for exchange.



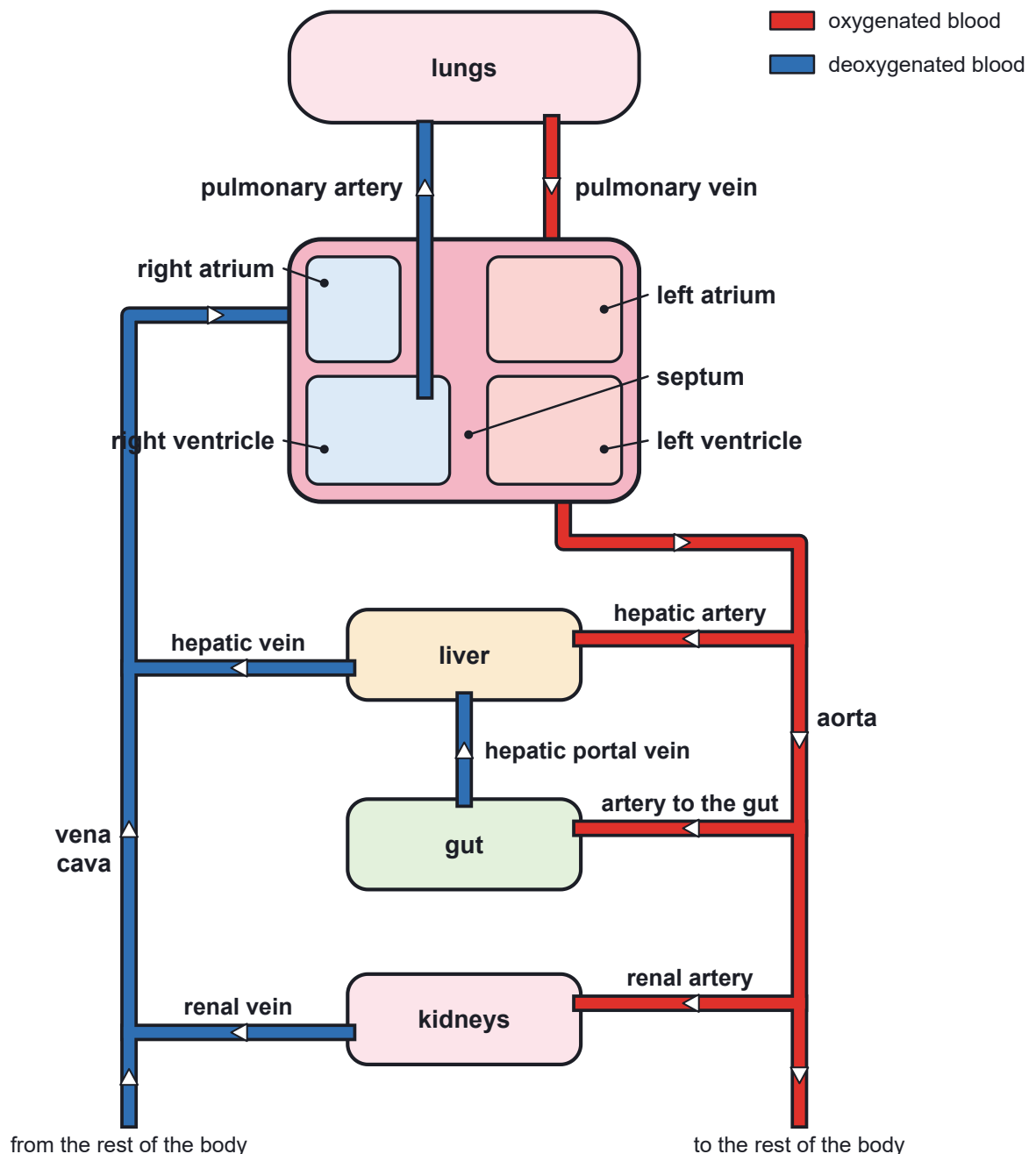
Arteries have **thick walls**, veins have a **wide lumen and valves**, capillaries have walls **one cell thick**. (The capillary is drawn much larger than its real size.)

Exam tip: Do not say that arteries always carry oxygenated blood and veins always carry deoxygenated blood. The pulmonary artery and pulmonary vein are the exceptions.

The circulation system Spec 2.69

Humans have a **double circulatory system**. In one circuit, blood goes from the heart to the lungs and back. In the other, it goes from the heart to the rest of the body and back. Blood passes through the heart twice on each complete circuit of the body.

Blood vessels to and from the main organs		
Organ	Vessel	Carries blood
Heart and body	Vena cava	From the body to the right atrium
Heart and body	Aorta	From the left ventricle to the body
Lungs	Pulmonary artery	From the right ventricle to the lungs (deoxygenated)
Lungs	Pulmonary vein	From the lungs to the left atrium (oxygenated)
Liver	Hepatic artery	From the aorta to the liver (oxygenated)
Liver	Hepatic portal vein	From the gut to the liver, carrying digested food
Liver	Hepatic vein	From the liver to the vena cava
Kidneys	Renal artery	From the aorta to the kidneys
Kidneys	Renal vein	From the kidneys to the vena cava



Blood from the gut goes to the liver in the **hepatic portal vein** before it returns to the heart.

Notice that the **hepatic portal vein** carries blood from the gut to the liver, not to the heart. After a meal this blood is rich in digested food. The liver processes it before the blood returns to the heart in the hepatic vein.

Common mistake: Do not mix up the hepatic artery (blood to the liver from the aorta), the hepatic portal vein (blood from the gut to the liver) and the hepatic vein (blood from the liver towards the heart).

Quick check

- 1 . What is the function of the septum?
- 2 . Why is the wall of the left ventricle thicker than the right?
- 3 . Why does heart rate rise during exercise?
- 4 . Name the blood vessels that supply the heart muscle.
- 5 . Which vessel carries blood from the gut to the liver?

Quick check answers

The heart and circulation

1. It separates the left and right sides of the heart, so oxygenated and deoxygenated blood do not mix.
2. It pumps blood around the whole body, which needs higher pressure.
3. Muscles respire faster, so more oxygen and glucose must be delivered and more carbon dioxide removed.
4. Coronary arteries.
5. The hepatic portal vein.