The heart and blood vessels

4.2.2.2 · Organisation · revision notes

How the heart pumps blood around a double circulatory system, how the lungs are adapted for gas exchange, what the pacemaker does, and how arteries, veins and capillaries are adapted to their functions. Questions include labelling the heart, tracing the path of blood, explaining adaptations and calculating the rate of blood flow.

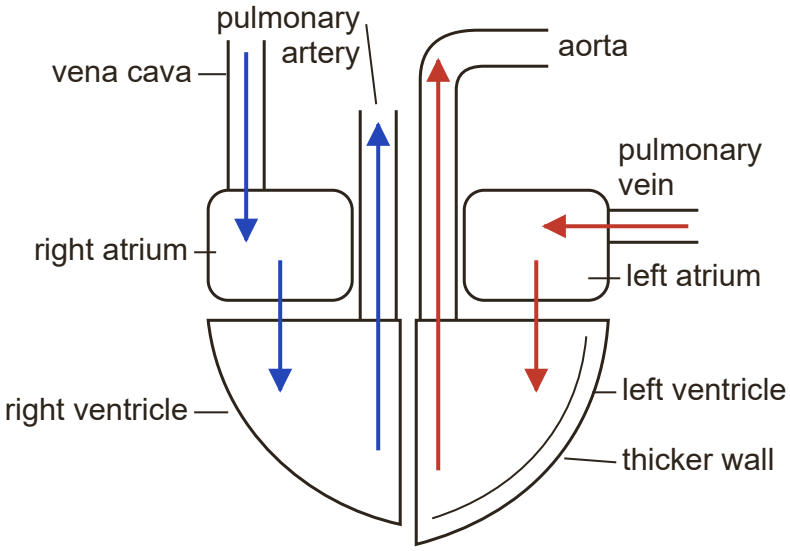
Key facts

- Right side of the heart → lungs; left side → rest of the body
- Arteries: away from the heart, high pressure, thick muscular and elastic walls, narrow lumen
- Capillaries: walls one cell thick, short diffusion distance
- Pacemaker: a group of cells in the right atrium
- Rate of blood flow = volume of blood ÷ time
- Vena cava → RA → RV → pulmonary artery → lungs → pulmonary vein → LA → LV → aorta
- Veins: back to the heart, low pressure, thin walls, wide lumen, valves
- Coronary arteries: supply the heart muscle with oxygenated blood
- Lungs: trachea → bronchi → bronchioles → alveoli (surrounded by capillaries)

Notes

The heart and double circulation

- The heart is an organ, made mainly of muscle, that pumps blood. It has two **atria** at the top and two **ventricles** below.
- Blood flows: vena cava → right atrium → right ventricle → pulmonary artery → lungs → pulmonary vein → left atrium → left ventricle → aorta → body.



The heart from the front: its right side is on the left of the diagram.
Blue = deoxygenated blood, red = oxygenated blood.

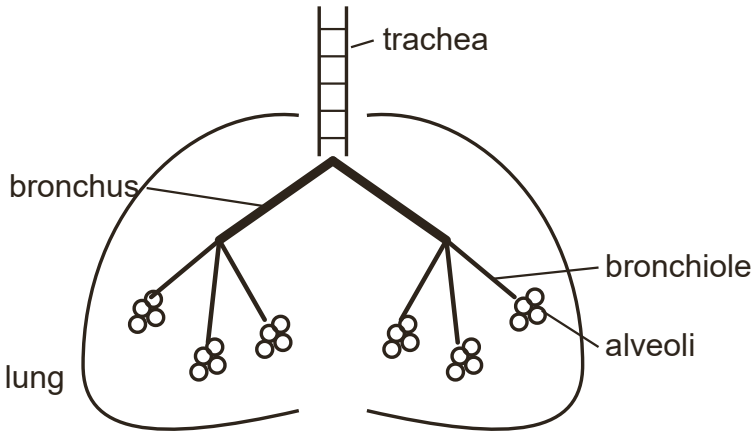
- This is a **double circulatory system**. The **right** ventricle pumps blood to the lungs, where gas exchange takes place. The **left** ventricle pumps blood around the rest of the body.
- The left ventricle has a thicker muscular wall because it pumps blood at a higher pressure, all the way round the body. Grade 7+ only
- Valves stop blood flowing backwards.
- The **coronary arteries** branch off the aorta and supply the heart muscle itself with oxygenated blood.

Heart rate

- The natural resting heart rate is controlled by a group of cells in the **right atrium** that act as a **pacemaker**.
- An **artificial pacemaker** is an electrical device fitted to correct irregularities in the heart rate.

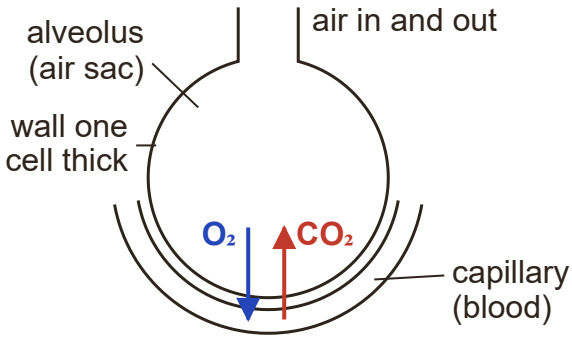
The lungs

- Air passes down the **trachea**, into the two **bronchi**, along the branching **bronchioles**, and on to millions of tiny air sacs called **alveoli**.



The lungs: trachea → bronchi → bronchioles → alveoli

- Each alveolus is surrounded by a network of **capillaries**. Oxygen diffuses from the air in the alveoli into the blood; carbon dioxide diffuses from the blood into the alveoli.

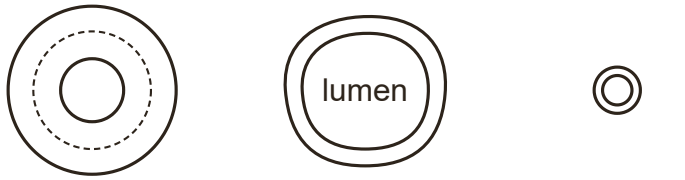


Gas exchange in an alveolus

- Adaptations: a very large surface area (many alveoli); thin walls (one cell thick), giving a short diffusion distance; a good blood supply and breathing, which keep a steep concentration gradient.

Blood vessels

- **Arteries** carry blood away from the heart at high pressure. They have thick walls containing muscle and elastic fibres and a narrow lumen, so they withstand the pressure and stretch and recoil with each heartbeat.
- **Veins** carry blood back to the heart at low pressure. They have thinner walls, a wide lumen and **valves** that stop blood flowing backwards.
- **Capillaries** are tiny vessels that run through tissues. Their walls are one cell thick, giving a short diffusion distance for substances to pass between the blood and the cells.



artery
thick muscular, elastic wall

vein
thin wall, wide lumen

capillary
wall one cell thick

Blood vessels in cross-section (not to scale). Veins also have valves.

- Rate of blood flow = volume of blood ÷ time.

How to answer each type of question

Trace the path of blood or label the heart — 1 to 4 marks — **Grade 4**

1. The heart is drawn as if you are facing the person, so the right side of the heart is on the left of the page.
2. Follow the order: vein → atrium → ventricle → artery.
3. Use the names in the specification: vena cava, pulmonary artery, pulmonary vein, aorta.

Example. Describe the path taken by blood from the vena cava until it leaves the heart on its way to the lungs.

Model answer. Vena cava → right atrium (1) → right ventricle (1) → pulmonary artery (1)

Explain how a blood vessel is adapted to its function — 2 to 3 marks — **Grade 5**

1. State a feature, e.g. 'wall one cell thick'.
2. Link it to the function with 'so', e.g. 'so there is a short diffusion distance'.
3. Give one feature-plus-reason for each pair of marks.

Example. Explain how capillaries are adapted for exchanging substances with body cells.

Model answer. The capillary wall is only one cell thick (1), so there is a short diffusion distance (1). There are very many capillaries forming a network, so every cell is close to a capillary / there is a large surface area (1).

Calculate the rate of blood flow

2 marks | Grade 6

1. Use rate of blood flow = volume of blood ÷ time.
2. Convert units first if needed, e.g. seconds to minutes.
3. Give the unit asked for, e.g. cm^3 per minute.

Example. In 15 seconds, 1200 cm^3 of blood flowed through the aorta.
Calculate the rate of blood flow in cm^3 per minute.

Model answer.

15 s = 0.25 min, so rate = 1200 ÷ 0.25 (1) = 4800 cm^3 per minute (1)

(or 1200 ÷ 15 = 80 cm^3 per second, × 60 = 4800)

Explain how the lungs are adapted for gas exchange

3 to 4 marks | Grade 5

1. Surface area: millions of alveoli.
2. Diffusion distance: thin walls of the alveoli and capillaries.
3. Concentration gradient: a good blood supply carries oxygen away and brings carbon dioxide, and breathing refreshes the air.

Example. Explain how the alveoli are adapted for efficient gas exchange.

Model answer. There are millions of alveoli, giving a very large surface area (1). The walls of the alveoli are thin / one cell thick, so the diffusion distance is short (1). Each alveolus is surrounded by a network of capillaries / has a good blood supply (1). This, with breathing, keeps a steep concentration gradient for oxygen and carbon dioxide (1).

Explain differences between the two sides of the heart

2 marks | Grade 7

1. Say where each ventricle pumps blood to.
2. Link the thicker wall to the higher pressure needed.

Example. The muscular wall of the left ventricle is much thicker than the wall of the right ventricle. Explain why.

Model answer. The left ventricle pumps blood all round the rest of the body, but the right ventricle only pumps blood to the lungs (1). So the left ventricle needs more muscle to pump blood at a higher pressure (1).

Don’t lose marks

- Mixing up left and right on a diagram. The heart is drawn as if you are facing the person.

- Saying arteries always carry oxygenated blood and veins always carry deoxygenated blood. The pulmonary vessels do the opposite.
- Writing only 'thin walls' for capillaries when 'walls one cell thick' is the precise answer, or writing 'cell wall' (animal cells do not have cell walls).
- Saying the pacemaker is in the left atrium or in a ventricle. It is in the right atrium.
- Saying the heart muscle gets its oxygen from the blood inside its chambers. It is supplied by the coronary arteries.
- Forgetting to convert seconds to minutes in blood flow calculations.

More tips

Memory tricks

- **A**rteries carry blood **a**way from the heart; veins carry it back in.
- 'Pulmonary' means 'to do with the lungs': the pulmonary artery goes to the lungs and the pulmonary vein comes back from them.
- Vessels are named by direction, not oxygen: the pulmonary artery carries deoxygenated blood and the pulmonary vein carries oxygenated blood.
- Blood always goes into an atrium first, then a ventricle: A before V, like the alphabet.
- The left side works harder (it pumps to the whole body), so the left side has the thicker wall.

Exam technique

- In adaptation questions, link each feature to its function: feature + 'so' + reason.
- Use the vessel names exactly: vena cava, pulmonary artery, pulmonary vein, aorta, coronary arteries.
- In calculations, check which unit the question asks for and show your working.
- For lung questions, use the terms surface area, diffusion distance and concentration gradient.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **Name the three types of blood vessel**
Arteries carry blood away from the heart, veins carry blood back to the heart, and capillaries link them inside tissues.

Grade 4 — **Label the heart's chambers and main vessels**
Right and left atria and ventricles, the vena cava, pulmonary artery, pulmonary vein, aorta and coronary arteries.

Grade 5 — **Describe the double circulatory system**
The right ventricle pumps blood to the lungs and the left ventricle pumps blood around the rest of the body.

Grade 5 — **Describe the role of the pacemaker**
A group of cells in the right atrium controls the natural resting heart rate; an artificial pacemaker is an electrical device that corrects an irregular heart rate.

Grade 5 — **Explain how blood vessels suit their functions**
Arteries have thick muscular, elastic walls for high pressure, veins have valves, and capillary walls are one cell thick for diffusion.

Grade 5

Explain how alveoli are adapted for gas exchange

Millions of alveoli give a large surface area, with thin walls and a rich capillary network keeping a steep concentration gradient.

Grade 6

Calculate the rate of blood flow

Rate of blood flow = volume of blood ÷ time, e.g. in cm^3 per minute.

Grade 7

Explain why the left ventricle wall is thicker

It pumps blood at a higher pressure all round the body, while the right ventricle only pumps blood to the nearby lungs.

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