

Transport

Revision notes · IB Biology B3.2 transport: capillaries, arteries, veins, pulse, coronary heart disease, xylem, stems and roots.

For IB Diploma Biology SL undefined. **HL only** is additional higher level content, for HL students only.

Transport Spec B3.2

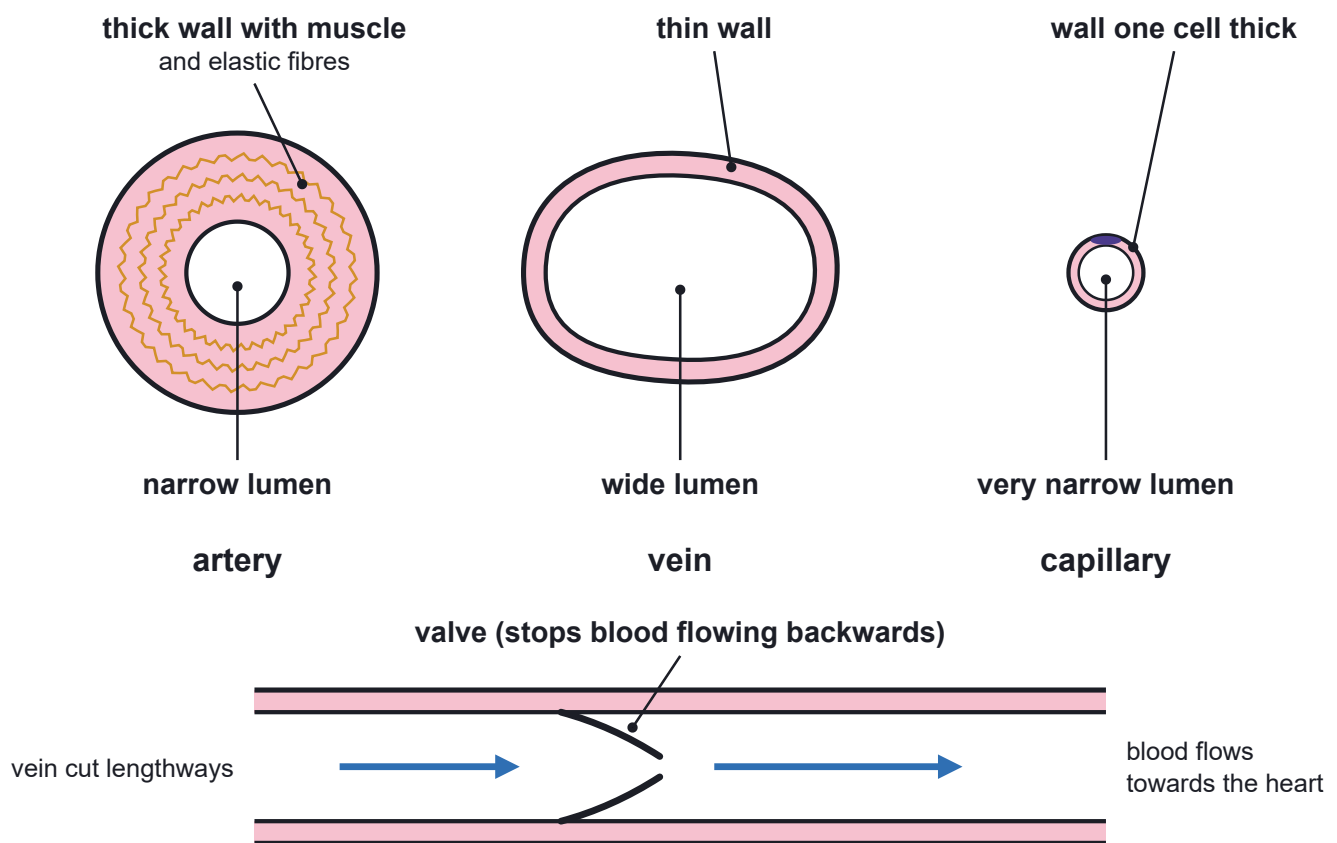
Adaptations of capillaries Spec B3.2.1

Arterioles divide into networks of **capillaries** called capillary beds, which pass close to every active cell. Capillaries rejoin to form venules. All exchange between blood and tissues happens in capillaries.

Adaptations of capillaries	
Adaptation	How it helps exchange
Branching into dense networks	Gives a large total surface area and brings blood close to every cell.
Narrow diameter (about the width of a red blood cell)	Large surface area relative to volume; red blood cells pass close to the wall.
Thin wall: one layer of flattened endothelium cells on a basement membrane	Short diffusion distance.
Fenestrations (pores) in some capillaries	Allow faster exchange of fluid and solutes where exchange needs to be particularly rapid, for example in the glomerulus of the kidney and in the villi of the small intestine.
Slow blood flow	More time for exchange.

Common mistake: Write 'the capillary wall is one cell thick', not 'the capillary has a cell wall'. Animal cells have no cell walls.

Structure and adaptations of arteries and veins Spec B3.2.2, B3.2.3, B3.2.5



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Arteries have thick walls and narrow lumens; veins have thin walls, wide lumens and valves.

Arteries and veins compared		
Feature	Artery	Vein
Wall thickness relative to lumen	Thick wall, narrow lumen	Thin wall, wide lumen
Tunica media (smooth muscle and elastic fibres)	Thick layer	Thin layer
Shape in a micrograph	Round, with a folded inner lining	Often flattened or irregular
Valves	None along their length	Present
Blood pressure	High, pulsing	Low, steady

Practical skill: To identify a vessel in a micrograph, compare the thickness of the wall with the diameter of the lumen. In an artery the wall is thick relative to a narrow, round lumen; in a vein the wall is much thinner than the width of its wide, often flattened lumen.

Adaptations of arteries

- Elastic fibres** stretch when the ventricles pump blood in, then recoil between beats. The recoil pushes blood on and keeps the pressure up, so flow is less pulsing further from the heart.
- A thick layer of **smooth muscle** can contract to narrow the lumen, helping to maintain blood pressure.

- The thick wall, with a tough outer layer of collagen fibres, withstands high pressure without bursting.
- The narrow lumen helps maintain high pressure.

Adaptations of veins

- Pressure in veins is too low to push blood back to the heart unaided.
- Pocket **valves** close if blood starts to flow backwards, so blood moves only towards the heart.
- The thin, **flexible wall** is compressed when nearby skeletal muscles contract, squeezing blood towards the heart.
- A wide lumen offers little resistance to flow.

Pulse rates and occlusion of the coronary arteries Spec B3.2.4, B3.2.6

Measuring pulse rate

Each heartbeat sends a surge of blood along the arteries, felt as a **pulse**. The pulse rate equals the heart rate.

Practical skill: Press two fingertips (not the thumb, which has its own pulse) on the radial artery on the inside of the wrist or the carotid artery in the neck. Count beats for 30 s and multiply by 2, repeat and find the mean. Compare the result with a digital heart rate monitor or pulse oximeter.

Pulse rate

A student counts 19 beats in 15 seconds. Calculate the pulse rate. (Practice data.)

1. Beats per minute = $19 \times (60 \div 15)$
2. = $19 \times 4 = 76$

Answer: 76 beats per minute

Occlusion of the coronary arteries

The **coronary arteries** branch from the aorta and supply cardiac muscle with oxygen and glucose.

1. Fatty deposits (atheroma or plaque) build up in the wall of a coronary artery, under the endothelium: atherosclerosis.
2. The lumen narrows and the wall hardens, so blood flow is reduced.
3. If a plaque ruptures, a blood clot (thrombus) can form and block the artery completely: **occlusion**.
4. Cardiac muscle beyond the blockage gets too little oxygen for aerobic respiration, causing chest pain (angina) or, if severe, a heart attack (myocardial infarction), when part of the heart muscle dies.

Risk factors include a diet high in saturated fat, high blood cholesterol, smoking, high blood pressure, obesity, lack of exercise, increasing age, male sex and family history.

Exam tip: A correlation coefficient (r) from -1 to +1 measures how strongly two variables are correlated. Even a strong correlation, such as between saturated fat intake and coronary heart disease, does not prove that one causes the other; a low r or no correlation can be evidence against a hypothesis.

Water transport in xylem Spec B3.2.7, B3.2.8

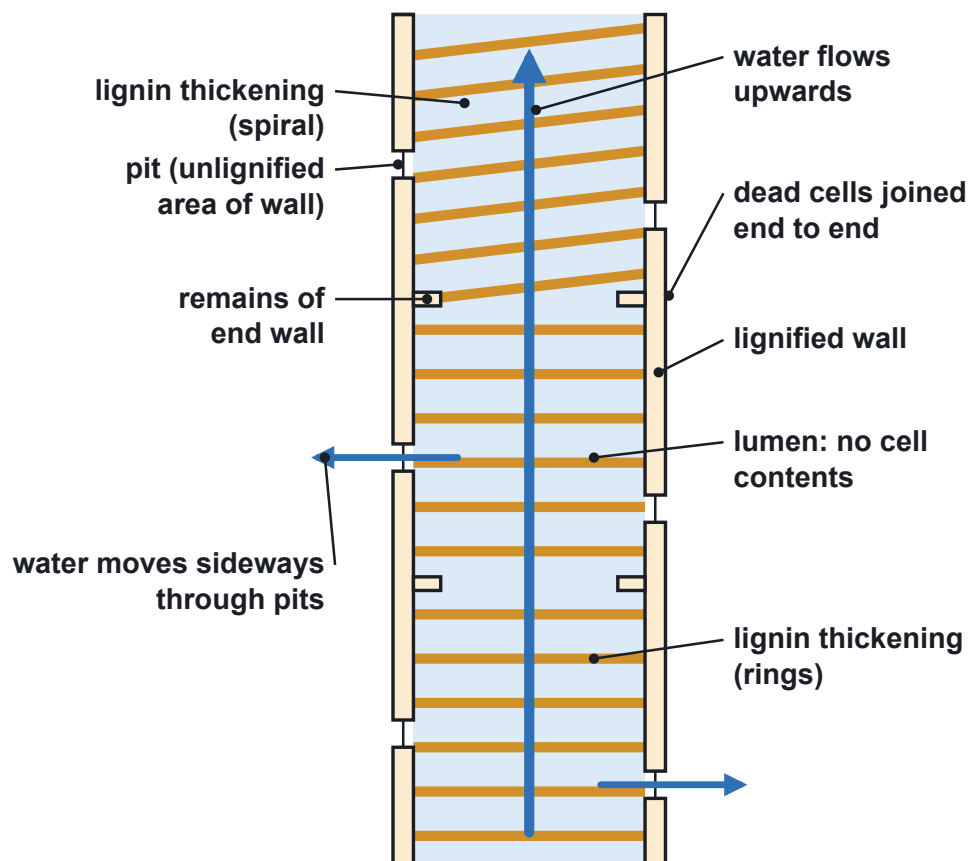
1. Water evaporates from the cell walls of spongy mesophyll cells and diffuses out of the leaf through stomata (transpiration).
2. Water is drawn out of the xylem vessels in the leaf veins and through the cell walls to replace it, by **capillary action** (adhesion of water to cellulose).
3. This generates **tension** (a negative pressure potential) in the xylem.
4. The tension pulls water up the xylem from the roots.

5. **Cohesion** between water molecules, due to hydrogen bonding, keeps the column of water continuous so it does not break.

This is the cohesion-tension mechanism. It is passive: the energy comes from evaporation, driven by heat from the sun, not from ATP.

Adaptations of xylem vessels

Xylem vessel adaptations	
Feature	Function
No cell contents (dead cells, no cytoplasm or nucleus)	Unimpeded flow of water.
Incomplete or absent end walls	Cells form a continuous tube, so water flows without obstruction.
Lignified walls (thickened in rings, spirals or networks)	Withstand the tension without collapsing inwards.
Pits (unlignified areas of wall)	Allow water to enter and leave the vessel, and pass between neighbouring vessels.



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A xylem vessel: a continuous tube of dead cells with **lignified walls** that resist tension, and pits for lateral movement of water.

Exam tip: Linking question: how do pressure differences contribute to the movement of materials?
Xylem uses negative pressure (tension); blood and phloem sap use positive pressure.

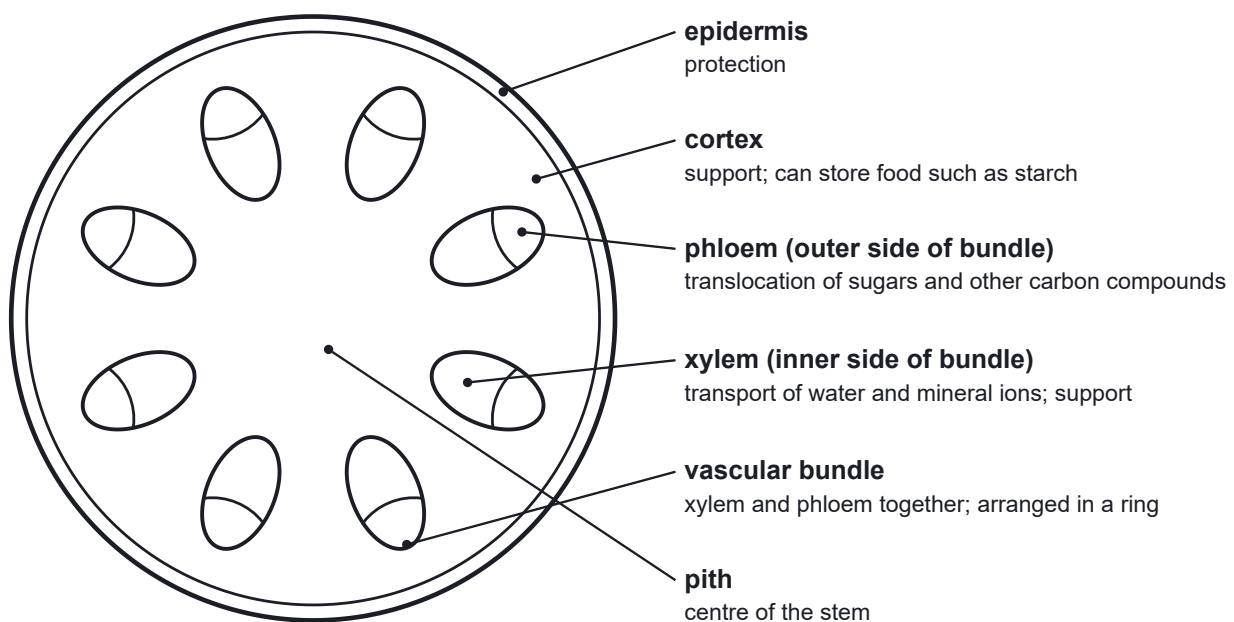
Tissues in dicotyledonous stems and roots Spec B3.2.9, B3.2.10

Functions of tissues in stems and roots

Tissue	Main function
Epidermis	Protective outer layer; in roots it bears root hairs that absorb water and mineral ions.
Cortex	Packing and support tissue between epidermis and vascular tissue; can store food such as starch; in roots water crosses it to reach the xylem.
Xylem	Transports water and mineral ions from roots to leaves; lignified walls give support.
Phloem	Transports sap containing sugars and other carbon compounds by translocation.
Vascular bundle	A strand of xylem and phloem together.

Stem

- Vascular bundles are arranged in a **ring** near the outside of the stem.
- In each bundle, phloem is on the outside and xylem on the inside.
- Cortex lies between the epidermis and the ring of bundles; the centre of the stem is pith.

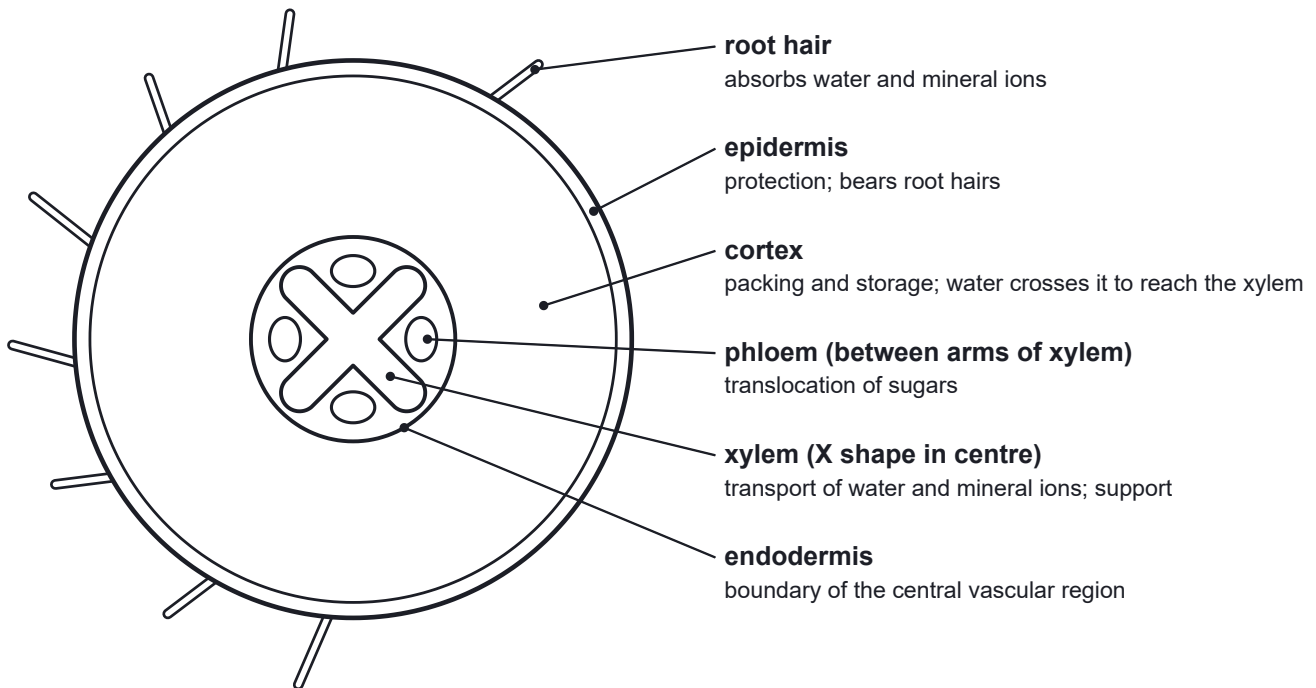


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Plan diagram of a dicotyledonous stem: vascular bundles in a **ring**, phloem outside and xylem inside each bundle.

Root

- Xylem and phloem form a **central vascular region**, not a ring: xylem in a star or X shape with phloem between its arms.
- The guide asks you to identify vascular bundles in the root too. In a root they are **radial**: the groups of xylem and phloem alternate on different radii inside one central vascular cylinder (the stele), instead of xylem and phloem sharing a bundle as in the stem.
- A wide cortex surrounds the vascular region, with the epidermis and root hairs on the outside.
- The central position of vascular tissue resists the pulling forces on a root.



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Plan diagram of a dicotyledonous root: xylem and phloem form a **central vascular region**, with phloem between the arms of the xylem.

Practical skill: Draw plan diagrams from micrographs: outline each tissue with a single clear line, keep proportions accurate, no cells and no shading. Label the tissues the guide lists (epidermis, cortex, vascular bundles, xylem and phloem; pith in the stem) and, for the stem, annotate each label with its main function.

Quick check

1. What are fenestrations in capillaries?
2. How do elastic fibres in artery walls help maintain blood pressure?
3. What causes tension in the xylem?
4. Where is xylem found in a dicotyledonous root?

Quick check answers

Transport

- 1 . Pores in the capillary wall that allow particularly rapid exchange, for example in the kidney glomerulus.
- 2 . They stretch when blood is pumped in and recoil between beats, pushing blood on and keeping the pressure up.
- 3 . Loss of water by transpiration from leaf cell walls draws water out of the xylem by capillary action.
- 4 . In the centre, in a star or X shape, with phloem between its arms.