

Science 7–8

Chapter 8 — Biological sciences B: cells, tissues, organs and systems

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Cell theory and the microscope: cells as the basic unit of life, unicellular against multicellular organisms, and the scale of a cell

What we teach here — VC2S8U02 (Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8):

“cell theory describes cells as the basic units of life; organisms may be unicellular or multicellular and have specialised structures and organelles (including cell walls, cell membranes, cytoplasm, nuclei containing DNA, mitochondria, ribosomes, chloroplasts and vacuoles) that perform specific functions”

This subtopic owns the first clause: cell theory, cells as the basic units of life, organisms as unicellular or multicellular, and the scale of a cell. The second clause — the specialised structures and organelles and their specific functions — belongs to the partner subtopic **8B** († split delivery, D6). **In our words:** everything that is alive is built from cells; a cell is the smallest piece of living matter that is still alive.

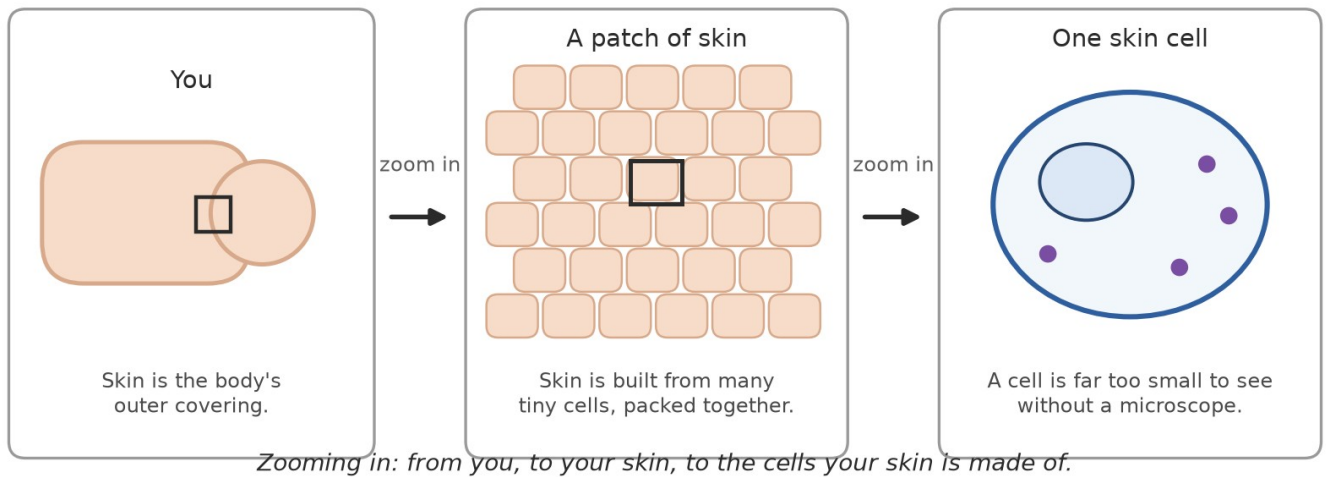
Some organisms are a single cell doing every job of life on its own, while others — like us — are teams of many cells working together. Cells are so small that a new unit is needed to measure them, and finding all of this out took a machine: the microscope. **Achievement-standard extract (D13):** *“They explain the role of specialised cell structures and organelles in cellular function, and distinguish between cells in selected examples of plants and animals, and unicellular and multicellular organisms.”* (The partner subtopic 8B cites this extract by reference to this header.) **Elaborations drawn on:** VC2S8U02 .E01 (zooming in on a plant, animal, bacterium and fungus to understand the scale of cells), VC2S8U02 .E02 (examining cells, including single-celled organisms, with a light microscope, a digital microscope, simulations and photomicrographs), VC2S8U02 .E03 (comparing student-made onion wet-mount slides with purchased slides) and VC2S8U02 .E07 (how developments in microscopes and medical imaging have improved understanding of cells, tissues and organs). **Maths interlock (D11):** ratios of lengths, areas and volumes when scaling a cell — VC2M7M06, cited at point of use. Very small lengths are written in a smaller unit (the micrometre), never in scientific notation, which is Level 9.

Word watch — *theory*. In everyday talk, *theory* often just means a guess or a hunch. In science, a **theory** is something much stronger: an explanation built up from a large body of evidence, that makes sense of many observations and has held up when tested. **Cell theory** is one of the great theories of science — it did not arrive as a guess, it was built over two centuries of looking, measuring and checking. In this subtopic, *theory* always carries the science meaning.

Theory

Everything alive is made of cells

Look at your hand. Look at a leaf, a beetle, a worm. Every one of these is an **organism** — the word science uses for any living thing (subtopic 7A). They look nothing alike on the outside, yet at the smallest scale they are built from the same kind of part: the **cell**. A cell is the basic unit of life — the smallest piece of living matter that is still alive. Your skin alone is made of many millions of them, packed together like bricks in a wall.

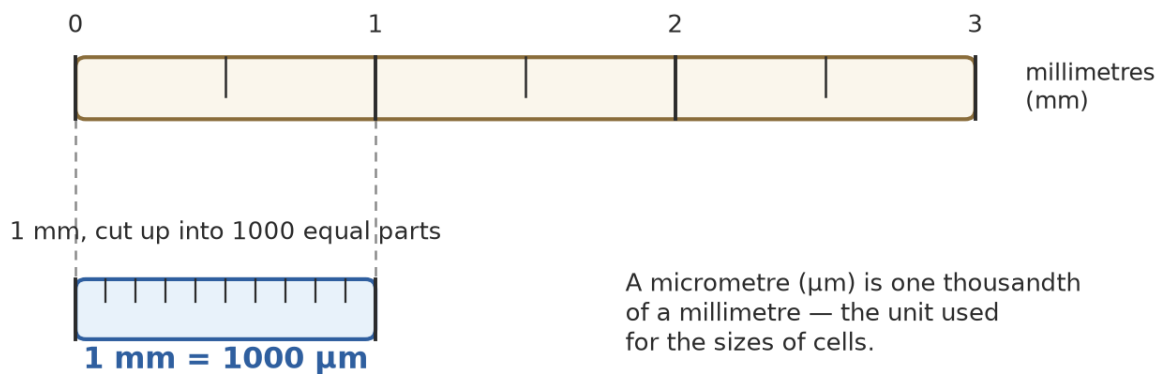


A zoom-in sequence in three panels: from you, to a patch of skin built from many tiny cells packed together, to one skin cell with its membrane, cytoplasm and nucleus

The idea that cells are the basic units of life is the heart of **cell theory**, and this subtopic builds that idea in three claims. First, though, we need to face the scale of the problem: cells are very, very small.

How small is a cell? A new unit

The millimetre (mm) is a good unit for the width of a coin or the length of an ant, but a cell is much smaller than a millimetre. For cells we use the **micrometre** (μm): one thousandth of a millimetre.



millimetres to micrometres:
multiply by 1000

$$0.05 \text{ mm} \times 1000 = 50 \mu\text{m}$$

micrometres to millimetres:
divide by 1000

$$250 \mu\text{m} \div 1000 = 0.25 \text{ mm}$$

A ruler in millimetres with one millimetre expanded into 1000 equal parts, showing 1 mm = 1000 μm , and two conversion examples: $0.05 \text{ mm} \times 1000 = 50 \mu\text{m}$ and $250 \mu\text{m} \div 1000 = 0.25 \text{ mm}$

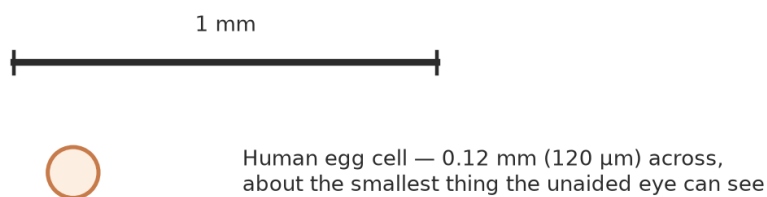
Going from millimetres to micrometres, multiply by 1000; going back, divide by 1000. A length of 0.05 mm is 50 μm ; a length of 250 μm is 0.25 mm. Always keep track of the unit — mixing mm and μm in one calculation is the classic way to go wrong.

The scale of a cell

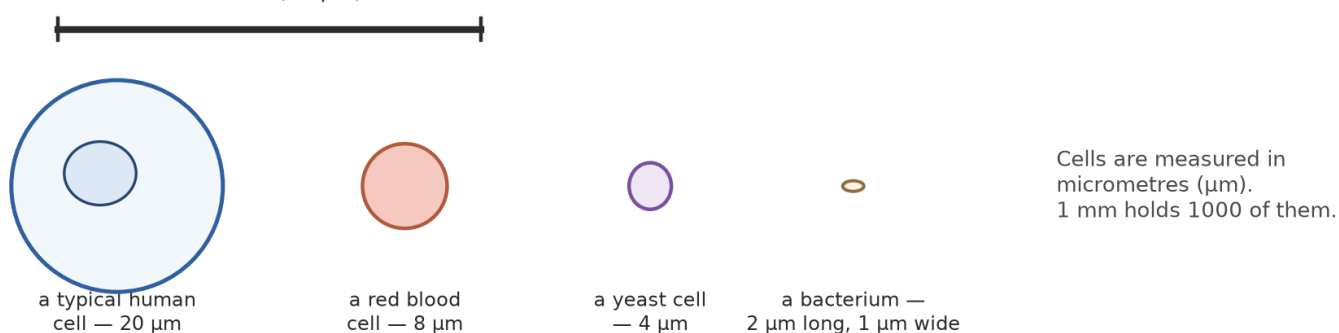
So how big is a cell? Sizes vary, and a few useful sizes are:

- a human **egg cell** is about 0.12 mm (120 μm) across — one of the largest human cells, and about the smallest thing the naked eye can see as a tiny dot;
- a **typical human cell** is about 0.02 mm (20 μm) across;
- a **red blood cell** is about 8 μm across;
- a **yeast cell** is about 4 μm across;
- a common **bacterium** is about 2 μm long and 1 μm wide.

Near the limit of the unaided eye



Seen with a microscope (each scale bar shows the true size)



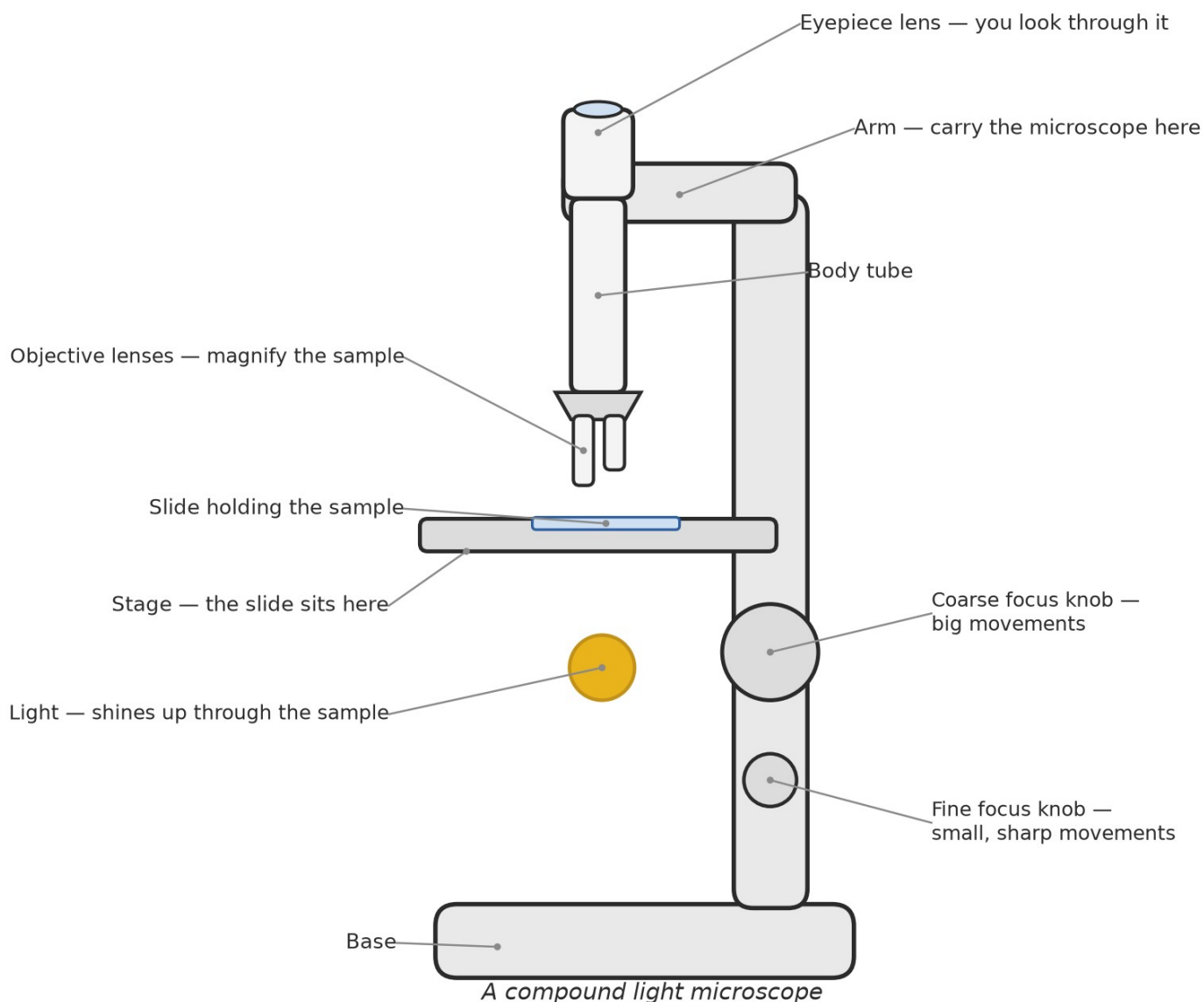
How big is a cell? Sizes here are typical values; real cells vary.

Two strips at different magnifications: near the limit of the naked eye, a 1 mm scale bar with a human egg cell at 0.12 mm; and seen with a microscope, a 0.02 mm scale bar with a typical human cell at 20 μm , a red blood cell at 8 μm , a yeast cell at 4 μm and a bacterium 2 μm long

The egg cell sits right at the edge of what the naked eye can see. Every other cell on that list is far below it — which is why, for most of human history, nobody knew cells were there at all. Finding them waited on a machine. (Sizes are typical values from the cell-biology literature; see Sources.)

Seeing cells — the light microscope (VC2S8U02.E02)

A **light microscope** shines light up through a thin sample and uses glass **lenses** to magnify it — to make it look many times bigger. With a school light microscope you can examine a variety of cells, including single-celled organisms from pond water. Other ways of examining cells in this band are a **digital microscope** (a camera and a screen instead of an eyepiece — the instrument met in subtopic 3C), **simulations**, and **photomicrographs** — photos taken through a microscope.



A labelled compound light microscope: eyepiece lens, body tube, arm, objective lenses, stage with slide, light, coarse and fine focus knobs, and base

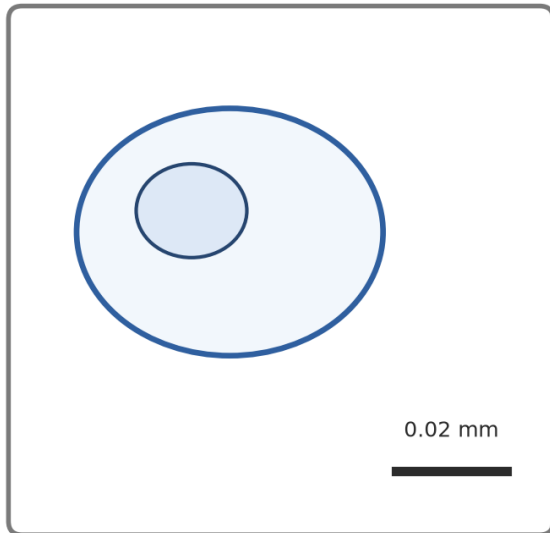
Using it well takes a routine: carry the microscope by the arm and base, start on the lowest power, clip the slide to the stage, bring the sample into view with the coarse focus knob, then sharpen the picture with the fine focus knob. The lenses close to the sample are the **objective lenses**; the lens you look through is the **eyepiece lens**. The total magnification is found by multiplying the eyepiece magnification by the objective magnification.

Magnification — how much bigger is the image?

Magnification says how many times bigger an image is than the real thing:

magnification = image size ÷ actual size

An image of a cell (a photomicrograph)



In the image, the cell measures 40 mm across.

magnification = image size ÷ actual size

$$40 \text{ mm} \div 0.02 \text{ mm} = 2000$$

The image is 2000 times bigger than the real cell — the magnification is $\times 2000$.

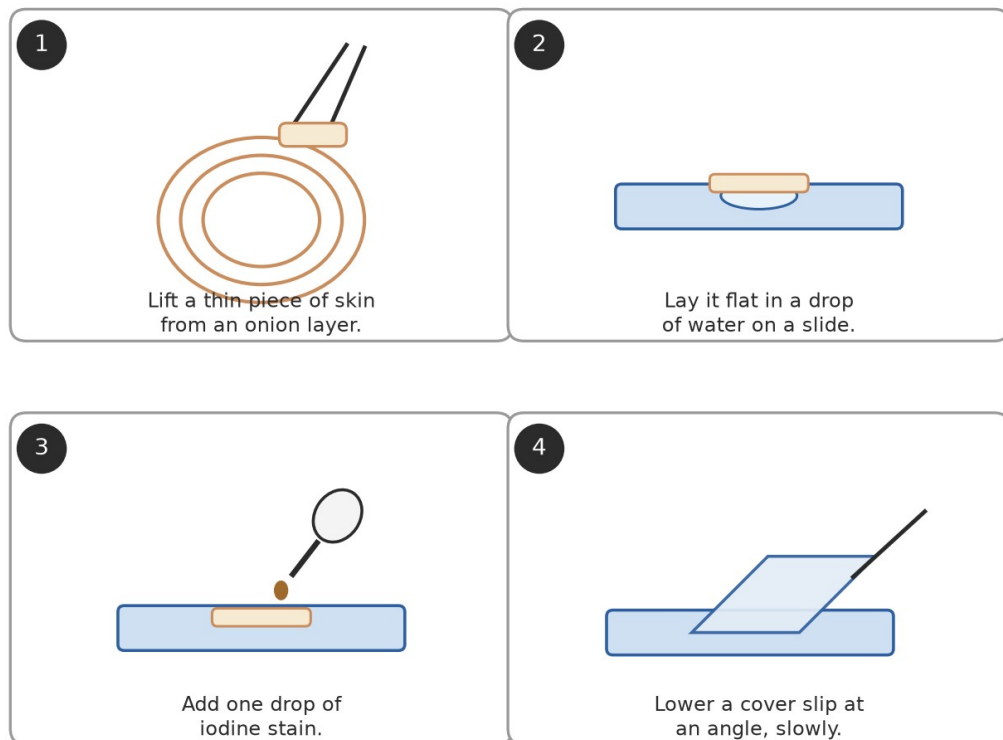
Magnification has no units — it only says how many times bigger the image is than the real thing. Check the two sizes use the same unit first.

A photomicrograph of a cell with a 0.02 mm scale bar, next to the formula magnification = image size ÷ actual size, worked as $40 \text{ mm} \div 0.02 \text{ mm} = 2000$, and a note that magnification has no units

Two rules make it safe. First, put both sizes in the **same unit** before dividing. Second, magnification carries **no unit** — it is only a “times bigger” number, written $\times 1000$ or $\times 2000$. A photomicrograph also usually carries a **scale bar** — a line labelled with the true length it stands for — so a size can be read straight off the image.

Making a wet mount of onion skin (VC2S8U02.E03)

To look at cells from a solid material like onion, the sample is mounted in a thin film of liquid on a slide — a **wet mount**.



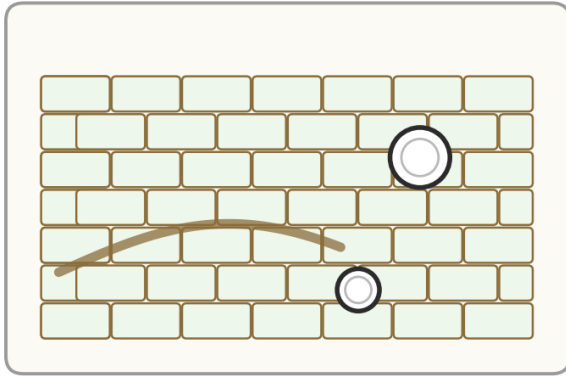
Making an onion wet-mount slide — four steps.

Four steps for making an onion wet mount: 1 lift a thin piece of skin from an onion layer, 2 lay it flat in a drop of water on a slide, 3 add one drop of iodine stain, 4 lower a cover slip at an angle, slowly

The thin **cover slip** is lowered at an angle, slowly, so that air is not trapped underneath — trapped air shows up as round bubbles that hide the cells. The iodine **stain** colours the cell parts so they are easier to see. *Risk:* glass slides and cover slips are thin and can break — handle them with care and report any breakage; iodine stains skin and clothing, so handle it with care too. Plan and run the practical with the risk-management guidance from Science ASSIST (see Sources).

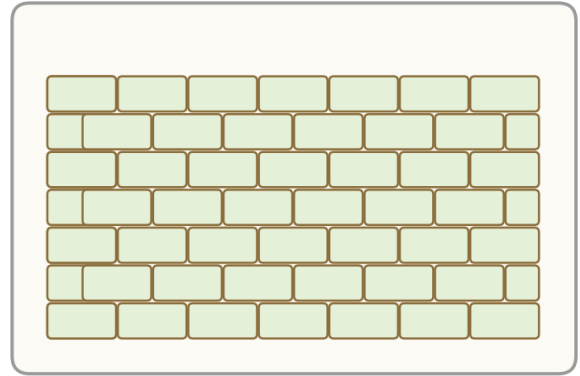
Under the microscope, onion skin looks like a brick wall: rows of box-shaped cells, each with a firm edge — the **cell wall** — and, with stain, a small darker dot in each cell, the **nucleus**. Comparing your own wet mount with a purchased slide is a proper scientific comparison:

A student's wet mount



The layer is folded here and there,
and round air bubbles are trapped.

A purchased slide



A flat, even layer of cells,
neatly stained — no folds, no bubbles.

Both views show onion skin cells with their walls. A carefully made wet mount looks closer to the purchased slide.

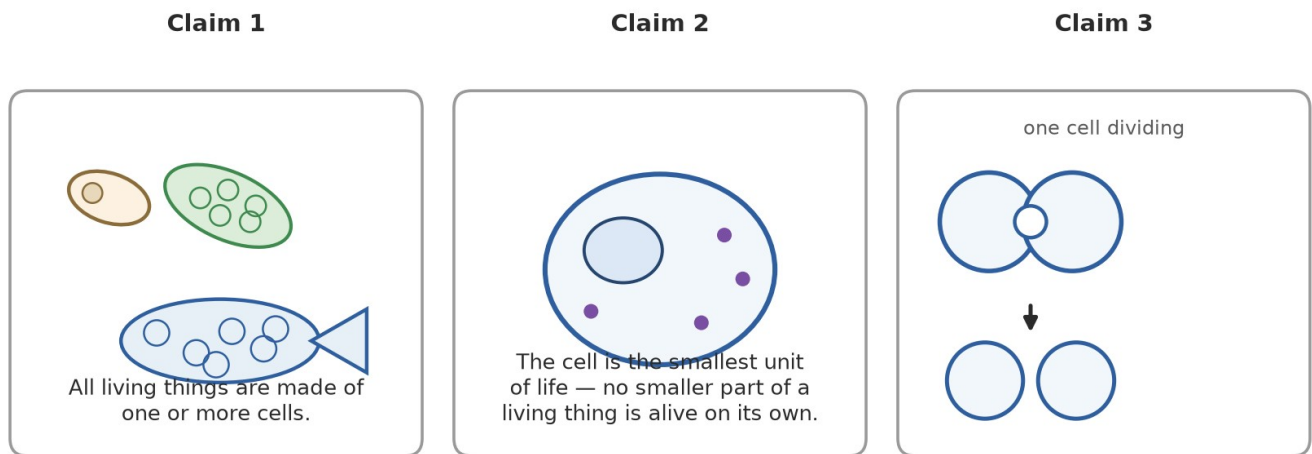
Two photomicrograph panels side by side: a student's wet mount with folded tissue and round air bubbles, and a purchased slide showing a flat, even layer of stained onion cells

A student's wet mount often shows folds and bubbles, because the skin is tricky to lay flat and air is easily trapped; a purchased slide is made with practice and good technique, so it shows a flat, even layer. Both show the same science — box-shaped plant cells with walls. (What the wall, the nucleus and the other parts *do* is the work of subtopic 8B.)

Cell theory — three claims

Pull the evidence together and it forms a theory in three claims:

1. **All living things are made of one or more cells.**
2. **The cell is the basic unit of life** — the smallest piece of living matter that is alive.
3. **All cells come from cells that already exist.**



Cell theory — three claims, built up from centuries of looking.

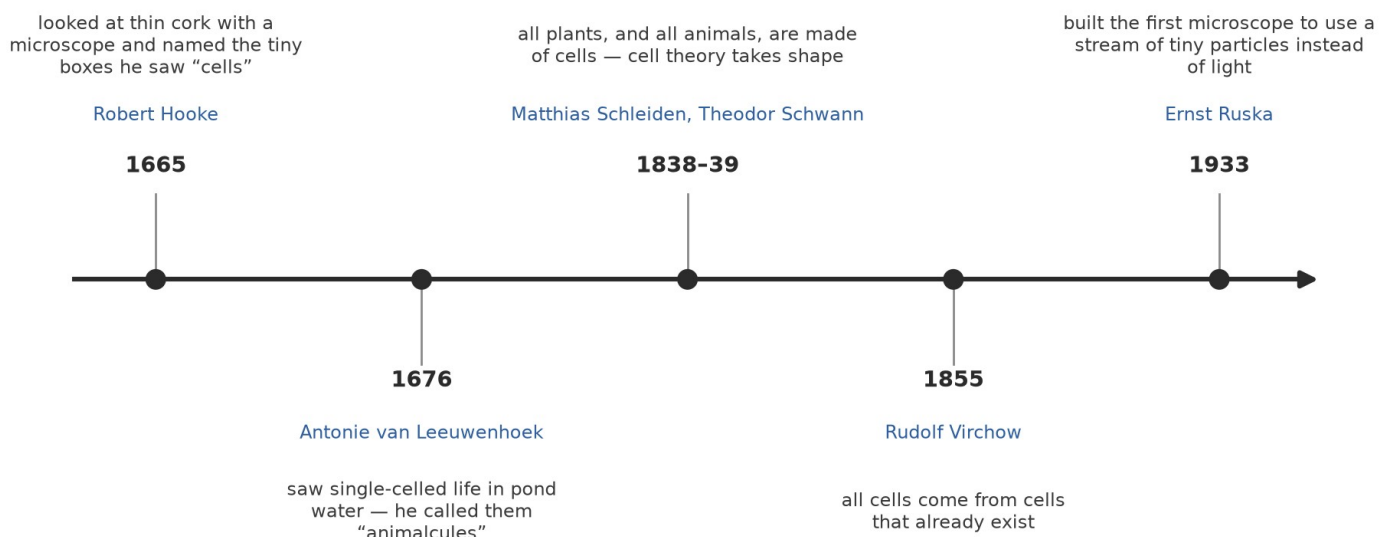
Three panels, one per claim: claim 1 shows a bacterium, a leaf and a fish each built from cells; claim 2 shows a single cell as the smallest unit of life; claim 3 shows one cell dividing into two

Claim 1 says the cell is universal — from a bacterium to a blue whale, life is built from cells. Claim 2 says nothing smaller than a cell is alive: a cell has parts, but no part of a cell is alive on its own. Claim 3 says life does not appear from nothing — every cell you have ever seen came from an earlier cell dividing.

How cell theory was built — better tools, better seeing (VC2S8U02.E07)

Cell theory was not written down in a day. It grew across centuries, and each step waited on a better tool:

Better tools, better seeing — the story behind cell theory



A timeline from 1665 to 1933: Hooke names the tiny boxes in cork "cells"; Leeuwenhoek sees single-celled life in pond water; Schleiden and Schwann find that plants and animals are made of cells; Virchow states that all cells come from cells; Ruska builds the first microscope to use a stream of tiny particles instead of light

- **1665** — **Robert Hooke** looked at thin slices of cork with an early microscope and saw tiny empty boxes, which he named **cells** (after the small rooms monks live in).
- **1676** — **Antonie van Leeuwenhoek**, using single lenses he ground himself, was the first person to see living single-celled organisms in pond water; he called them “animalcules”.
- **1838–39** — **Matthias Schleiden** (plants) and **Theodor Schwann** (animals) showed that both great groups of living things are built from cells — cell theory takes shape.
- **1855** — **Rudolf Virchow** added the third claim: all cells come from cells that already exist.
- **1933** — **Ernst Ruska** built the first microscope to use a **stream of tiny particles instead of light**. Far more powerful than the light microscope, it brings the parts *inside* cells into view.

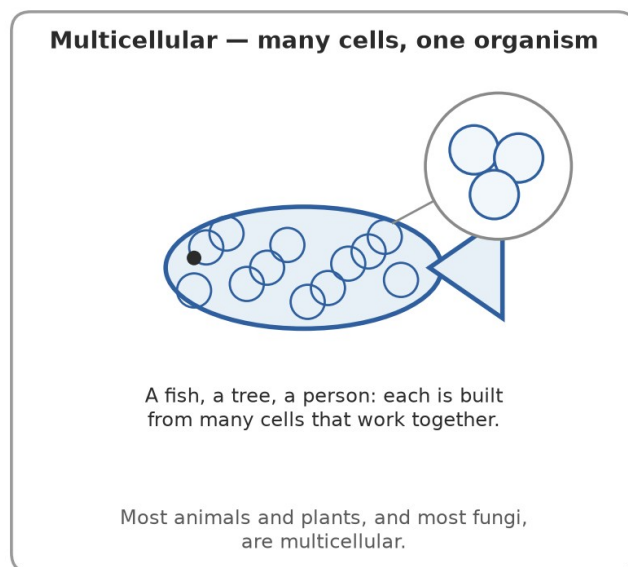
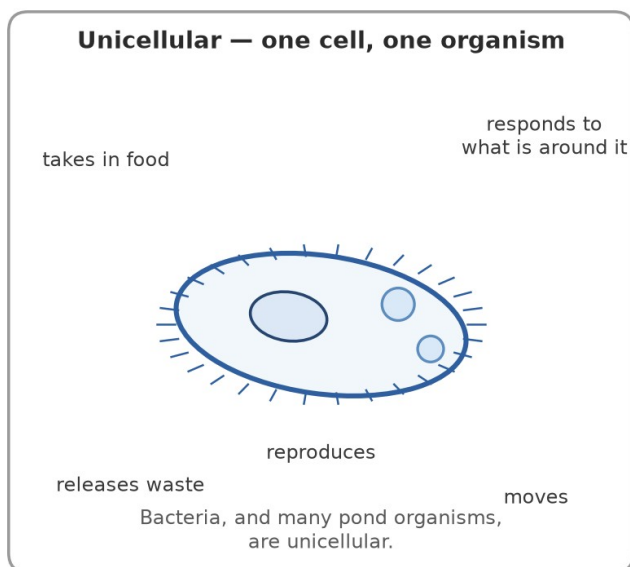
Notice the pattern: each new claim followed a better instrument. In science, seeing more is how understanding grows (the theme of Chapter 1).

The basic unit of life

Claim 2 deserves a closer look, because it is the one that gives the cell its title as the basic unit of life. An organism shows the requirements for life (subtopic 7A): it takes in materials, releases wastes, responds to what is around it, grows and reproduces. A single living cell does all of these too. But no part of a cell — none of the tiny structures inside it — can do them on its own. The cell is the smallest unit at which life happens. That is why a broken-open cell is not a smaller living thing; it is parts, and parts are not alive.

Unicellular organisms — one cell, one whole organism

An organism made of a single cell is **unicellular**. That one cell must do every job of life by itself: taking in food, releasing wastes, responding, moving and reproducing.



One cell can be a whole organism — or many cells can share the work.

Two panels: a unicellular organism drawn as one cell covered in tiny hairs, with labels for taking in food, releasing waste, responding, moving and reproducing; and a multicellular organism drawn as a fish built from many cells, with a zoom showing the individual cells

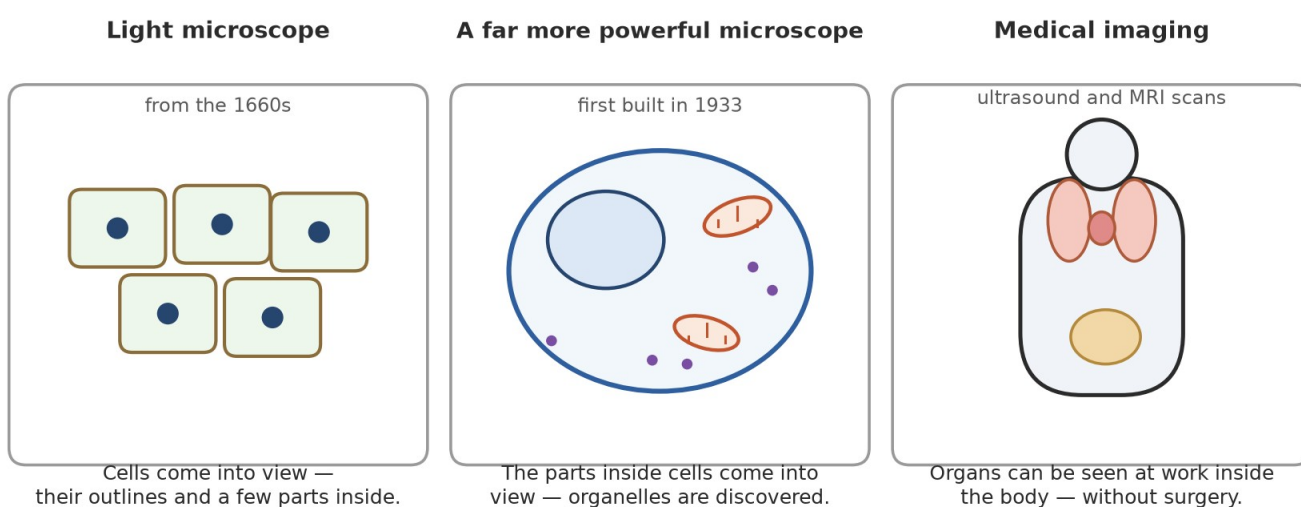
Bacteria are unicellular, and so are many of the organisms Leeuwenhoek saw in pond water. Yeast — the fungus used in bread — is unicellular too. A unicellular organism is not a *part* of anything larger; the single cell *is* the whole organism.

Multicellular organisms — many cells working together

An organism built from many cells is **multicellular**. Most animals, most plants and most fungi are multicellular — you are. In a multicellular organism the cells work together, and they are often shaped for particular jobs: a red blood cell is a small flexible disc for squeezing through narrow tubes, while a nerve cell is a long thin wire for carrying messages over a distance. The story of those specialised structures is told in subtopic 8B, and the way cells group into tissues and organs is told in subtopic 8C. Here, the claim is the simpler one: many cells, one organism.

Technology kept improving understanding (VC2S8U02.E07)

The story did not stop with the light microscope. Each new tool opened a new layer of the living world:



As tools improved, seeing improved — and understanding of cells, tissues and organs grew with it.

Three panels: a light microscope view showing cell outlines and a few parts inside; a view through a far more powerful microscope showing the parts inside a cell, from which organelles were discovered; and medical imaging (ultrasound and MRI scans) showing organs at work inside the body without surgery

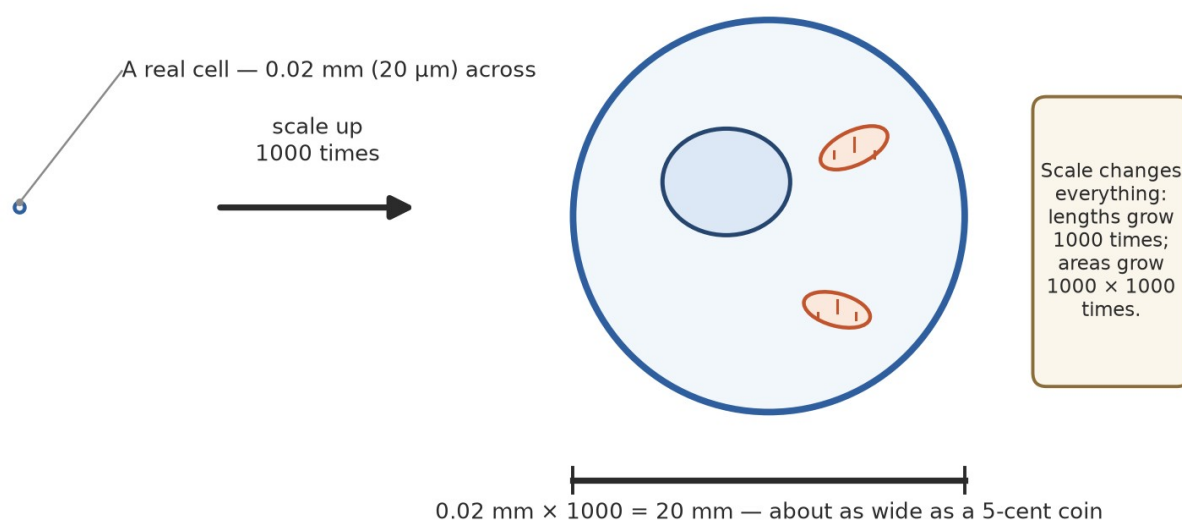
- The **light microscope** (from the 1660s) brought cells themselves into view.
- A **far more powerful microscope** (first built in 1933), using a stream of tiny particles instead of light, magnifies thousands of times more, bringing the tiny structures *inside* cells into view — this is how the organelles named in 8B were discovered.
- **Medical imaging**, such as ultrasound and MRI scans, lets doctors see organs at work inside the living body without cutting it open — feeding the tissues-and-organs story of 8C.

Better tools, better seeing, better understanding: cells, then the parts inside cells, then organs at work. That sequence is the clearest example in this book of technology driving science forward.

Scaling a cell up — making the tiny big enough to hold (VC2M7M06)

Because cells are so small, scaling them up is a powerful way to think about them. Scale a typical 20 μm cell up 1000 times and it becomes 20 mm across — about as wide as a 5-cent coin, a size you can hold.

A model cell, 1000 times bigger



Scaling a cell up to a size you can hold is how models make the tiny visible.

A tiny real cell (0.02 mm across) scaled up 1000 times into a 20 mm model cell beside a 20 mm scale bar, with a note that lengths grow 1000 times while areas grow 1000×1000 times

Scaling obeys the ratio rules of VC2M7M06: if every **length** grows 1000 times, then every **area** grows 1000×1000 times and every **volume** grows $1000 \times 1000 \times 1000$ times. Scale is never just “bigger” — it changes lengths, areas and volumes by different ratios, which is exactly why a model cell (subtopic 4B) must be read with its strengths and its limits in mind.

Words to know in 8A

Word	What it means here
cell	the basic unit of life — the smallest piece of living matter that is still alive
cell theory	the theory in three claims: all living things are made of one or more cells; the cell is the basic unit of life; all cells come from cells that already exist
organism	any living thing
unicellular	made of a single cell that does every job of life
multicellular	built from many cells working together
micrometre (μ m)	one thousandth of a millimetre; the unit used for the sizes of cells
light microscope	an instrument that shines light through a thin sample and uses lenses to magnify it
eyepiece lens	the lens of a microscope that you look through
objective lens	a lens of a microscope close to the sample
stage	the flat part of a microscope that the slide sits on
magnification	how many times bigger an image is than the real thing; image size $\div$ actual size
photomicrograph	a photo taken through a microscope
scale bar	a line on an image, labelled with the true length it stands for

Word	What it means here
wet mount	a sample mounted in a thin film of liquid on a slide, under a cover slip
cover slip	the very thin glass square lowered over a wet mount
stain	a coloured liquid, such as iodine, used to make cell parts easier to see
bacterium (bacteria)	a unicellular organism, much smaller than a plant or animal cell, with no nucleus

Worked examples

Example 1 — scaffolded

Work with the micrometre.

Working	Comment
1. 0.05 mm to μm : $0.05 \times 1000 = 50 \mu\text{m}$.	Millimetres to micrometres: multiply by 1000.
2. 250 μm to mm: $250 \div 1000 = 0.25 \text{ mm}$.	Micrometres to millimetres: divide by 1000.
3. Which is bigger, a 15 μm cell or a 0.02 mm cell? 0.02 mm = 20 μm , and $20 \mu\text{m} > 15 \mu\text{m}$, so the 0.02 mm cell is bigger.	To compare two sizes, put them in the same unit first.

Example 2 — scaffolded

A photomicrograph shows a cell. In the image the cell measures 30 mm across; the real cell is 0.03 mm across. Find the magnification.

Working	Comment
1. Units: both sizes are in mm.	Same unit before dividing — rule one.
2. magnification = image size $\div$ actual size = $30 \text{ mm} \div 0.03 \text{ mm} = 1000$.	The $\div$ gives a plain number.
3. Check: $0.03 \text{ mm} \times 1000 = 30 \text{ mm} \checkmark$. The magnification is $\times 1000$.	Magnification has no unit — write it as $\times 1000$.

Example 3 — unscaffolded

A drop of pond water is examined under a light microscope. One organism in it is a single cell about 0.2 mm long that moves, takes in food, releases wastes and reproduces. (a) Is this organism unicellular or multicellular? (b) Which claim of cell theory says that this organism, being alive, must be made of one or more cells? (c) Name the instrument that made this observation possible, and say why the organism cannot be studied this way with the naked eye.

This organism is **one cell doing every job of life**, so it is **unicellular**. The claim that says a living thing must be made of one or more cells is **claim 1 — all living things are made of one or more cells** (here, exactly one). The instrument is the **light microscope**; at 0.2 mm the organism is only just above the 0.1 mm limit of the naked eye, so its cell structure — the fact that it *is* a single cell — can only be made out with magnification. $\therefore$ a unicellular organism, placed under cell theory's first claim, seen with a light microscope.

Example 4 — unscaffolded

A class builds a model of a typical human cell (20 μm across) at a scale of 1000 times. (a) Find the width of the model in mm. (b) How many times greater than the cell's area is the model's area? (c) How many times greater than the cell's volume is the model's volume? (*Maths interlock VC2M7M06*.)

- (a) $20 \mu\text{m} = 0.02 \text{ mm}$; $0.02 \text{ mm} \times 1000 = 20 \text{ mm}$, about as wide as a 5-cent coin. (b) Areas grow by the length ratio twice over: $1000 \times 1000 = 1\,000\,000$ times. (c) Volumes grow by the length ratio three times over: $1000 \times 1000 \times 1000 = 1\,000\,000\,000$ times. $\therefore$ the model is easy to hold, but its area and volume are out of all proportion to the real cell — a limit to name when using the model.

Practice questions

Scaffolded

- Q1.** Define each of the following, as the words are used in this subtopic: (a) cell; (b) cell theory; (c) unicellular; (d) multicellular.
- Q2.** Work with the units of cell size. (a) Name the unit, one thousandth of a millimetre, used for the sizes of cells. (b) Copy and complete: $1\text{ mm} = \text{---}\text{ }\mu\text{m}$. (c) Convert 0.08 mm to μm . (d) Convert $60\text{ }\mu\text{m}$ to mm .
- Q3.** Name the part of the light microscope that matches each description. (a) The lens you look through. (b) The lenses close to the sample. (c) The flat part the slide sits on. (d) The knob used for small, sharp focusing movements.
- Q4.** The steps below for making an onion wet mount are in the wrong order. Rewrite them in the correct order. (a) Add one drop of iodine stain. (b) Lift a thin piece of skin from an onion layer. (c) Lower a cover slip at an angle, slowly. (d) Lay the skin flat in a drop of water on a clean slide.
- Q5.** State the three claims of cell theory.
- Q6.** In a photomicrograph a cell measures 20 mm across. The real cell is 0.02 mm across. Calculate the magnification.

Unscaffolded

- Q7.** A human egg cell is about 0.12 mm across, and the naked eye can just see a dot of about 0.1 mm . Explain why an egg cell sits at the very edge of what we can see, and why almost all other cells need a microscope to be seen at all.
- Q8.** In 1665 Robert Hooke looked at cork and named the boxes he saw “cells”; in 1676 Antonie van Leeuwenhoek saw living single-celled organisms in pond water. (a) Which of the two was looking at living cells? (b) Explain why neither discovery could have been made a hundred years earlier.
- Q9.** A student says: “*Cell theory is called a theory, so it is only a guess.*” Using the science meaning of *theory*, evaluate this claim.
- Q10.** Compare a student’s onion wet mount with a purchased slide. Name two things the student’s wet mount may show that the purchased slide does not, and give the step in the method that prevents one of them.
- Q11.** Classify each of the following as unicellular or multicellular, with a reason: (a) a bacterium; (b) yeast; (c) an onion.
- Q12.** A class builds a model of a red blood cell ($8\text{ }\mu\text{m}$ across) at a scale of 500 times. (a) Find the width of the model in mm . (b) How many times greater than the cell’s area is the model’s area? (*Maths interlock VC2M7M06.*)
- Q13.** Before 1855, some people thought that living things could simply appear from non-living material left to stand. Explain how Virchow’s claim — all cells come from cells that already exist — disagrees with that idea, and say how a microscope lets the claim be checked.
- Q14.** For each of the following, state what it lets us see and one thing understanding gained: (a) the light microscope; (b) the far more powerful microscope first built in 1933; (c) medical imaging such as ultrasound and MRI scans.
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Answers

Q1. (a) The basic unit of life — the smallest piece of living matter that is still alive. (b) The theory in three claims: all living things are made of one or more cells; the cell is the basic unit of life; all cells come from cells that already exist. (c) Made of a single cell that does every job of life. (d) Built from many cells working together. **Q2.** (a) The micrometre (μm). (b) 1000. (c) 80 μm . (d) 0.06 mm. **Q3.** (a) The eyepiece lens. (b) The objective lenses. (c) The stage. (d) The fine focus knob. **Q4.** (b), (d), (a), (c). **Q5.** 1: all living things are made of one or more cells; 2: the cell is the basic unit of life; 3: all cells come from cells that already exist. **Q6.** $\times 1000$. **Q7.** 0.12 mm is only just above the 0.1 mm the naked eye can see, so the egg cell is at the edge of visibility; other cells (typically 20 μm or less, down to 1–2 μm for bacteria) are far below 0.1 mm, so they cannot be seen without magnification. **Q8.** (a) Leeuwenhoek — the pond-water organisms were alive; Hooke's cork boxes were empty cell walls. (b) Both discoveries needed lenses that magnify; no such instrument existed a century earlier, so the cells were simply not there to be seen. **Q9.** Wrong: in science a theory is an explanation built from a large body of evidence, not a guess; cell theory rests on centuries of observations with microscopes and has held up when tested. **Q10.** Folds in the skin layer, and round air bubbles. Lowering the cover slip at an angle, slowly, prevents the bubbles. **Q11.** (a) Unicellular — one cell, no nucleus, doing all jobs of life. (b) Unicellular — a single-celled fungus. (c) Multicellular — a plant, built from many cells (the wet mount shows them as a brick wall). **Q12.** (a) 4 mm. (b) $500 \times 500 = 250\,000$ times. **Q13.** If all cells come from earlier cells, life cannot appear from non-living material; with a microscope, a sealed sample of sterile liquid can be watched and checked — no cells ever appear in it unless cells get in. **Q14.** (a) Cells themselves — leading to cell theory. (b) The parts inside cells — the organelles were discovered. (c) Organs at work inside the living body — how healthy and disordered organs behave, without surgery.

Fully-worked solutions

Q1. (a) A **cell** is the basic unit of life — the smallest piece of living matter that is still alive (1 mark). (b) **Cell theory** is the theory in three claims: all living things are made of one or more cells; the cell is the basic unit of life; all cells come from cells that already exist (1 mark). (c) **Unicellular** means made of a single cell that does every job of life (1 mark). (d) **Multicellular** means built from many cells working together (1 mark).

Q2. (a) The **micrometre (μm)** (1 mark). (b) 1 mm = **1000 μm** (1 mark). (c) $0.08\text{ mm} \times 1000 = \mathbf{80\text{ }\mu\text{m}}$ (1 mark). (d) $60\text{ }\mu\text{m} \div 1000 = \mathbf{0.06\text{ mm}}$ (1 mark).

Q3. (a) The **eyepiece lens** (1 mark). (b) The **objective lenses** (1 mark). (c) The **stage** (1 mark). (d) The **fine focus knob** (1 mark).

Q4. Correct order: **(b)** lift a thin piece of skin; **(d)** lay it flat in a drop of water on a clean slide; **(a)** add one drop of iodine stain; **(c)** lower a cover slip at an angle, slowly (4 marks — one per correctly placed step).

Q5. Claim 1: **all living things are made of one or more cells**; claim 2: **the cell is the basic unit of life**; claim 3: **all cells come from cells that already exist** (3 marks — one each).

Q6. magnification = image size $\div$ actual size = $20\text{ mm} \div 0.02\text{ mm} = \mathbf{1000}$, written $\times \mathbf{1000}$ (2 marks — one for the working, one for the value).

Q7. At **0.12 mm**, the egg cell is only just above the **0.1 mm** dot the naked eye can see, so it sits at the very edge of visibility (1 mark). A typical cell is about **20 μm (0.02 mm)** and bacteria are **1–2 μm** — far below 0.1 mm — so they are invisible without the magnification a microscope supplies (1 mark).

Q8. (a) **Leeuwenhoek** — his pond-water “animalcules” were living single cells, while Hooke's cork showed only the empty walls of dead cells (1 mark). (b) Both discoveries needed a **magnifying instrument**; a century earlier no microscope existed, so no amount of careful naked-eye looking could have shown cells — the tool came first, the seeing followed (1 mark).

Q9. The claim is **wrong** (1 mark). In science a *theory* is an explanation built from a **large body of evidence**, not a guess; cell theory rests on **centuries of microscope observations** by many independent workers and has held up when tested — the everyday and the science meanings of *theory* are not the same (1 mark).

Q10. A student's wet mount may show **folds** in the skin layer and **round air bubbles**, which a purchased slide does not (2 marks — one each). Bubbles are prevented by **lowering the cover slip at an angle, slowly** (1 mark).

Q11. (a) A bacterium is **unicellular**: it is a single cell, with no nucleus, doing every job of life on its own (1 mark). (b) Yeast is **unicellular**: it is a single-celled fungus (1 mark). (c) An onion is **multicellular**: it is a plant, built from many cells — the wet mount shows them packed like a brick wall (1 mark).

Q12. (a) $8\text{ }\mu\text{m} = 0.008\text{ mm}$; $0.008\text{ mm} \times 500 = 4\text{ mm}$ (2 marks — one for the conversion, one for the scale-up). (b) Areas grow by the length ratio twice over: $500 \times 500 = 250\text{ }000\text{ times}$ (1 mark).

Q13. Virchow's claim says every cell has a parent cell, so **living things cannot appear from non-living material** (1 mark). The claim can be checked with a **microscope**: watch a sealed sample of sterile liquid and **no cells ever appear in it** unless cells are let in — exactly what the claim predicts (1 mark).

Q14. (a) The light microscope lets us see **cells themselves**; from it, **cell theory** was built (1 mark). (b) The far more powerful microscope first built in 1933 — it uses a stream of tiny particles instead of light — lets us see **the parts inside cells**; from it, the **organelles** were discovered (1 mark). (c) Medical imaging lets us see **organs at work inside the living body** without cutting it open; from it, understanding of **how healthy and disordered organs behave** (1 mark).

Sources

Web sources below were retrieved 2026-08-21.

- Wikipedia, "Cell theory", 2026. en.wikipedia.org
- NobelPrize.org, "Ernst Ruska – Facts", n.d. nobelprize.org
- Milo, R. and R. Phillips, *Cell Biology by the Numbers* — Book of BioNumbers, "How big is a human cell?" (red blood cell 7–8 μm , egg cell $\approx 120\text{ }\mu\text{m}$, typical human cell $\approx 20\text{ }\mu\text{m}$), n.d. book.bionumbers.org
- Milo, R. and R. Phillips, *Cell Biology by the Numbers* — Book of BioNumbers, "How big is an *E. coli* cell and what is its mass?" ($\approx 2\text{ }\mu\text{m}$ long, $1\text{ }\mu\text{m}$ wide), n.d. book.bionumbers.org
- Milo, R. and R. Phillips, *Cell Biology by the Numbers* — Book of BioNumbers, "How big is a budding yeast cell?" ($\approx 4\text{ }\mu\text{m}$), n.d. book.bionumbers.org
- Science ASSIST (Australian Science Teachers' Association), "Science Assist", n.d. asta.edu.au

The cell sizes quoted are **typical values** from the cell-biology literature; real cells vary. The historical sequence (Hooke 1665, Leeuwenhoek 1676, Schleiden 1838, Schwann 1839, Virchow 1855, Ruska 1933) follows the standard account in the sources above.

Elaboration contexts used: VC2S8U02.E01 (the zoom-in and the scale of cells), VC2S8U02.E02 (the labelled light microscope and the ways of examining cells), VC2S8U02.E03 (the wet-mount method and the student-against-purchased comparison) and VC2S8U02.E07 (the history timeline and the sequence of improving microscopes and medical imaging).

Organelles and what they do: cell walls, cell membranes, cytoplasm, nuclei containing DNA, mitochondria, ribosomes, chloroplasts and vacuoles — plant against animal

What we teach here — VC2S8U02 (Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8):

“cell theory describes cells as the basic units of life; organisms may be unicellular or multicellular and have specialised structures and organelles (including cell walls, cell membranes, cytoplasm, nuclei containing DNA, mitochondria, ribosomes, chloroplasts and vacuoles) that perform specific functions”

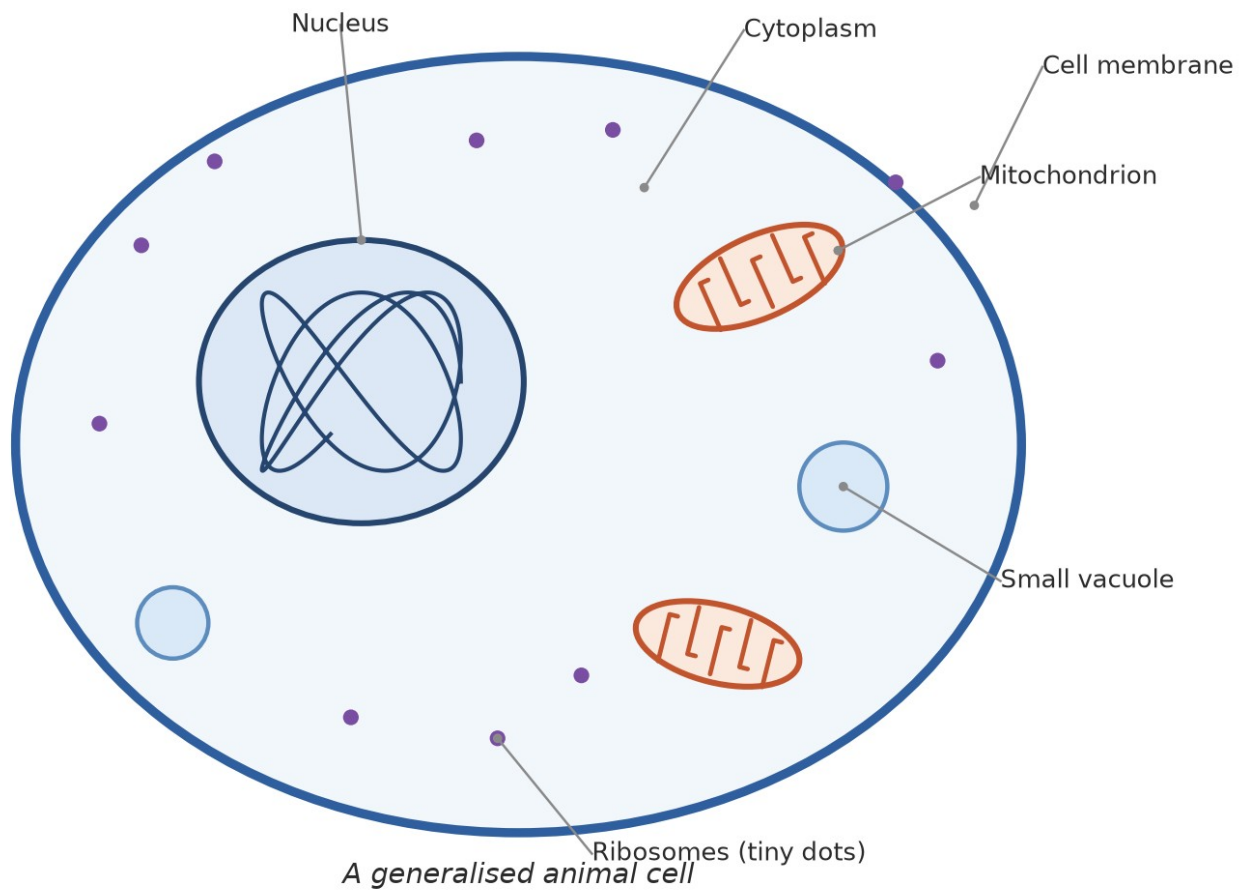
This subtopic owns the second clause only: the specialised structures and organelles listed in the CD, the specific function of each, and plant cells set against animal cells. The first clause — cell theory, and unicellular and multicellular organisms — belongs to the partner subtopic **8A** (+ split delivery, D6). **In our words:** every cell is a tiny busy workshop — a gate that lets things in and out, a control centre holding the DNA instructions, tiny machines that release energy, build proteins and capture light to make food, and storage sacs. Plant cells add three extras on top: a firm wall, food-making chloroplasts and a large central vacuole. **Achievement-standard extract served here (D13):** cited by reference to the header of the owner subtopic 8A, where the extract appears in full. **Elaborations drawn on:** VC2S8U02 . E04 (comparing plant, animal, bacteria and fungi cells), VC2S8U02 . E05 (designing and constructing a cell model, with feedback from classmates on its strengths and limits) and VC2S8U02 . E06 (a practical investigation modelling a cell process — here, diffusion). **Authored from the CD text and the elaboration contexts (D12):** the CD names each organelle but not its job; the jobs taught here are the standard functions of each structure, and the three elaborations above supply the comparison, modelling and investigation contexts.

Word watch — *respiration*. In everyday talk, *respiration* sometimes just means breathing. In science, breathing and respiration are not the same thing. **Respiration** is the process that releases energy from food inside every living cell, so the cell has energy to do its work. Breathing only moves air in and out of the body; respiration happens in cells — in every cell of your body, all the time. In this subtopic, *respiration* always carries the science meaning, and the organelle where most of that energy release happens is the **mitochondrion**.

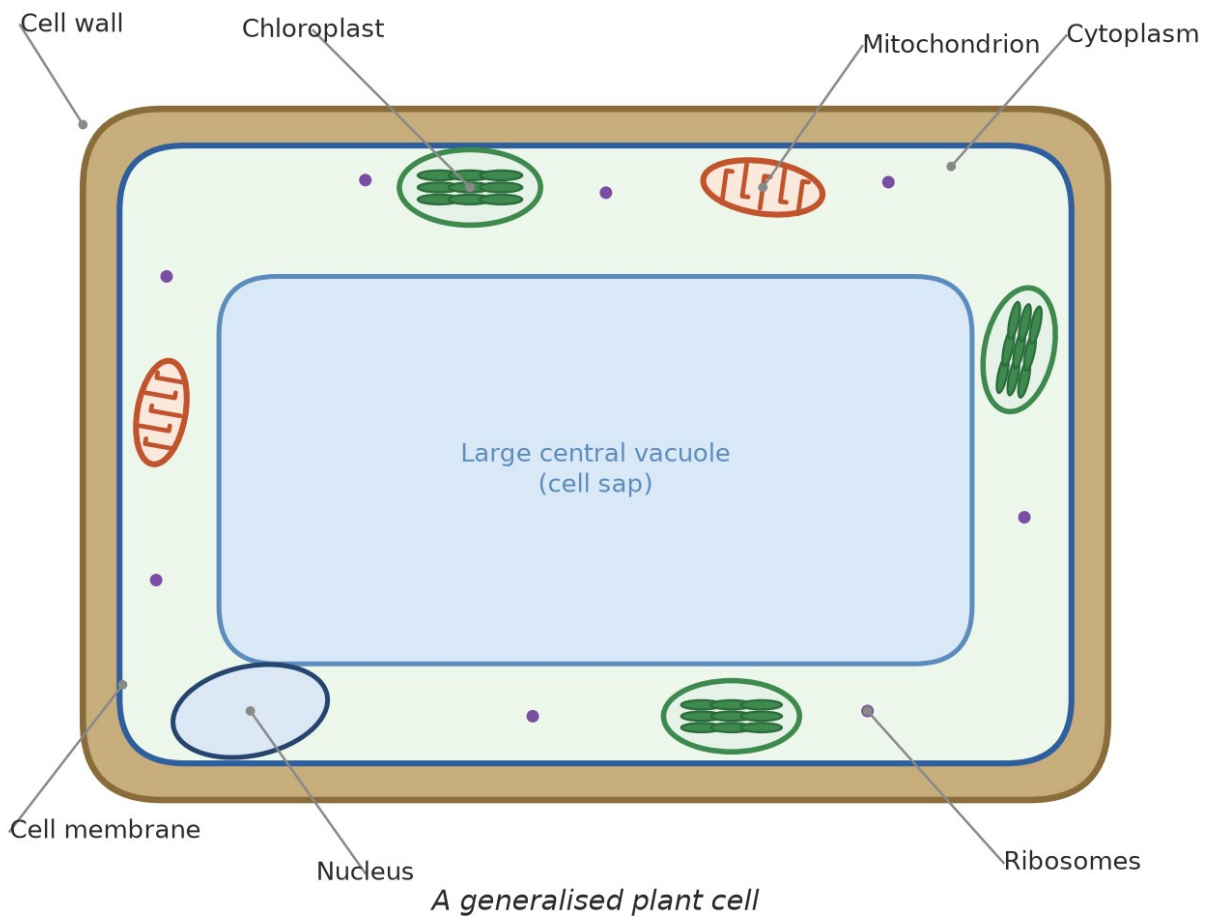
Theory

Opening the cell (8A looked at the whole cell)

Subtopic 8A showed that all living things are made of cells, and that some organisms are single cells while others are built from many. Here we open the cell and meet the parts inside it. Each part is an **organelle** — a structure inside a cell that has a specific job. This subtopic tours the organelles one by one, sets a plant cell against an animal cell, and ends with a model and an investigation, because building and testing are how the parts become real.



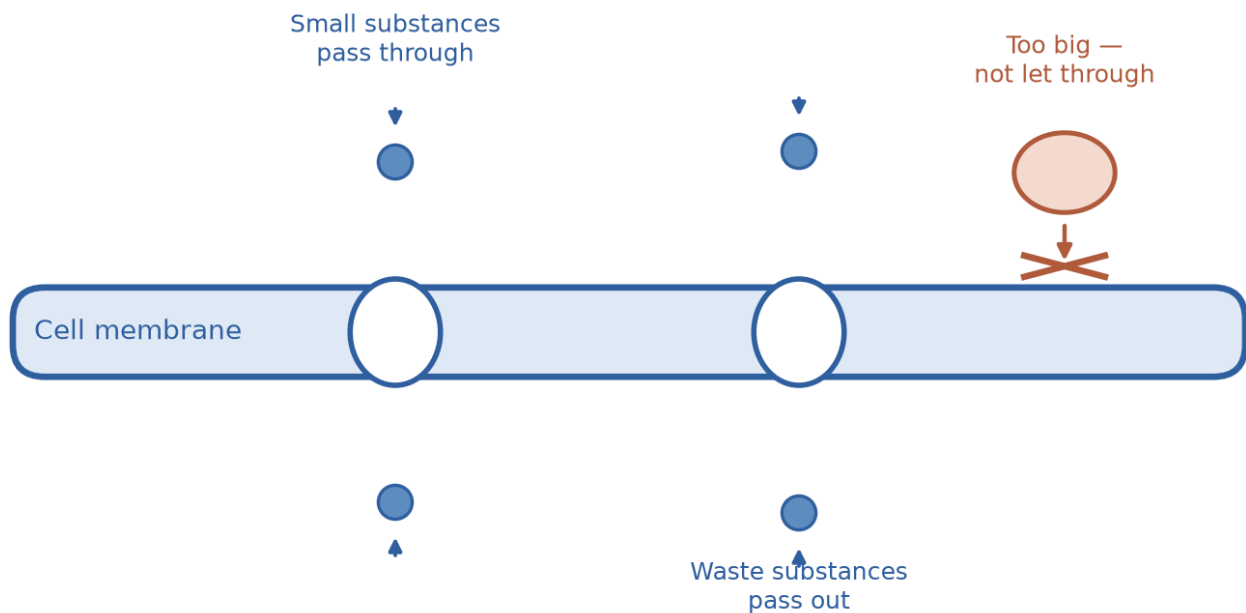
A labelled animal cell: a rounded cell with a cell membrane on the outside and, in the cytoplasm, a nucleus holding DNA, mitochondria and ribosomes



A labelled plant cell: a box-shaped cell with a cell wall outside the cell membrane, and a large central vacuole, chloroplasts, a nucleus, mitochondria and ribosomes in the cytoplasm

The cell membrane — the gatekeeper

Every cell is wrapped in a **cell membrane**, a thin layer that works like a gatekeeper. Useful substances are let in, wastes are let out, and things the cell does not want are kept out. A membrane that lets some substances through and not others is called **selectively permeable**. Without this gate, the cell could not keep its inside different from the outside.



The cell membrane lets some substances through and keeps others out.

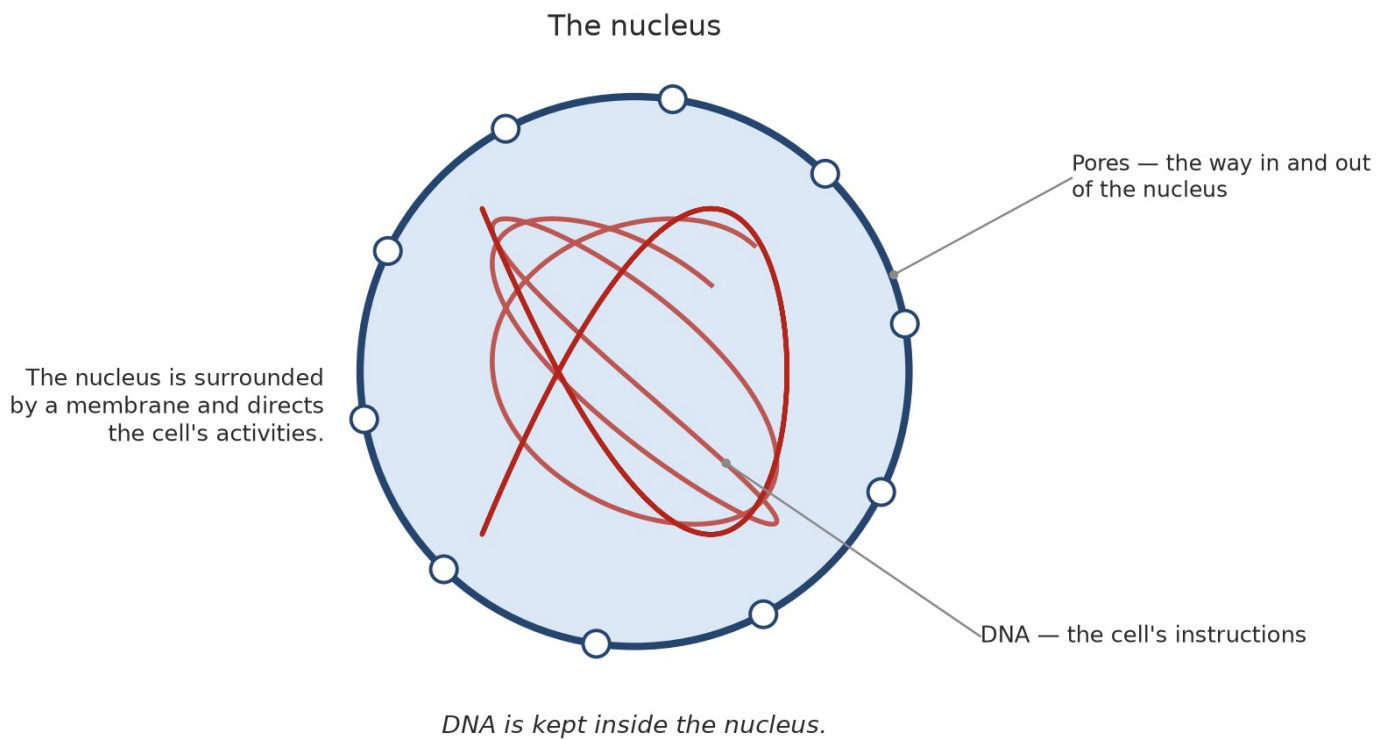
The cell membrane drawn as a gate: useful substances and oxygen let in, wastes and carbon dioxide let out, harmful things kept out

The cytoplasm — where most of the action happens

Inside the membrane, the space is filled with **cytoplasm**, a jelly-like material in which the organelles sit. Most of the cell's day-to-day chemistry happens in the cytoplasm, and substances move about through it.

The nucleus — the control centre holding the DNA

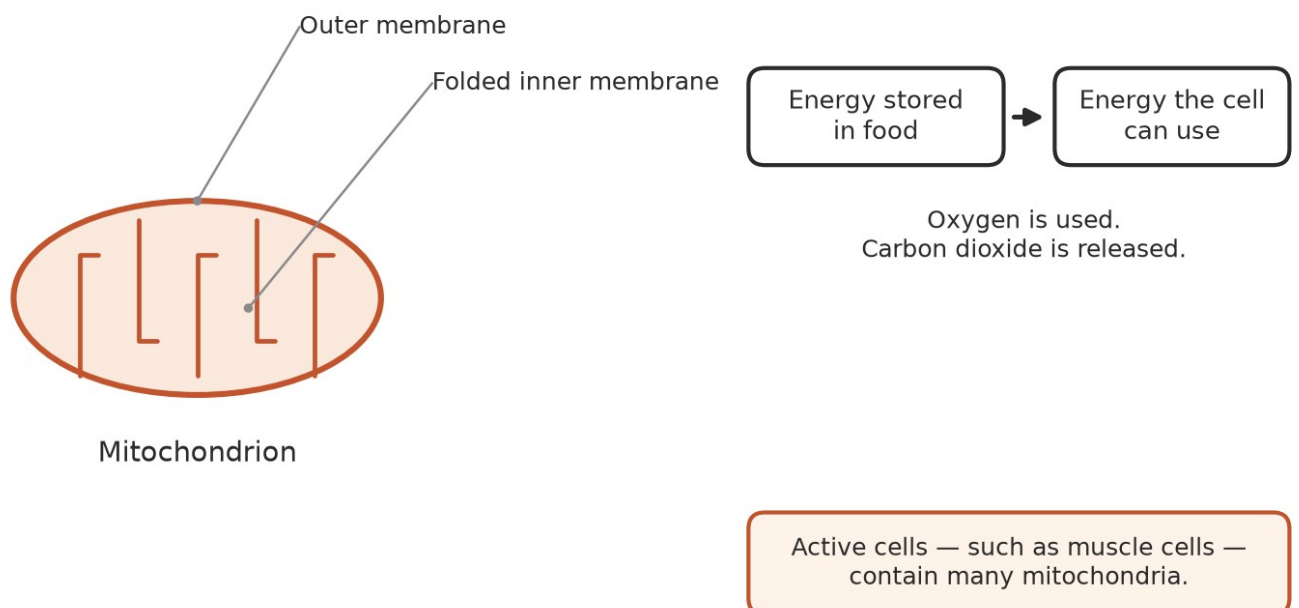
The **nucleus** is the control centre of the cell. It holds the cell's **DNA** — the material that carries the instructions for building and running the cell. When the cell needs something made, the instructions for it come from the DNA in the nucleus. (What the DNA is like in detail, and how it is passed on, is saved for later years — here, DNA is the all-important content of the nucleus.)



A nucleus drawn as the control centre of the cell, with the DNA instructions coiled inside it

Mitochondria — releasing energy from food

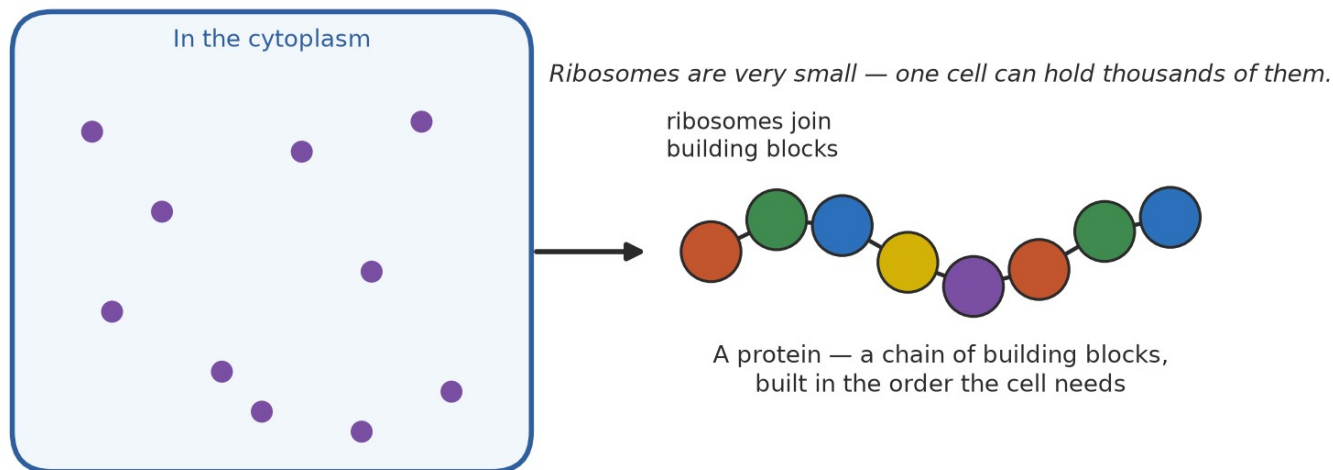
Mitochondria (one is a **mitochondrion**) release the energy stored in food, using oxygen, so the cell can use it for its work. This release of energy from food inside cells is **respiration** — see the Word watch above. Carbon dioxide is given off as a waste gas. Cells that work hard, like muscle cells, hold many mitochondria.



A mitochondrion: food and oxygen go in, energy is released for the cell to use, and carbon dioxide and water leave as wastes

Ribosomes — building proteins

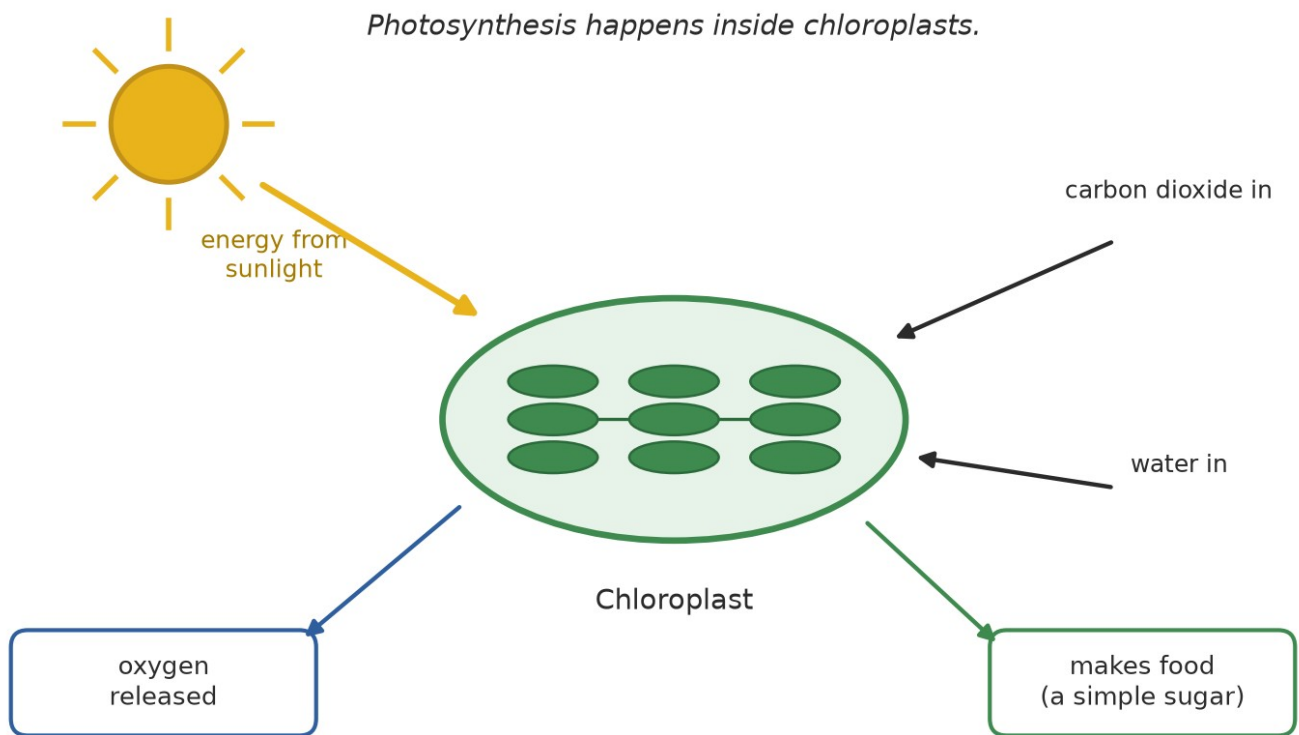
Ribosomes are the cell's smallest machines, scattered in the cytoplasm. They join small building blocks into chains to make **proteins** — the building and working materials of the cell, needed for growth and repair. Each protein is built in the order the cell needs it. Ribosomes are very small — one cell can hold thousands of them.



Ribosomes in the cytoplasm joining building blocks into a protein chain, built in the order the cell needs

Chloroplasts — capturing light to make food

Chloroplasts are found in plant cells (and not in animal cells). Inside them is **chlorophyll**, a green **pigment** — a coloured substance — that captures light energy. The chloroplast uses that energy to make food for the cell: a simple sugar, built from carbon dioxide and water. Oxygen is released as well. This food-making process is **photosynthesis**. Chloroplasts are why plants can make their own food, and why leaves are green.

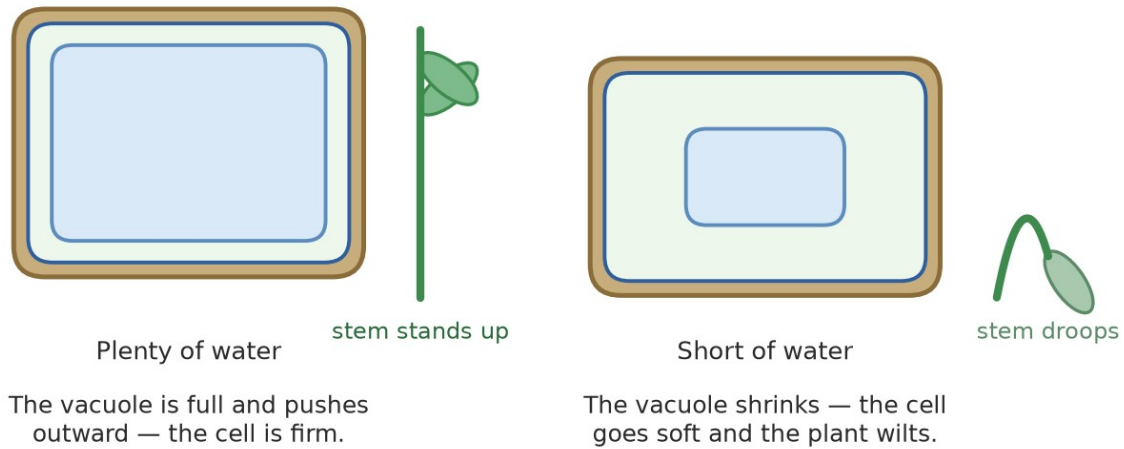


A chloroplast capturing sunlight: carbon dioxide and water go in, the chloroplast makes food, and oxygen is released

Vacuoles — storage sacs

A **vacuole** is a storage sac. Plant cells have one **large central vacuole**, filled with water and useful substances dissolved in it. When the vacuole is full, it pushes outward against the rest of the cell and keeps the cell firm — which is why a well-watered plant stands up. When water is short, the vacuole shrinks, the cell goes soft, and the plant sags. Animal cells, if they have vacuoles at all, have only small ones that come and go.

A plant cell's large central vacuole stores water and helps keep the plant firm.



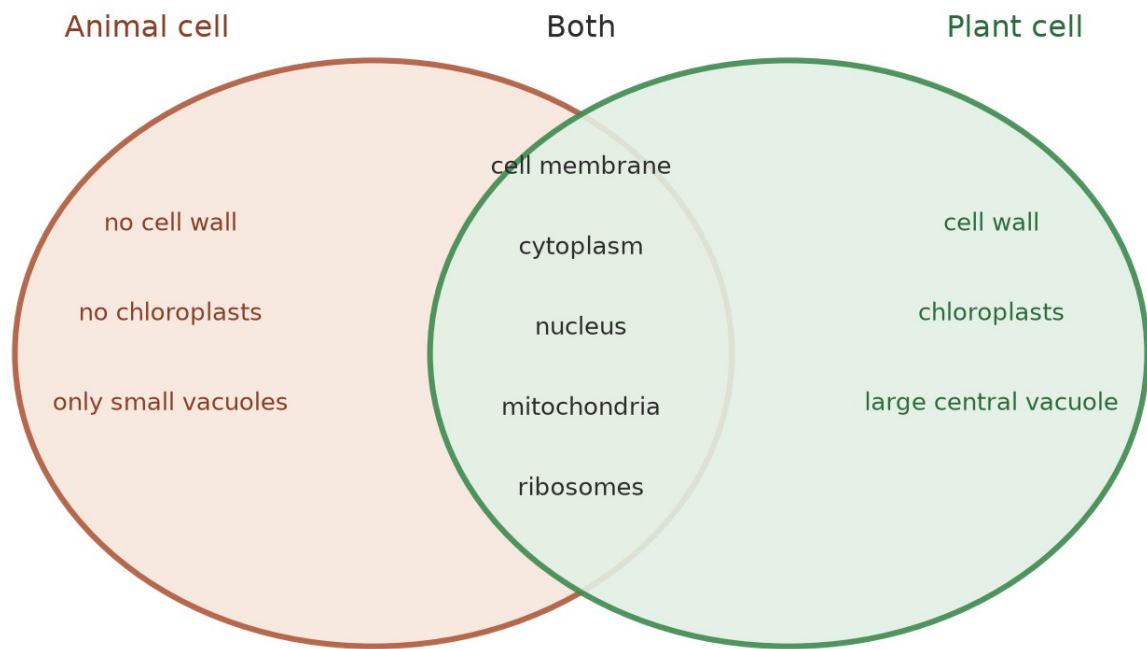
Two plant cells side by side: with plenty of water the vacuole is full and the stem stands up; short of water the vacuole shrinks and the stem droops

The cell wall — a firm outer layer

Outside its membrane, a plant cell has a **cell wall**, a firm layer built mostly from a strong material called **cellulose**. The wall gives the cell its shape and support, and protects it. Animal cells have no cell wall — the membrane is their outer layer.

Plant against animal

Set a plant cell against an animal cell and the two share most of their parts: cell membrane, cytoplasm, nucleus with its DNA, mitochondria and ribosomes. The differences are the three plant-only structures — the cell wall, the chloroplasts and the large central vacuole. An animal cell has none of these.



Plant and animal cells share most of their parts — the differences are the plant-only structures.

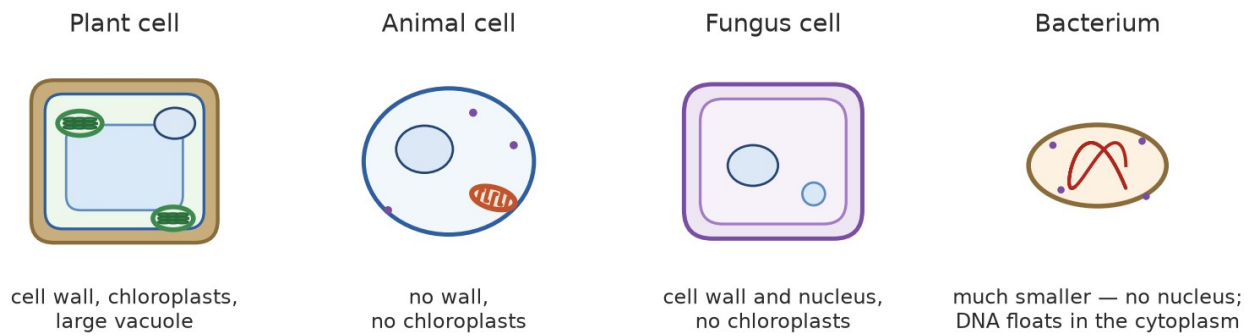
A Venn diagram comparing animal and plant cells: both share the cell membrane, cytoplasm, nucleus, mitochondria and ribosomes; the plant cell adds the cell wall, chloroplasts and a large central vacuole

Four kinds of cell (VC2S8U02.E04)

Cells are not all alike across living things. Compare four kinds:

- A **plant cell** has a cell wall, chloroplasts and a large central vacuole, plus the parts all these cells share.
- An **animal cell** has no wall and no chloroplasts, and only small vacuoles.
- A **fungus cell** — the group that includes mushrooms — has a cell wall and a nucleus, but no chloroplasts, so a fungus cannot make its own food the way a plant does.
- A **bacterium** is a single cell, much smaller than the other three. It has no nucleus — its DNA floats free in the cytoplasm.

The same basic parts keep appearing — membrane, cytoplasm, DNA — but not every cell has every part.



Four kinds of cell, drawn to one idea: cells share the same basic parts, but not every cell has every part.

Four kinds of cell drawn side by side: a plant cell with wall, chloroplasts and large vacuole; an animal cell with no wall and no chloroplasts; a fungus cell with wall and nucleus but no chloroplasts; and a much smaller bacterium with no nucleus and its DNA floating free

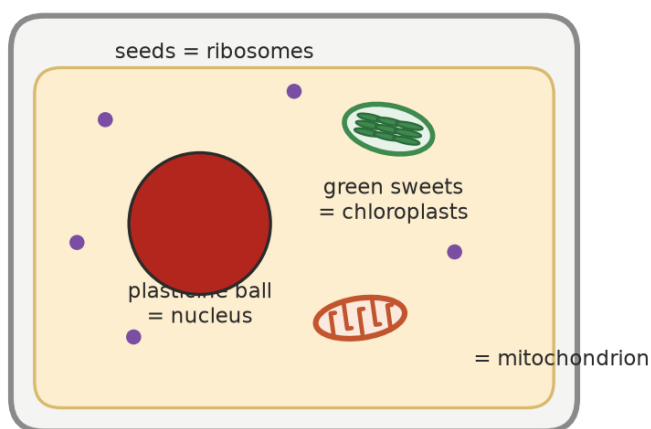
Building a cell model — strengths and limits (VC2S8U02.E05)

A good way to learn the organelles is to build a model. Picture a model made from a plastic bag (the membrane), jelly (the cytoplasm), a marble (the nucleus), small beads (ribosomes) and green peas (chloroplasts). Building it, and getting feedback from classmates, sharpens the picture — and so does asking what the model shows well and where it falls short.

- **Shows well:** the parts of a plant cell and where they sit; the membrane as an outer wrapping; the cytoplasm as the material the parts sit in.
- **Falls short:** the bag cannot choose what goes through it, the way a real membrane does; the jelly does not move and work like real cytoplasm; the parts are not the right sizes relative to each other; and a model sits still, while a real cell is busy all the time.

Every model has strengths and limits. Naming both is what makes a model useful in science.

A student's model cell — a container of jelly



Strengths

shows what parts a cell has,
and roughly where they sit

Limits

the sizes and colours are not real;
the model is not alive and does not show
the parts working

Every model is useful and incomplete — saying both is part of building one (subtopic 4B).

A student's cell model made from a bag, jelly, a marble, beads and peas, with boxes listing what the model shows well and where it falls short

Investigation: watching diffusion happen (VC2S8U02.E06)

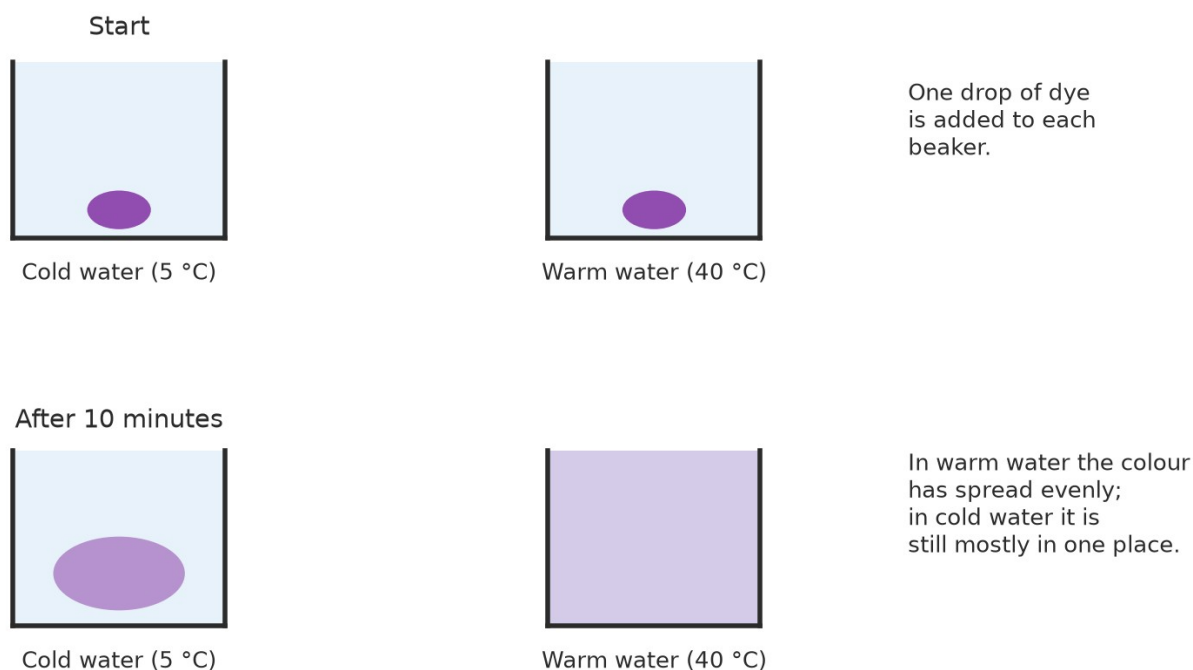
Substances move into, out of and about cells by **diffusion** — the spreading of a substance from where there is a lot of it to where there is little, until it is even. This investigation models that spreading with a drop of food dye in water, and asks whether warmth changes how fast it happens.

- **Equipment (subtopic 3C):** three identical beakers, a measuring cylinder to give each the same volume of water, a thermometer, a dropper for same-sized drops of dye, and a timer.
- **Variables (subtopic 3A):** what is changed is the water temperature (5 °C, 22 °C and 40 °C); what is measured is the time taken for the dye to spread evenly; what is kept the same includes the volume of water, the beakers, the dye and the drop size, and no stirring.
- **Risk (subtopic 3B):** warm water at 40 °C will not burn skin, but pour slowly and carry beakers with two hands; wipe up spills straight away so nobody slips; handle glass beakers with care and report any breakage. Plan and run the investigation with the risk-management guidance from Science ASSIST (see Sources).

Method: set up the three beakers at their three temperatures, drop one drop of dye into each at the same moment, start the timer, and record the time each beaker takes to reach an even colour.

Beaker	Water temperature	Time for the dye to spread evenly
1	5 °C	14 minutes
2	22 °C	8 minutes
3	40 °C	4 minutes

(Simulated data for practice.)



The investigation is drawn here with simulated data for practice.

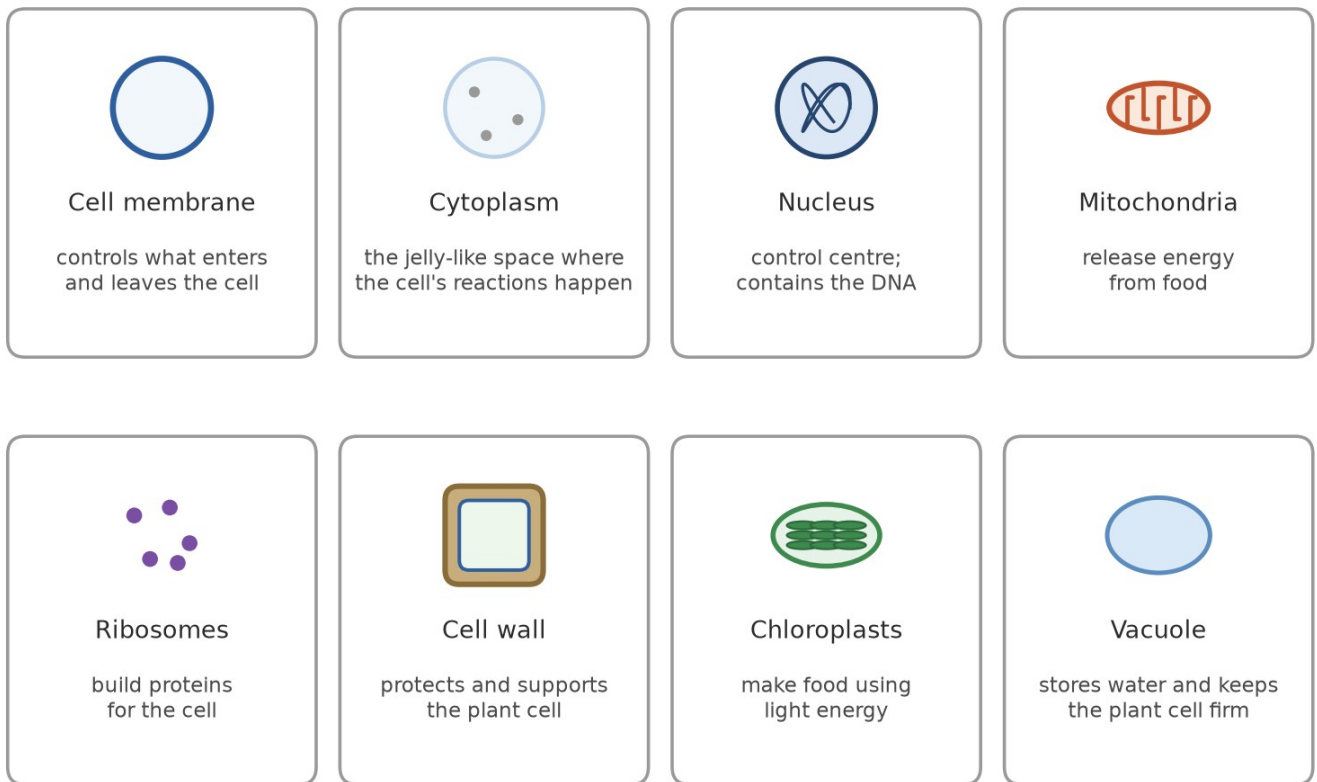
The investigation drawn with simulated data: dye just dropped into cold (5 degrees) and warm (40 degrees) water beakers at the start, and after 10 minutes the dye has spread evenly in the warm beaker but is still patchy in the cold one

Reading the pattern (subtopic 4C): the warmer the water, the shorter the time. The dye spreads faster in warm water than in cold. In cells too, diffusion moves substances about — and, as the investigation shows, warmth speeds the spreading up.

Evaluation (subtopic 5A): the investigation shows diffusion clearly, but a beaker of water is not a cell: real diffusion in a cell happens across a selectively permeable membrane and in a far tinier space, and warmth in a living cell stays within a narrow range. The model is still worth having — it shows the spreading itself, and how a changed variable alters it.

The organelle team

The organelles do not work alone; they work as a team inside one cell. The membrane lets in what the team needs; the nucleus supplies the instructions; ribosomes build the proteins; mitochondria release the energy the building takes; and in plant cells, chloroplasts make the food the mitochondria then draw energy from, while the vacuole and the wall keep the cell firm. Knowing each job is the first step — seeing the jobs fit together is what the CD’s “specific functions” adds up to.



One job per part — the cell works because all of its parts work together.

The organelle team: the membrane, nucleus, ribosomes, mitochondria and chloroplasts drawn as team members, each labelled with its job, all working together in one cell

Words to know in 8B

Word	What it means here
organelle	a structure inside a cell that has a specific job
cell membrane	the thin outer layer of a cell that lets some substances through and not others
selectively permeable	letting some substances through and keeping others out
cytoplasm	the jelly-like material inside the cell membrane, in which the organelles sit
nucleus	the control centre of the cell, which holds the DNA
DNA	the material that carries the instructions for building and running the cell
mitochondrion (mitochondria)	an organelle that releases energy from food, using oxygen
respiration	the process that releases energy from food inside living cells
ribosomes	tiny structures in the cytoplasm that join building blocks into proteins
protein	a building and working material of the cell, made as a chain of building blocks
chloroplast	an organelle in plant cells that captures light energy to make food
chlorophyll	the green pigment in chloroplasts that captures light

Word	What it means here
	energy
pigment	a coloured substance
simple sugar	the food a chloroplast makes; the cell uses it as fuel
photosynthesis	the food-making process in chloroplasts, using light energy, carbon dioxide and water
vacuole	a storage sac in a cell; plant cells have one large central vacuole
cell wall	the firm outer layer of a plant cell, built mostly from cellulose
cellulose	the strong material that plant cell walls are mostly built from
diffusion	the spreading of a substance from where there is a lot of it to where there is little

Worked examples

Example 1 — scaffolded

Four organelles are described by their jobs. Name each one.

Working	Comment
1. “I hold the DNA instructions for building and running the cell.” — the nucleus .	The DNA content is the clue: the nucleus is the control centre because it holds the instructions.
2. “I release energy from food, using oxygen.” — a mitochondrion .	Releasing energy from food is respiration, and that is the mitochondrion’s job.
3. “I capture light energy and make food (a simple sugar).” — a chloroplast .	Light energy, food-making, and the green pigment chlorophyll all point to the chloroplast — plant cells only.
4. “We join building blocks into proteins.” — ribosomes .	Proteins built from building blocks, in the order the cell needs: ribosomes, the smallest machines in the cytoplasm.

Example 2 — scaffolded

Two cells are drawn. Cell X is box-shaped and has a cell wall, chloroplasts and a large central vacuole. Cell Y is rounded, with no wall, no chloroplasts and no large vacuole.

Working	Comment
(a) Cell X is a plant cell : it has all three plant-only structures — cell wall, chloroplasts and a large central vacuole.	Any one of the three would identify it; all three make it certain.
(b) Cell Y is an animal cell : no wall, no chloroplasts, and at most small vacuoles.	The differences are exactly the plant-only structures, read in reverse.
(c) Both cells still share the cell membrane, cytoplasm, nucleus with DNA, mitochondria and ribosomes.	Plant against animal is a story of three differences on top of many shared parts.

Example 3 — unscaffolded

A heart muscle cell contracts around 100 000 times a day, every day. A cell from the outer layer of the skin does much less mechanical work. Which of these two cells would you expect to hold **more mitochondria**? Explain your answer by linking the organelle’s job to the cell’s work.

Mitochondria release the energy a cell can use, from food and oxygen. A heart muscle cell works hard and non-stop, so it needs a large, steady supply of energy; a skin-surface cell does much less work and needs much less. $\therefore$ the heart muscle cell holds more mitochondria — the number of mitochondria in a cell matches the energy its job demands.

Example 4 — unscaffolded

A classmate builds the bag–jelly–marble–bead–pea plant-cell model described in the Theory section and asks for feedback. Identify two things the model shows well and two ways it falls short. (*Draws on VC2S8U02.E05; evaluating a model against the real thing is the skill taught in subtopic 5A.*)

The model shows well that a plant cell has distinct parts sitting in the cytoplasm, with the membrane as the outer wrapping (and, with the peas, the plant-only chloroplasts) — the *layout* of the cell is easy to see. It falls short because the plastic bag cannot choose what passes through it the way a selectively permeable membrane does, and because the model sits still, with parts that are not the right sizes relative to each other, while a real cell is busy and moving all the time. $\therefore$ the model is strong on the parts and where they sit, and weak on the jobs those parts do — which is exactly the pair of things a good feedback comment should name.

Practice questions

Scaffolded

- Q1.** Define each of the following, as the words are used in this subtopic: (a) organelle; (b) cytoplasm; (c) selectively permeable; (d) diffusion.
- Q2.** Answer the following about the jobs inside a cell. (a) Name the organelle that acts as the control centre of the cell. (b) State what that organelle holds inside it. (c) State the job of mitochondria. (d) State what ribosomes build.
- Q3.** A plant cell and an animal cell are set against each other. (a) Name the three structures found in a plant cell but not in an animal cell. (b) For each of the three, state one job it does. (c) Name two structures found in both cells.
- Q4.** The cell membrane is described as a gatekeeper. (a) What does *selectively permeable* mean? (b) Give one reason a cell needs its membrane to be a gate, not an open door.
- Q5.** A plant is left without water for several days. (a) State what a plant cell's large central vacuole stores. (b) Describe what happens to the vacuole as water runs short. (c) Explain what that change does to the plant.
- Q6.** The diffusion investigation in the Theory section produced this table. (*Simulated data for practice.*)

Beaker	Water temperature	Time for the dye to spread evenly
1	5 °C	14 minutes
2	22 °C	8 minutes
3	40 °C	4 minutes

- (a) State the variable that was changed.
- (b) State the variable that was measured.
- (c) State two things that were kept the same.
- (d) Describe the pattern in the results.

Unscaffolded

- Q7.** Leaf cells are full of chloroplasts, and heart muscle cells are full of mitochondria. Explain why each cell has many of that organelle, linking the organelle's job to the cell's work.
- Q8.** Look again at the bag–jelly–marble–bead–pea model of a plant cell. State two things the model shows well and two ways it falls short.
- Q9.** A well-watered plant stands firm, but a plant kept dry goes soft and sags. Explain why, using the vacuole and the idea of the cell going firm or soft.

Q10. For the diffusion investigation, state one risk and the step taken to manage it, and name the piece of equipment that makes the drop of dye the same size each time.

Q11. A fungus cell has a cell wall and a nucleus, like a plant cell. Explain why a fungus still cannot make its own food the way a plant does.

Q12. A bacterium is compared with an animal cell. State two ways the bacterium's cell is different.

Q13. A student says: "*A plant cell does not need mitochondria, because its chloroplasts already make its food.*" Evaluate this claim.

Q14. The organelle team figure shows the organelles working together. Choose **three** organelles and explain how the job of each one helps or depends on the job of another.

Answers

Q1. (a) A structure inside a cell that has a specific job. (b) The jelly-like material inside the cell membrane, in which the organelles sit. (c) Letting some substances through and keeping others out. (d) The spreading of a substance from where there is a lot of it to where there is little. **Q2.** (a) The nucleus. (b) The DNA — the instructions for building and running the cell. (c) They release energy from food, using oxygen. (d) Proteins. **Q3.** (a) Cell wall, chloroplasts, large central vacuole. (b) Wall: shape and support (protection also accepted). Chloroplasts: capture light energy to make food. Vacuole: stores water and useful substances; keeps the cell firm. (c) Any two of: cell membrane, cytoplasm, nucleus, mitochondria, ribosomes. **Q4.** (a) Letting some substances through and keeping others out. (b) Any one: so useful substances are kept in and let in, wastes are let out, and harmful things are kept out — the cell keeps its inside different from the outside. **Q5.** (a) Water with useful substances dissolved in it. (b) It shrinks. (c) The cell loses its outward push and goes soft, so the plant sags. **Q6.** (a) The water temperature. (b) The time for the dye to spread evenly. (c) Any two of: volume of water; the beakers; the dye and the drop size; no stirring. (d) The warmer the water, the shorter the time — the dye spreads faster in warmer water. **Q7.** Chloroplasts capture light energy to make food, so leaf cells — which must make the plant's food — are full of them; mitochondria release energy from food, so heart muscle cells — which work hard and non-stop — are full of them. In each case the number of the organelle matches the cell's job. **Q8.** Shows well (any two): the parts of a plant cell and where they sit; the membrane as the outer wrapping; the cytoplasm as the material the parts sit in; the plant-only chloroplasts (peas). Falls short (any two): the bag cannot choose what goes through; the jelly does not move and work like real cytoplasm; the parts are not the right sizes relative to each other; the model sits still while a real cell is busy. **Q9.** With water, the full vacuole pushes outward and keeps the cells firm, so the plant stands up; kept dry, the vacuole shrinks, the cells go soft, and the plant sags. **Q10.** Risk and control (any one pair): warm water — pour slowly and carry beakers with two hands; spills — wipe up straight away so nobody slips; glass — handle with care and report breakage. Equipment: the dropper. **Q11.** A fungus cell has no chloroplasts, so it cannot capture light energy to make food; it must take in food from where it grows. **Q12.** Any two: the bacterium has no nucleus (its DNA floats free in the cytoplasm); it is much smaller than an animal cell. **Q13.** Wrong: chloroplasts make and store food, but the energy in that food is released by mitochondria; plant cells have mitochondria too, and need them for the same reason animal cells do. **Q14.** Any three, correctly linked, e.g. chloroplasts make the cell's food, and mitochondria release energy from that food; the nucleus supplies the instructions ribosomes follow to build proteins; mitochondria release the energy ribosomes need for building; the membrane lets in the oxygen and substances the mitochondria and ribosomes use.

Fully-worked solutions

Q1. (a) An **organelle** is a structure inside a cell that has a specific job (1 mark). (b) The **cytoplasm** is the jelly-like material inside the cell membrane, in which the organelles sit (1 mark). (c) **Selectively permeable** means letting some substances through and keeping others out (1 mark). (d) **Diffusion** is the spreading of a substance from where there is a lot of it to where there is little (1 mark).

Q2. (a) The **nucleus** is the control centre of the cell (1 mark). (b) It holds the cell's **DNA** — the material carrying the instructions for building and running the cell (1 mark). (c) Mitochondria **release the energy stored in food**, using oxygen, so the cell can use it — respiration (1 mark). (d) Ribosomes build **proteins**, by joining building blocks into chains (1 mark).

Q3. (a) The three plant-only structures are the **cell wall**, the **chloroplasts** and the **large central vacuole** (3 marks — one each). (b) The wall gives the cell **shape and support** and protects it; chloroplasts **capture light energy to make food** by photosynthesis; the vacuole **stores water and useful substances** and, when full, keeps the cell firm (3 marks — one each). (c) Any two of the shared parts: **cell membrane, cytoplasm, nucleus, mitochondria, ribosomes** (2 marks).

Q4. (a) *Selectively permeable* means the membrane **lets some substances through and keeps others out** (1 mark). (b) The cell needs a gate, not an open door, **so that useful substances get in and stay in, wastes get out, and harmful things are kept out** — the membrane keeps the cell's inside different from the outside (1 mark).

Q5. (a) The large central vacuole stores **water with useful substances dissolved in it** (1 mark). (b) As water runs short, the vacuole **shrinks** (1 mark). (c) With a shrunken vacuole the cell loses its outward push and **goes soft, so the plant sags** — the firm, well-watered state is lost (1 mark).

Q6. (a) The variable changed was the **water temperature** (1 mark). (b) The variable measured was the **time for the dye to spread evenly** (1 mark). (c) Any two kept the same: **the volume of water; the (identical) beakers; the dye and the drop size; no stirring** (2 marks — one each). (d) The pattern: **the warmer the water, the shorter the time** — the dye spreads faster in warmer water (1 mark).

Q7. A **chloroplast's** job is capturing light energy to make food, and a leaf's job is making the plant's food — so leaf cells are full of chloroplasts (2 marks). A **mitochondrion's** job is releasing energy from food, and a heart muscle cell works hard and non-stop, needing a large steady supply of energy — so it is full of mitochondria (2 marks). In each case, the number of the organelle matches the work the cell does.

Q8. Shows well (any two): the model shows **the parts of a plant cell and where they sit**; the **membrane as the outer wrapping** (the bag); the **cytoplasm as the material the parts sit in** (the jelly); the **plant-only chloroplasts** (the peas) (2 marks — one each). Falls short (any two): the bag **cannot choose what goes through it**, as a selectively permeable membrane does; the jelly **does not move and work** like real cytoplasm; the parts are **not the right sizes relative to each other**; the model **sits still**, while a real cell is busy all the time (2 marks — one each).

Q9. In a well-watered plant the vacuole is **full and pushes outward**, keeping the cells firm, so the plant stands up (1 mark). Kept dry, the vacuole **shrinks**, the cells **lose their outward push and go soft**, and the soft cells let the plant **sag** (2 marks). The same vacuole, full or shrunken, is the difference between firm and soft.

Q10. One risk and its control (any one pair): **warm water** — pour slowly and carry beakers with two hands; **spills** — wipe up straight away so nobody slips; **glass beakers** — handle with care and report breakage (2 marks — one for the risk, one for the control). The piece of equipment that makes each drop the same size is the **dropper** (1 mark).

Q11. Making food by photosynthesis needs **chloroplasts**, and a fungus cell has **none** (2 marks) — so, wall and nucleus or not, a fungus cannot capture light energy to make food and must **take in food from where it grows** (1 mark).

Q12. Any two (1 mark each): the bacterium has **no nucleus** — its DNA **floats free in the cytoplasm**, while an animal cell's DNA is held in a nucleus; and a bacterium is **much smaller** than an animal cell.

Q13. The claim is **wrong** (1 mark). Chloroplasts **make and store food**, but the energy stored in that food is **released by mitochondria** — so plant cells have mitochondria too, and need them for the same reason animal cells do: to release usable energy from food (2 marks). Making food and releasing its energy are two different jobs.

Q14. Any three organelles, each correctly linked to another (1 mark each), e.g.: **chloroplasts** make the cell's food, and **mitochondria** then release energy from that food; the **nucleus** supplies the instructions that **ribosomes** follow to build proteins; **mitochondria** release the energy that **ribosomes** need for their building; the **membrane** lets in the oxygen and substances that **mitochondria** and **ribosomes** use.

Sources

Web sources below were retrieved 2026-08-20.

- Science ASSIST (Australian Science Teachers' Association), "Risk management", n.d. asta.edu.au

The diffusion investigation's results table is **simulated data for practice**; the pattern it shows — dye spreading faster in warmer water — is the real behaviour of diffusion.

Elaboration contexts used: VC2S8U02.E04 (comparing plant, animal, bacteria and fungi cells), VC2S8U02.E05 (designing and constructing a cell model, with feedback from classmates on strengths and limits) and VC2S8U02.E06 (a practical investigation modelling a cell process — diffusion).

From cells to tissues to organs: structure related to function in one plant and one animal organ system

What we teach here — VC2S8U03 (Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8):

“the structure of cells, tissues and organs in a plant and an animal organ system are related to their function; plant and animal organ systems enable survival of the organism” **This subtopic owns the first clause only:** the structure of cells, tissues and organs, related to their function, in one plant organ system (the transport system) and one animal organ system (the circulatory system). The second clause — how organ systems enable the survival of the organism, and what a disorder of a cell, tissue or organ does — belongs to the partner subtopic **8D** (+ split delivery, D6). **In our words:** a plant and an animal both run a transport network that moves materials to where they are needed — and every part of each network is built to match its job. Tubes stiffened so they cannot squash, a pump made of thick muscle, cells shaped like a straw to soak up water, cells shaped like a dished disc to pick up oxygen. This subtopic climbs the ladder from cell to tissue to organ to organ system, and keeps asking one question all the way up: *how does the structure suit the function?* **Achievement-standard extract served here (D13):** *“They analyse the relationship between structure and function at organ and body system levels for a selected plant and an animal, and explain how a disorder in the cells, tissues or organs of these systems affects the survival of each organism.”* The first half of the extract is what this subtopic teaches and practises; the disorder half is taken up by 8D. **Elaborations drawn on:** VC2S8U03.E01 (using two-dimensional and three-dimensional representations to locate and compare analogous systems in a plant and an animal), VC2S8U03.E02 (examining the specialised cells and tissues involved in the structure and function of particular organs in an organ system) and VC2S8U03.E03 (describing the structure of each organ in a system and relating its function to the overall function of the system).

Word watch — *tissue* and *organ*. In everyday talk, a *tissue* is soft paper you wipe your hands on, and an *organ* is a large keyboard instrument in a church. In science both words carry a different, precisely stated meaning, and this whole subtopic rests on them. A **tissue** is a group of similar cells working together at one job. An **organ** is a structure made of different tissues working together. From here on, both words carry the science meaning only.

Theory

Climbing the ladder of life

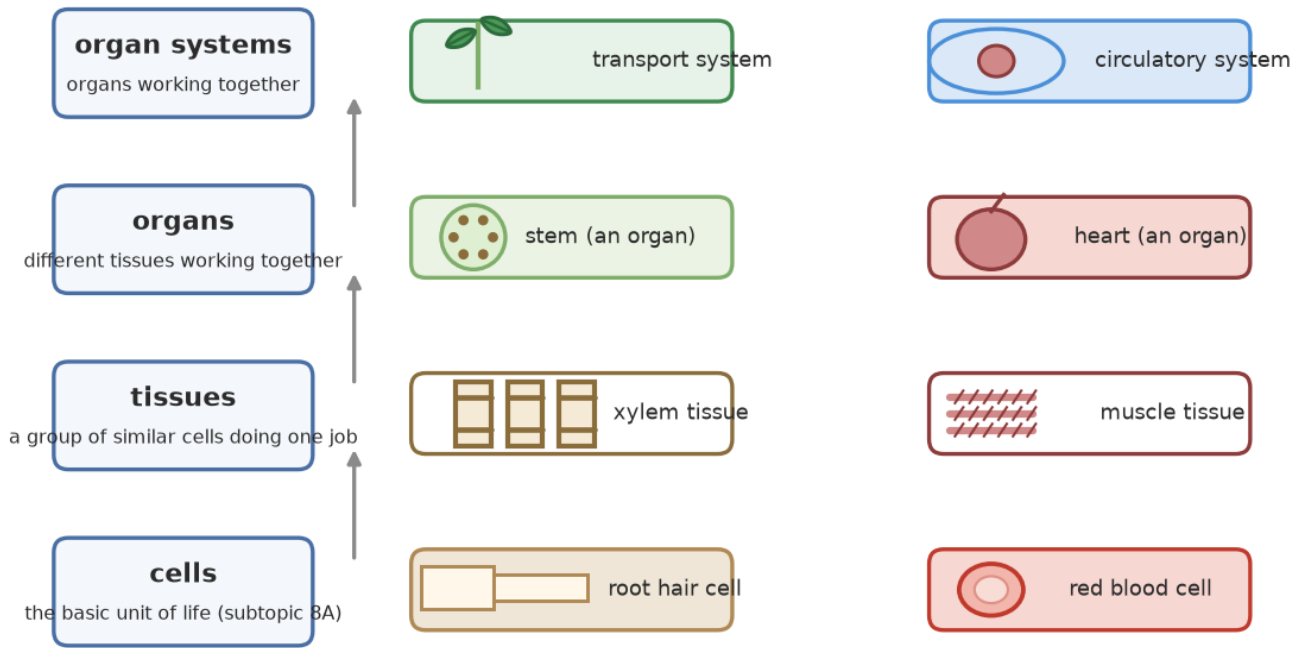
Subtopic 8A showed that every living thing is built from cells, and subtopic 8B opened the cell to meet the organelles inside it. Here we zoom out. A multicellular organism is not just a bag of separate cells — its cells are organised into larger and larger working levels:

- **cells** — the basic unit of life;
- **tissues** — a group of similar cells doing one job;
- **organs** — different tissues working together;
- **organ systems** — organs working together.

Each level is built from the one below it, and this subtopic follows two tracks all the way up the ladder: a **plant track** (the transport system) and an **animal track** (the circulatory system). The two systems do a very similar job — moving materials around the organism — which makes them a perfect pair for seeing how structure suits function at every level.

From cells to tissues to organs to organ systems

the plant track the animal track



Each level is built from the one below: many cells make a tissue, tissues make an organ, and organs work together as an organ system.

The levels of organisation as a ladder with two tracks: the plant track shows a root hair cell, xylem tissue, the stem as an organ and the transport system; the animal track shows a red blood cell, muscle tissue, the heart as an organ and the circulatory system; each level is built from the one below

Specialised cells — shape matches job (VC2S8U03.E02)

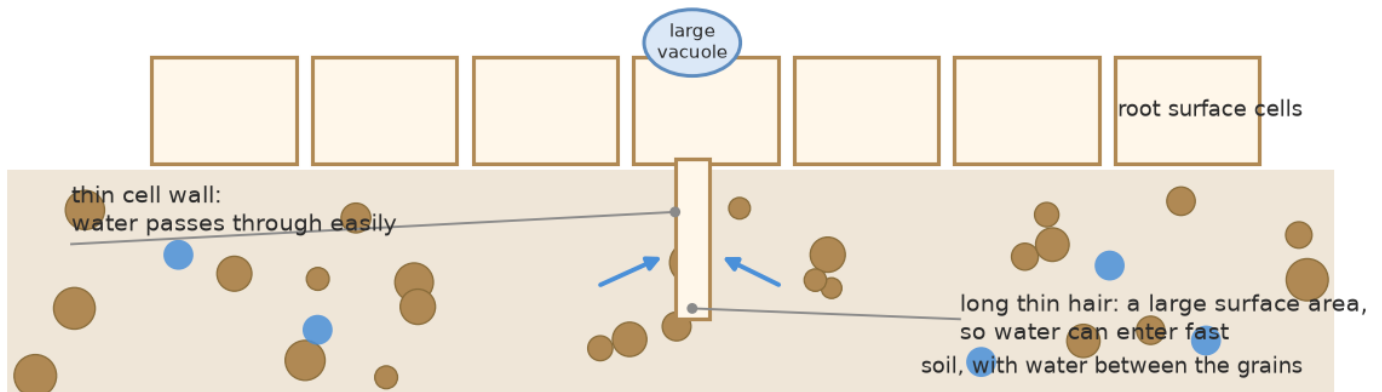
At the bottom of the ladder are cells, and not all cells are alike. A **specialised cell** is a cell whose shape and parts suit one particular job. Two examples, one from each track.

The root hair cell. On the outside of a plant's roots, some surface cells grow a long, thin finger called a **root hair**. The hair reaches out between the soil grains, where water sits, and gives the root a much larger **surface area** — the area of its outside — so water and minerals can pass in fast. The cell wall is thin, so water passes through it easily, and inside, a large vacuole stores the water taken in. Every feature of the cell is built for taking in water: long and thin for surface area, thin-walled for easy passage.

A root hair cell — shaped for taking in water

Structure suits function

One root surface cell grows a long hair, so the root has a much larger surface area for taking in water and minerals. Root hair cells are specialised cells: their shape matches their job.

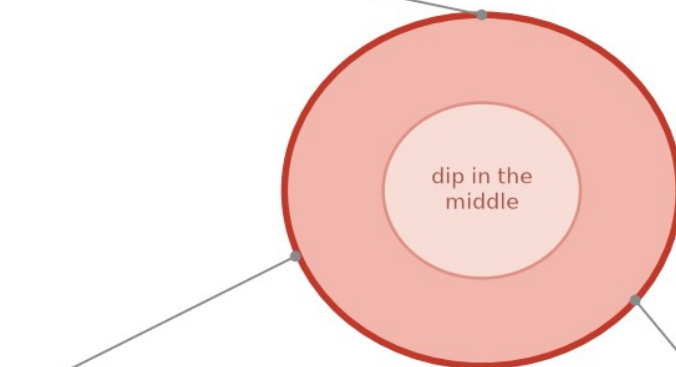


A root hair cell in soil: a root surface cell growing one long thin hair between the soil grains, with a thin cell wall and a large vacuole, and arrows showing water passing in from the water between the soil grains

The red blood cell. An animal's blood carries oxygen from the lungs to every cell of the body, and the carrier is the **red blood cell**. Its structure suits the job in three ways. First, it is shaped like a disc with a dip in the middle on both sides — a shape called **biconcave** — which gives it a large surface area, so oxygen passes in and out of it fast. Second, it has **no nucleus**, which leaves more room inside for **haemoglobin** — the red material in the cell that binds oxygen and carries it. Third, it is small and flexible, so it bends and squeezes through a **capillary**, the narrowest kind of blood vessel, where oxygen is handed over to the body's cells.

A red blood cell — built to carry oxygen

biconcave disc: a large surface area, so oxygen passes in and out fast



dip in the middle

red colour from haemoglobin — the material that binds oxygen

no nucleus: more room for haemoglobin

squeezing through a capillary

capillary: the narrowest vessel



small and flexible: it bends to fit

A red blood cell is a specialised animal cell: every part of its structure helps it carry oxygen.

A red blood cell drawn as a biconcave disc with a dip in the middle, labelled with no nucleus and more room for haemoglobin, and an inset panel showing the cell bending to squeeze through a narrow capillary

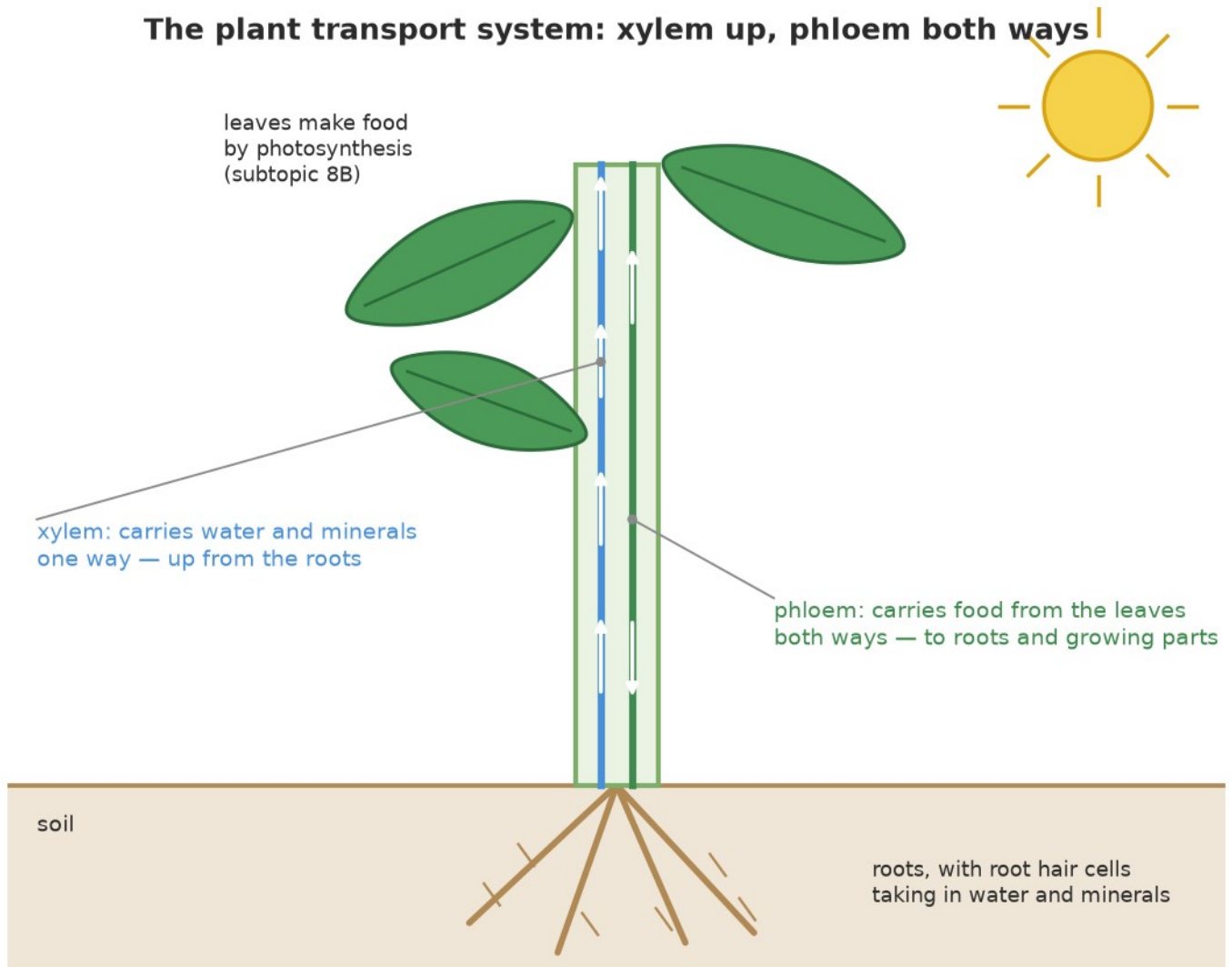
Two organisms, two cells, one pattern: the structure suits the function.

The plant track: the transport system

A plant's transport system has three organs, each doing its part of the job. The **roots** take in water and minerals from the soil, using thousands of root hair cells. The **stem** holds the plant up and carries the transport tubes between root and leaf. The **leaves** make food by photosynthesis (subtopic 8B), and it is the leaves losing water to the air that pulls water up the plant — there is no pump.

The tubes themselves are two tissues. **Xylem** (say: *zy-lem*) carries water and dissolved minerals **one way** — **up** from the roots to the leaves. **Phloem** (say: *flo-em*) carries the food made in the leaves **both ways** — down to the roots and up to growing parts.

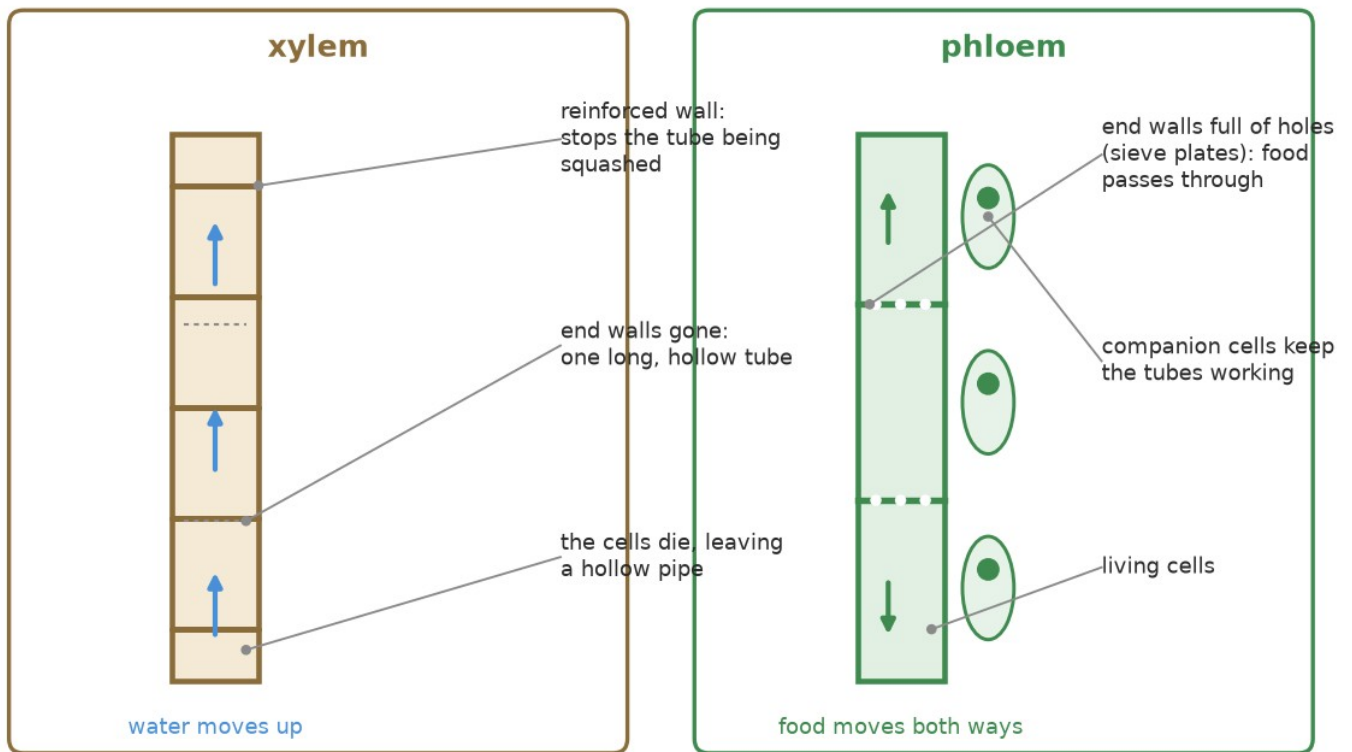
The plant transport system: xylem up, phloem both ways



A whole plant showing the transport system: roots with root hair cells taking in water and minerals, a stem with a blue xylem channel carrying water one way up and a green phloem channel carrying food both ways, and leaves making food by photosynthesis with the sun shining

The two transport tissues up close. Zoom in and each tissue's structure matches its job. A xylem tube is made of cells that **die** when they finish growing, leaving one long, hollow pipe with no end walls to slow the water. Its wall is **reinforced** with rings of a strong material, so the tube does not squash shut. A phloem tube is made of **living** cells joined end to end, with end walls full of holes — called **sieve plates** — that food passes through, and **companion cells** alongside that keep the tube working.

Two plant transport tissues: xylem and phloem

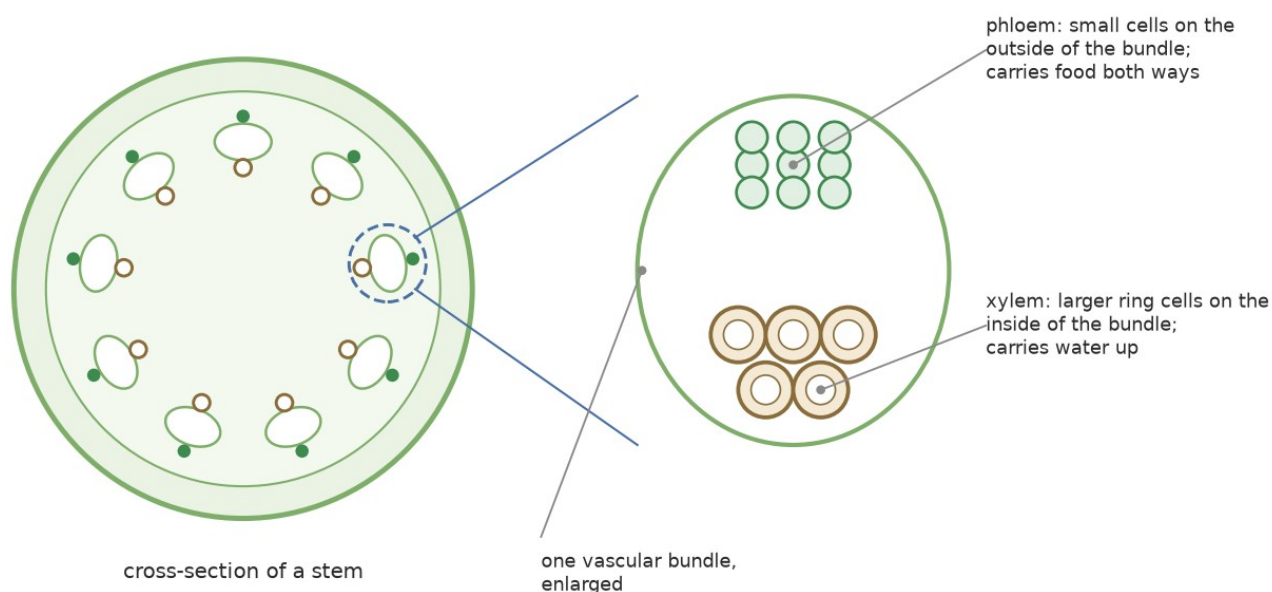


Both are tissues — groups of similar cells doing one job: moving materials around the plant.

Two panels comparing the plant transport tissues: xylem as dead cells joined into one long hollow tube with reinforced walls and no end walls, water moving up; phloem as living cells with sieve plates full of holes and companion cells alongside, food moving both ways

A stem cross-section: transport in bundles. Cut across a stem and the xylem and phloem travel together in **vascular bundles** — small groups of transport tissue arranged in a ring. In each bundle the xylem sits on the inside and the phloem on the outside. These bundles are the “veins” you can see in a celery stalk.

A stem cross-section: transport tissues in bundles



In a stem, xylem and phloem travel together in bundles — the veins you can see in celery.

A stem cross-section showing a ring of vascular bundles, with one bundle enlarged to show the larger, thick-walled xylem cells on the inside and the smaller phloem cells on the outside

Investigation: watching water move up a stem

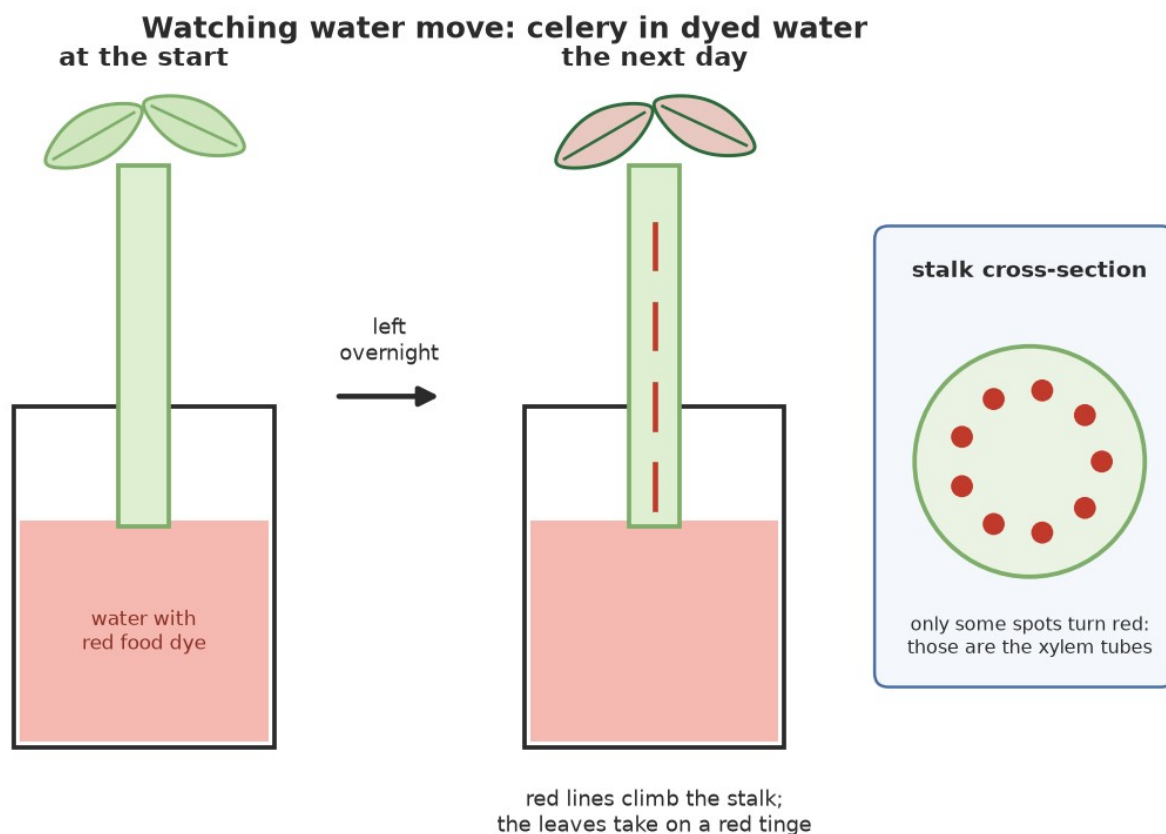
Celery in dyed water makes the xylem visible. The method is simple, and the observation does the teaching.

- **Equipment (subtopic 3C):** a fresh celery stalk with leaves, a beaker, water, red food dye, a sharp blade for the cross-section, and paper towel.
- **Variables (subtopic 3A):** this is a demonstration, not a fair test — nothing is changed and nothing is compared. What matters is the observation: *where* does the dye end up?
- **Risk (subtopic 3B):** food dye stains skin and clothing — use a few drops only, and wipe spills up straight away so nobody slips; handle the glass beaker with care; the cross-section is cut with a sharp blade, so the teacher cuts it or a student cuts only under direct supervision. Plan and run the activity with the risk-management guidance from Science ASSIST (see Sources).

Method: stand the celery stalk in the beaker of water with a few drops of red dye, leave it in bright light, and the next day look at the stalk, the leaves and a freshly cut cross-section.

Time since start	What you see
At the start	pale green stalk, green leaves
After 2 hours	faint red lines low on the stalk
After 6 hours	red lines higher up; leaf edges take the colour
Next morning	strong red lines the whole length; leaves tinged red
Cross-section	a ring of red dots near the outside of the stalk

(Simulated observations for practice.)



The celery investigation: at the start a pale celery stalk stands in a beaker of red-dyed water; the next day red lines climb the stalk and the leaves take a red tinge; a cross-section panel shows only some spots turned red, and those are the xylem tubes

Reading the pattern (subtopic 4C): the red lines climb the stalk over time and end up in the leaves, so the water — and the dye riding in it — moved *up*. The cross-section shows the dye in a ring of separate dots, not everywhere, so the water travelled in particular tubes: the xylem of the vascular bundles.

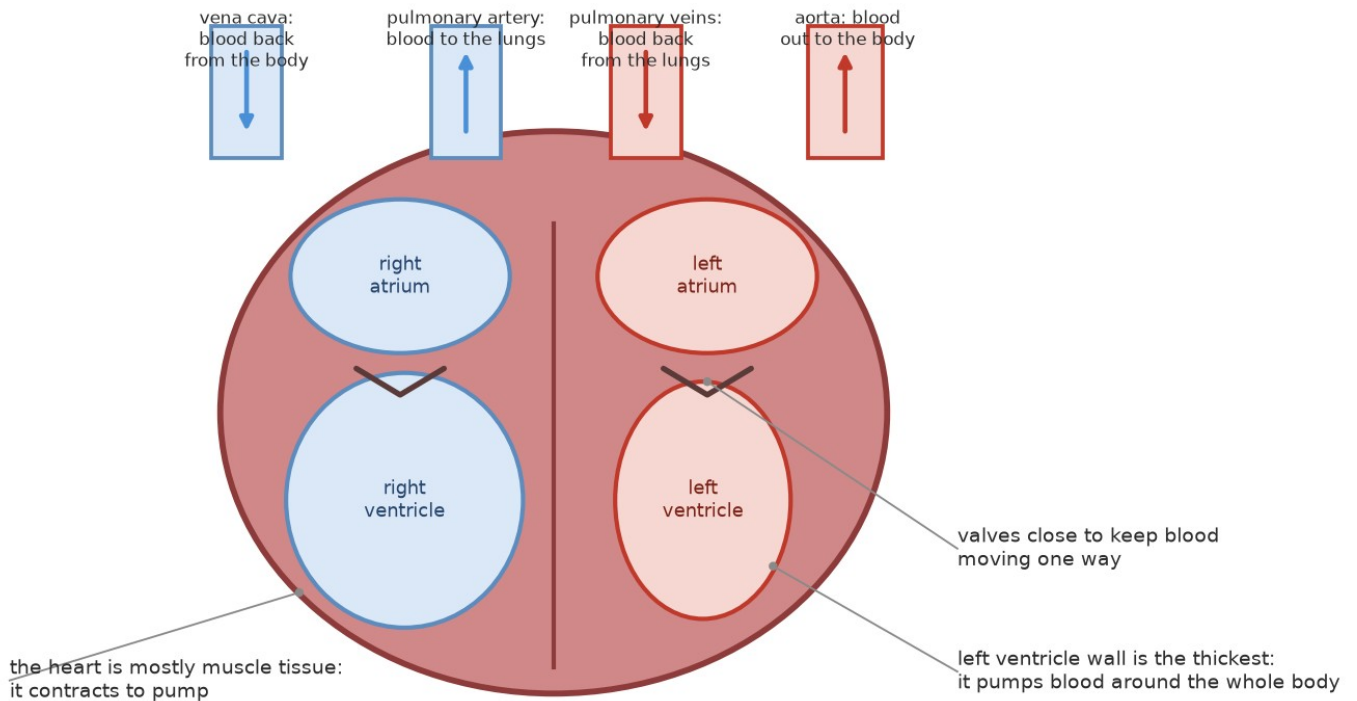
Evaluation (subtopic 5A): the dye shows where water moved, which is exactly what the investigation asks. Its limit is that dye is not pure water — it may move a little slower than water alone — and one stalk shows one plant, so the class should compare stalks before generalising. Even so, the pattern it shows is the real behaviour of xylem.

The animal track: the circulatory system

An animal's **circulatory system** moves blood around the body, and it has three parts: the **heart** (the pump), the **blood vessels** (the tubes) and the **blood** (what flows).

The heart. The heart is an organ made mostly of **muscle tissue** — tissue that can contract, which means squeeze tighter, and that contraction is the pump. Inside, the heart has four chambers: two upper rooms called **atria** (one is an **atrium**) that receive blood coming in, and two lower rooms called **ventricles** that pump blood out. Between each atrium and ventricle is a **valve** that closes to keep blood moving one way — without the valves, blood would slop backwards at every beat. Four large vessels join the heart: the **vena cava** brings blood back from the body, the **pulmonary artery** carries it to the lungs, the **pulmonary veins** bring it back from the lungs, and the **aorta** carries it out to the body. Notice the structure that suits the function: the **left ventricle has the thickest wall**, because it pumps blood around the whole body — the hardest push in the system — while the right ventricle only pushes blood as far as the lungs.

The heart: a pump made of muscle



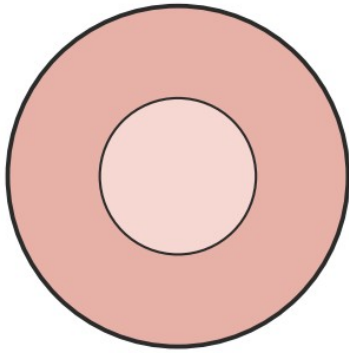
A simple front view: the heart's right side is drawn on your left, like looking at someone's chest.

A simple front view of the heart showing the four chambers (right atrium, left atrium, right ventricle, left ventricle), valves between the atria and ventricles, and the four large vessels (vena cava, pulmonary artery, pulmonary veins, aorta) with arrows showing the direction blood moves; labels note the muscle tissue, the valves and the thickest wall on the left ventricle

The blood vessels. The tubes come in three kinds, and each wall matches its job. An **artery** carries blood *away* from the heart at high pressure, so it has a thick, springy muscle wall that handles the push. A **vein** carries blood *back* to the heart at much lower pressure, so it has a thinner wall, a wider space inside, and valves of its own to keep the blood moving one way. A **capillary** is the narrowest vessel, with a wall **one cell thick**, so oxygen, food and wastes pass straight through it between the blood and the body's cells.

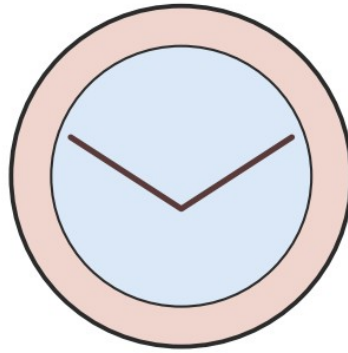
Three blood vessels — three different walls

artery



thick muscle wall handles the high pressure from the heart; carries blood away from the heart

vein



thinner wall and a wider space; a valve keeps blood moving one way back to the heart

capillary



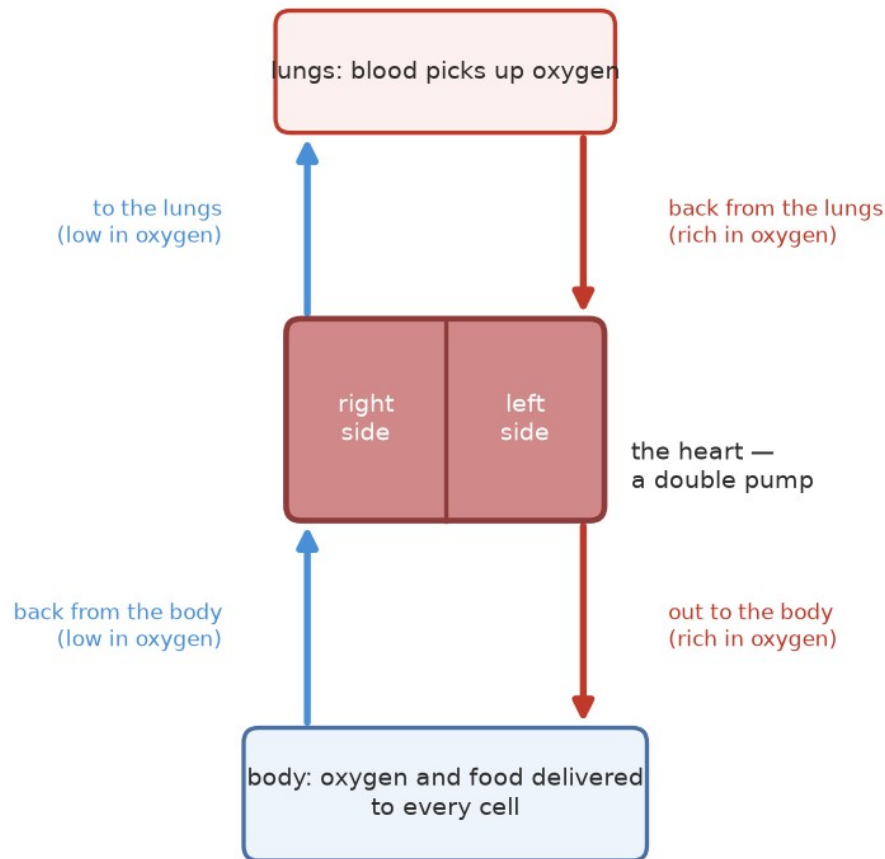
wall one cell thick: food, oxygen and wastes pass through easily; so narrow that red blood cells squeeze through one at a time

Same job — moving blood — but each vessel's wall matches the pressure and the job it does.

Cross-sections of the three blood vessels compared: an artery with a thick muscle wall and a narrow space inside; a vein with a thinner wall, a wider space and a valve; a capillary with a wall one cell thick and a single red blood cell squeezing through

One circuit of the blood. Follow the blood and the whole system's design appears. Blood returns from the body low in oxygen, enters the right side of the heart, and is pumped to the **lungs**, where it picks up oxygen. Back it comes to the left side of the heart, and out through the aorta to the **body**, handing oxygen and food to every cell and collecting wastes. Each full circuit passes through the heart **twice** — which is why the heart is called a double pump.

One circuit of the blood: the body and the lungs



Each full circuit passes through the heart twice: body → heart → lungs → heart → body.

The double circulation loop: the heart drawn as a double pump in the middle, with the lungs above and the body below; blue arrows show blood low in oxygen going body to heart to lungs, and red arrows show blood rich in oxygen going lungs to heart to body

Blood as a tissue. Blood itself counts as a tissue — a group of cells doing one job, carried in a liquid called **plasma**. The plasma carries dissolved food and wastes; the red blood cells carry oxygen; and other cells in the blood fight infection. (How the blood's work keeps the organism alive, and what happens when a part of the system fails, is 8D's story.)

Investigation: your pulse — the heart at work

You can feel the heart's pumping at your wrist or neck as the **pulse** — the push of blood through an artery each time the heart contracts. Counting it before and after exercise shows the system responding to demand.

- **Equipment (subtopic 3C):** a timer with a seconds display, a chair, and a clear floor space.
- **Variables (subtopic 3A):** what is changed is the activity (resting, walking on the spot, jogging on the spot); what is measured is the pulse rate in beats per minute; what is kept the same includes the person, the timer, the counting method, and a minute of sitting before the resting count.
- **Risk (subtopic 3B):** clear the space before starting; anyone with a heart or breathing condition adjusts the exercise or takes the observer's role; stop at once if anyone feels dizzy; wipe up sweat or spills so nobody slips. Plan and run the activity with the risk-management guidance from Science ASSIST (see Sources).

Method: sit quietly for a minute, find the pulse at the wrist, count beats for 30 s and double the count. Repeat after walking on the spot for one minute, and after jogging on the spot for one minute, sitting for one minute between each.

Activity	Count in 30 s	Beats per minute (count × 2)
Resting	36	72
Walking on the spot, 1 minute	45	90
Jogging on the spot, 1 minute	60	120

(Simulated data for practice.)

Reading the pattern (subtopic 4C): the harder the activity, the faster the pulse. The heart beats faster when the body works harder.

Explaining the pattern: working muscle cells do more respiration — the process, taught in 8B, that releases energy from food using oxygen — so they need oxygen and food delivered faster, and wastes carried away faster. A faster heart rate moves the blood around more often, so the delivery happens faster. Structure and function again: the heart is muscle, muscle contracts, and the rate of contraction matches the body's demand.

Evaluation (subtopic 5A): counting for 30 s and doubling is quick, but a counting slip doubles too — counting a full minute would be more reliable. One person's results are one person's; the class should pool results before making a general claim.

Two systems, one job (VC2S8U03.E01)

Lay the two systems side by side and the analogy is plain: different structures, same job. Both move what the organism needs to where it is needed. Both have tubes. The animal system adds a pump, because blood is pushed around a closed loop; the plant system has no pump, because its water is pulled up from below as the leaves lose water to the air. And where the animal system loops around and around, the plant system's xylem runs one way up while its phloem runs both ways.

Two transport systems, compared (VC2S8U03.E01)

 plant transport system (xylem and phloem)	 animal circulatory system (heart, blood vessels, blood)
moves water, minerals and food around the plant	job moves oxygen, food and wastes around the body
xylem and phloem	tubes arteries, veins and capillaries
no pump — water is pulled up as leaves lose water to the air	pump the heart: a muscle pump
xylem: one way up · phloem: both ways	path a closed loop, around and around
water with minerals; food dissolved in water	what flows blood: cells in a liquid called plasma
Different structures, same job: both systems move what the organism needs to where it is needed.	

A comparison table of the plant transport system and the animal circulatory system, row by row: the job of each, the tubes of each, the pump or lack of one, the path, and what flows in each

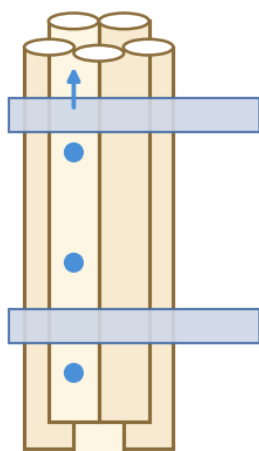
A three-dimensional model: straws as xylem (VC2S8U03.E01)

Representations are not only drawings. Build a 3-D model of xylem from five drinking straws taped into a bundle, push the bundle upright in a shallow dish of coloured water, and watch the water climb the tubes. Then do what makes a model useful in science — name what it shows well and where it falls short.

- **Shows well:** the tubes are hollow; many tubes run together in a bundle; water can move up through them.
- **Falls short:** straw walls are not reinforced the way xylem walls are; the straws are enormously wider than a real xylem tube; and the model cannot pull water up the way a living plant does.

A 3-D model of xylem: what it shows, where it falls short

five drinking straws, taped into a bundle



What the model shows well

- the tubes are hollow
- many tubes run together
- water can flow up through them

Where the model falls short

- straw walls are not reinforced like xylem walls
- the model is far wider than a real xylem tube
- it cannot pull water up the way a living plant does

Every model has strengths and limits (subtopic 5A). Naming both is what makes a model useful.

A three-dimensional model of xylem made from five drinking straws taped into a bundle with water climbing one straw, beside two boxes: what the model shows well (hollow tubes, many tubes together, water flowing up) and where it falls short (walls not reinforced, far wider than a real xylem tube, cannot pull water like a living plant)

Naming strengths *and* limits is the skill (see subtopics 4B and 5A): a model that is only praised teaches nothing, and a model that is only criticised throws away a useful picture.

Putting it together: structure and function (VC2S8U03.E03)

Every part of both systems can be described in one sentence pattern: *it has this structure, so it can do this function* — and each organ's function serves the whole system's function.

Part	Structure	Function it makes possible	How it serves the whole system
root hair cell	long thin hair, thin wall	water and minerals pass in fast	roots supply the water the xylem carries up
xylem tube	hollow, reinforced, end walls gone	water moves up without the tube squashing	water reaches every leaf
leaf	flat and broad	catches light; loses water to the air	pulls water up; makes the food the phloem carries
red blood cell	biconcave, no nucleus, flexible	carries much oxygen; squeezes through capillaries	oxygen reaches every cell
artery	thick muscle wall	handles the high pressure from the heart	blood is pushed out to the body
capillary	wall one cell thick	oxygen and food pass straight through	the delivery happens at the cells
heart	muscle walls, valves, thick	pumps blood one way,	the blood keeps moving,

Part	Structure	Function it makes possible	How it serves the whole system
	left ventricle	hard enough for the whole body	beat after beat

That table *is* the analysis the achievement standard asks for: structure and function related at cell, tissue, organ and system level, in a selected plant and a selected animal.

Words to know in 8C

Word	What it means here
tissue	a group of similar cells working together at one job
organ	a structure made of different tissues working together
organ system	organs working together
specialised cell	a cell whose shape and parts suit one particular job
surface area	the area of the outside of something; more of it lets more pass in or out at once
root hair cell	a root surface cell with one long thin hair, built for taking in water and minerals
xylem	the plant tissue that carries water and minerals one way, up from the roots
phloem	the plant tissue that carries food from the leaves both ways
vascular bundle	a group of xylem and phloem travelling together in a stem or leaf
sieve plate	the hole-filled end wall between two phloem cells
companion cell	a living cell alongside a phloem tube that keeps it working
haemoglobin	the red material in a red blood cell that binds oxygen and carries it
biconcave	shaped like a disc with a dip in the middle on both sides
heart	the organ, made mostly of muscle tissue, that pumps the blood
atrium (atria)	an upper chamber of the heart that receives blood coming in
ventricle	a lower chamber of the heart that pumps blood out
valve	a flap that closes to keep blood moving one way
artery	a vessel carrying blood away from the heart, with a thick muscle wall
vein	a vessel carrying blood back to the heart, with a thinner wall, a wider space and valves
capillary	the narrowest vessel, with a wall one cell thick, where delivery to the cells happens
plasma	the liquid part of the blood, carrying dissolved food and wastes
pulse	the push of blood through an artery each time the heart contracts

Worked examples

Example 1 — scaffolded

Place each item on the ladder of life (cell, tissue, organ or organ system) and name its track (plant or animal).

Working	Comment
1. A red blood cell — a cell , animal track.	It is one specialised cell, the bottom rung of the ladder.
2. Xylem — a tissue , plant track.	Xylem is a group of similar cells doing one job (carrying water up), so it sits at the tissue rung.
3. The heart — an organ , animal track.	The heart is made of different tissues working together — mostly muscle tissue, plus the tissue lining the valves and vessels — so it is an organ.
4. The transport system of a plant — an organ system , plant track.	Roots, stem and leaves working together to move water, minerals and food: organs working together make a system.

Example 2 — scaffolded

Match each structure on the left to the function it makes possible on the right.

Structure	Function
(a) reinforced xylem wall	(i) more room for haemoglobin
(b) no nucleus in a red blood cell	(ii) food passes from one phloem cell to the next
(c) sieve plate	(iii) the tube does not squash shut under the pull of water
(d) valve in a vein	(iv) blood keeps moving one way back to the heart

Working	Comment
(a)–(iii): the reinforcement stops the hollow tube squashing, so the water column holds.	Structure suits function: a soft tube would collapse and the water would stop.
(b)–(i): with no nucleus there is more room inside for the oxygen-carrying haemoglobin.	The cell gives up one part to be better at its job.
(c)–(ii): the holes in the sieve plate let food pass between the living phloem cells.	The phloem tube stays alive, so its food passes through holes, not through an open pipe.
(d)–(iv): the valve closes against backward flow, so blood in a low-pressure vein still travels to the heart.	The same one-way design as the heart's valves, repeated in the tubes.

Example 3 — unscaffolded

The wall of the left ventricle is thicker than the wall of the right ventricle. Explain why, relating the structure to the function of each chamber.

Both ventricles pump blood out of the heart, but they pump it different distances. The right ventricle only pushes blood as far as the lungs, a short trip at low push, so it needs less muscle. The left ventricle pushes blood out through the aorta and around the **whole body** — the longest, hardest push in the system. $\therefore$ the left ventricle has the thicker muscle wall: the structure (more muscle) suits the function (a harder pump).

Example 4 — unscaffolded

A classmate looks at the comparison figure and says: “*The plant transport system and the circulatory system do the same job, so they must work the same way.*” Evaluate this claim.

The claim is **right in one part and wrong in another**. **Right part:** the two systems do have the same overall job — moving materials to where they are needed — and both use tubes to do it. **Wrong part:** same job does not mean same way. The circulatory system pushes blood around a **closed loop** with a muscle **pump**, and the blood goes around and around. The plant system has **no pump** — water is pulled up as the leaves lose water to the air — its xylem runs **one**

way up, its phloem runs both ways, and nothing loops. $\therefore$ the systems are alike in job and unlike in working — which is exactly what “analogous” means here: different structures solving the same problem.

Practice questions

Scaffolded

- Q1.** Define each of the following, as the words are used in this subtopic: (a) tissue; (b) organ; (c) organ system; (d) specialised cell.
- Q2.** Answer the following about the plant transport system. (a) Name the tissue that carries water and minerals up from the roots. (b) Name the tissue that carries food from the leaves. (c) State the direction each tissue moves its load. (d) Name the three organs of the plant transport system.
- Q3.** Answer the following about the heart. (a) Name the tissue the heart is mostly made of. (b) State what the heart’s valves do. (c) Name the chamber with the thickest wall. (d) Name the large vessel that carries blood out to the body.
- Q4.** The three blood vessels are drawn in the vessels figure. (a) Name the vessel with a thick muscle wall that carries blood away from the heart. (b) Name the vessel with a wall one cell thick. (c) State one structure that helps a vein keep blood moving one way.
- Q5.** Put these in order from smallest level to largest level: organ, cell, organ system, tissue. Then give one plant example and one animal example of an organ.
- Q6.** In the celery investigation, the cross-section showed the red dye in a ring of separate dots, not everywhere. (a) Name the tissue the dye moved through. (b) State what that tissue normally carries. (c) State what the pattern over time (faint lines, then strong lines, then red-tinged leaves) shows about the direction of movement.

Unscaffolded

- Q7.** Root hair cells are found on the outside of roots, and each one grows a single long, thin hair. Explain how this structure suits the cell’s function.
- Q8.** A mature red blood cell has no nucleus, even though most other cells in the body have one. Explain how losing the nucleus suits the red blood cell’s function.
- Q9.** Xylem tubes have walls reinforced with rings of a strong material. Predict and explain what would happen to water transport in a plant if the xylem walls were soft like a straw instead.
- Q10.** An artery has a thick muscle wall, but a capillary has a wall only one cell thick. Explain why each wall suits the vessel’s function.
- Q11.** In the pulse investigation the heart beat faster after jogging than at rest. Explain why the body’s cells need this, using respiration (subtopic 8B).
- Q12.** A student says: “Xylem and arteries both carry things under pressure-ish conditions, so their walls must be built the same.” Evaluate this claim using what you know about both structures.
- Q13.** Look at the drinking-straw model of xylem. State two things the model shows well and two ways it falls short.
- Q14.** Choose **one** part from the plant track and **one** part from the animal track. For each, write the structure–function sentence the whole subtopic is built on: *it has this structure, so it can do this function — and that serves the whole system because...*
-

Answers

Q1. (a) A group of similar cells working together at one job. (b) A structure made of different tissues working together. (c) Organs working together. (d) A cell whose shape and parts suit one particular job. **Q2.** (a) Xylem. (b) Phloem. (c) Xylem: one way, up. Phloem: both ways. (d) Roots, stem, leaves. **Q3.** (a) Muscle tissue. (b) They close to keep blood moving one way. (c) The left ventricle. (d) The aorta. **Q4.** (a) An artery. (b) A capillary. (c) A valve. **Q5.** Cell, tissue, organ, organ system. Plant organ: root, stem or leaf (any one). Animal organ: heart (or any correct organ, e.g. lung). **Q6.** (a) Xylem. (b) Water and dissolved minerals. (c) Water moved up the stalk toward the leaves. **Q7.** The long thin hair gives the cell a large surface area, so water and minerals pass in fast; the thin wall lets them pass through easily. **Q8.** With no nucleus there is more room inside the cell for haemoglobin, so the cell can carry more oxygen — the cell's job. **Q9.** The soft tubes would squash or collapse, the hollow pipe would close, and water would stop moving up — the plant would not get water to its leaves. **Q10.** The artery's thick muscle wall handles the high pressure of blood pushed from the heart; the capillary's one-cell-thick wall lets oxygen, food and wastes pass straight through to the body's cells. **Q11.** Working cells do more respiration, which needs oxygen and food and makes wastes; a faster heart moves the blood around more often, delivering oxygen and food faster and carrying wastes away faster. **Q12.** Wrong. An artery's thick muscle wall handles the push of blood from the heart; xylem's reinforced, hollow, dead-walled tube resists squashing while water is pulled up. Both resist collapse, but they are built from different materials for different kinds of flow — muscle for a pumped loop, reinforced dead tubes for a one-way pull. **Q13.** Shows well (any two): the tubes are hollow; many tubes run together; water can move up through them. Falls short (any two): the straw walls are not reinforced like xylem walls; the straws are far wider than a real xylem tube; the model cannot pull water up the way a living plant does. **Q14.** Any two parts, each with a correct structure, a correct function and a link to the whole system (see the fully worked solutions for models).

Fully-worked solutions

Q1. (a) A **tissue** is a group of similar cells working together at one job (1 mark). (b) An **organ** is a structure made of different tissues working together (1 mark). (c) An **organ system** is organs working together (1 mark). (d) A **specialised cell** is a cell whose shape and parts suit one particular job (1 mark).

Q2. (a) **Xylem** (1 mark). (b) **Phloem** (1 mark). (c) Xylem moves its load **one way, up**; phloem moves its load **both ways** (1 mark). (d) **Roots, stem and leaves** (1 mark).

Q3. (a) **Muscle tissue** (1 mark). (b) The valves **close to keep the blood moving one way** (1 mark). (c) The **left ventricle** (1 mark). (d) The **aorta** (1 mark).

Q4. (a) An **artery** (1 mark). (b) A **capillary** (1 mark). (c) A **valve** keeps the blood in a vein moving one way (1 mark).

Q5. Order: **cell** → **tissue** → **organ** → **organ system** (1 mark). Plant organ: **a root, a stem or a leaf** (1 mark); animal organ: **the heart** (a lung also accepted) (1 mark).

Q6. (a) The dye moved through the **xylem** (1 mark). (b) Xylem normally carries **water and dissolved minerals** (1 mark). (c) The pattern — lines climbing the stalk, then red-tinged leaves — shows the water moved **up**, from the beaker toward the leaves (1 mark).

Q7. The hair is **long and thin**, which gives the cell a **large surface area**, so water and minerals can pass in fast (2 marks); and its **thin wall** lets them pass through easily (1 mark). Structure and function match: a wide, short cell would soak up far less.

Q8. The nucleus is one part taking up room; **without it there is more room for haemoglobin**, the oxygen-carrying material, so **the cell carries more oxygen** (2 marks) — the cell gives up one part to be better at its one job (1 mark).

Q9. Soft walls would **squash or collapse**, closing the hollow tube (1 mark); with the tube closed, **water would stop moving up** and the leaves would not get water (1 mark); the reinforcement exists precisely to stop that (1 mark).

Q10. Blood leaves the heart **at high pressure**, so the artery needs a **thick muscle wall** to handle the push without bursting (2 marks). The capillary's job is **delivery** — oxygen, food and wastes passing to and from the cells — so its **one-cell-thick wall** lets them pass straight through (2 marks).

Q11. Working muscle cells do **more respiration**, which uses **oxygen and food** and makes wastes (*1 mark*); a **faster heart** moves the blood around **more often**, so oxygen and food arrive faster and wastes leave faster (*2 marks*).

Q12. The claim is **wrong** (*1 mark*). An artery's wall is **living muscle**, thick to handle the push of blood the heart pumps around a loop (*1 mark*); a xylem tube's wall is **reinforced dead tube**, stiff so it does not squash while water is pulled up one way (*1 mark*). Both resist collapse, but the structures are different because the workings — pumped loop versus one-way pull — are different (*1 mark*).

Q13. Shows well (any two): the tubes are **hollow**; **many tubes run together** in a bundle; **water can move up** through them (*2 marks — one each*). Falls short (any two): the straw walls are **not reinforced** like xylem walls; the straws are **far wider** than a real xylem tube; the model **cannot pull water up** the way a living plant does (*2 marks — one each*).

Q14. One mark per part for a correct structure, one for a correct function, one for the link to the whole system (6 marks total). Model answer: **Root hair cell** — it has **one long thin hair and a thin wall** (structure), so it can **take in water and minerals fast** (function), and that serves the whole system because **it supplies the water the xylem carries up to every leaf** (system link). **Capillary** — it has **a wall one cell thick** (structure), so **oxygen and food pass straight through to the body's cells** (function), and that serves the whole system because **the delivery the circulation exists for happens exactly there** (system link).

Sources

- Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8 — content description VC2S8U03 (first clause owned here; second clause owned by 8D) and elaborations VC2S8U03.E01, VC2S8U03.E02 and VC2S8U03.E03, used as elaboration contexts (D6/D12).
- ASTA (Science ASSIST), [Science Safety Essentials: Risk Management in Science](#) (published 2022-10-26, modified 2025-12-15)
- The celery and pulse activities are class-standard safe practice written to the ASTA guidance above; their results tables are **simulated data for practice**, and the patterns they show — dye climbing in the xylem, and a faster pulse with harder exercise — are the real behaviour of the systems.

Web sources below were retrieved 2026-08-21.

Elaboration contexts used: VC2S8U03.E01 (two- and three-dimensional representations locating and comparing analogous systems in a plant and an animal), VC2S8U03.E02 (specialised cells and tissues in particular organs) and VC2S8U03.E03 (each organ's structure related to the overall function of the system).

Organ systems and survival — and what a disorder of a cell, tissue or organ does to the whole organism

What we teach here — VC2S8U03 (Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8):

“the structure of cells, tissues and organs in a plant and an animal organ system are related to their function; plant and animal organ systems enable survival of the organism” **This subtopic owns the**

second clause only: what the organ systems of a plant and an animal actually do that enables the organism to survive, and what a disorder of a cell, tissue or organ does to the whole organism. The first clause — the structure of cells, tissues and organs set against their function — belongs to the partner subtopic **8C** (+ split delivery, D6). **In our words:** a plant or an animal stays alive because its organ systems work as a team — keeping every cell supplied with what it needs and cleared of what it does not. When a disorder knocks one part of the team out of action, the effect does not stay put: it climbs the levels of organisation — cells, tissue, organ, system — and lands on the whole organism. **Achievement-standard extract served here (D13):** cited by reference to the header of the owner subtopic 8C, where the extract appears in full. The second clause of that extract — explaining how a disorder in the cells, tissues or organs of these systems affects the survival of a selected plant and a selected animal — is the clause this subtopic serves.

Elaborations drawn on: VC2S8U03 .E04 (researching how a disorder of cells or tissues can affect an organ’s function — here, hardening of the arteries leading to poor circulation or heart disease), VC2S8U03 .E05 (researching and discussing ethical issues that arise from organ transplantation), VC2S8U03 .E06 (investigating how an artificial organ mimics or augments the functions of a real organ — here, a kidney dialysis machine) and VC2S8U03 .E07 (relating the loss of a non-vital organ such as the tonsils, appendix, spleen, gall bladder or a reproductive organ to effects on body systems). **Authored from the CD text and the elaboration contexts (D12):** the CD states that plant and animal organ systems enable survival; the teaching here builds the supply-and-removal picture that “enable survival” means, then studies four disorders — two animal (hardened arteries, flattened villi) and two plant (ringbarking, dieback) — with the four elaborations above supplying the disorder, ethics, artificial-organ and non-vital-organ contexts.

Word watch — *disorder*. In everyday talk, a *disorder* can just mean a mess — a disordered room. In science, a **disorder** is a condition in which part of an organism stops working as it should. A disorder is not always caused by germs: it can come from a build-up in a tissue, from damage, or from the body reacting wrongly to something harmless. In this subtopic, *disorder* always carries the science meaning.

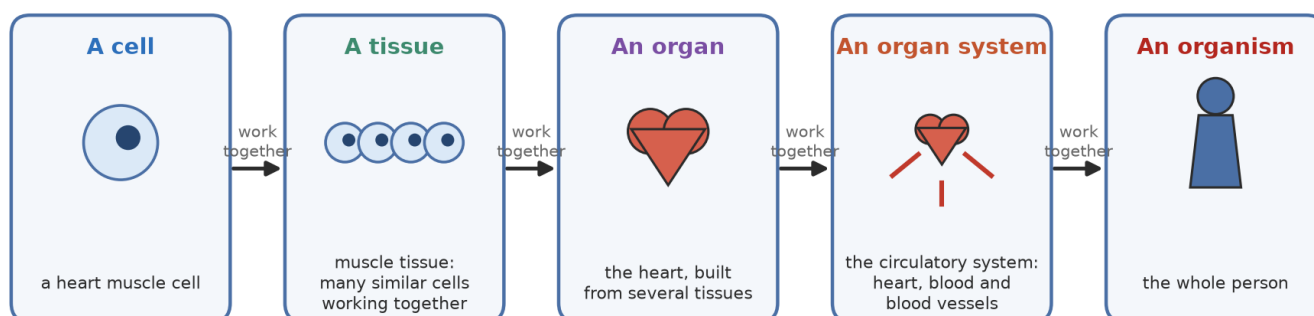
Word watch — *vital*. In everyday talk, *vital* often just means “very important” — a vital part of the plan. In science the meaning is stronger: a **vital organ** is one the organism cannot live without. The heart, the brain, the liver and the lungs are vital organs. A **non-vital organ** is one the organism can live without — not because it does nothing, but because the rest of the body can manage without it.

Theory

From cells to organism — the ladder 8C built

Subtopic 8C taught the levels of organisation: cells group into **tissues**, tissues group into **organs**, organs group into **organ systems**, and the organ systems together make the whole **organism**. 8C also taught that at every level, structure and function fit — the shape of a part suits its job. This subtopic takes that ladder and asks two new questions. First: what do the organ systems of a plant or an animal actually do that keeps the organism alive? Second: when a disorder starts at one level of the ladder, what does it do to the whole organism? The two questions belong together, because the levels are nested — the whole organism rests on every level below it working.

Levels of organisation — each level is built from the one below



A problem at any level can ripple up and affect every level above it.

The levels of organisation as a chain from cell to tissue to organ to organ system to organism, shown with the heart example: one heart muscle cell, heart muscle tissue, the heart as an organ, the circulatory system, and the whole person

Organ systems work as a team

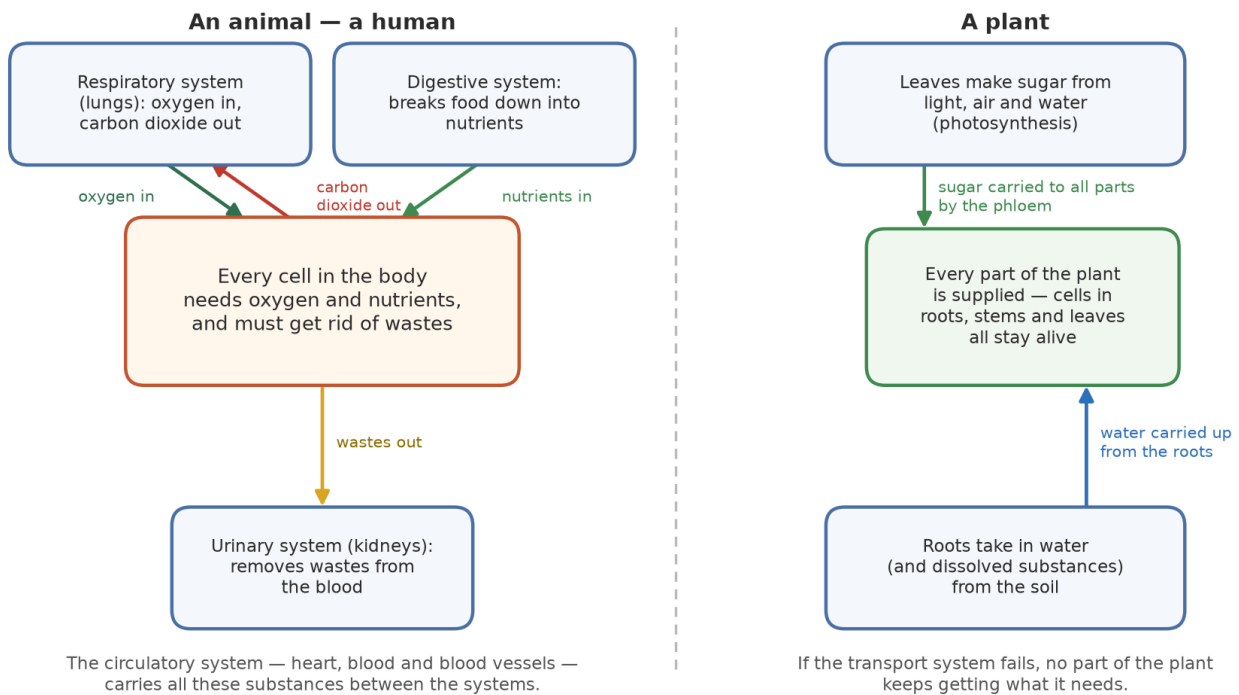
An **organ system** is a group of organs working together at one big job. In an animal, four systems show the idea well:

- The **respiratory system** brings oxygen into the body and removes carbon dioxide, the waste gas.
- The **digestive system** breaks down food into small dissolved food substances the body can use.
- The **circulatory system** — the heart, the blood and the blood vessels — is the transport team: it carries oxygen and food substances to every cell, and carries waste substances away from them.
- The **urinary system** — which includes the two **kidneys** — removes some waste substances from the blood and keeps the amount of water in the body right.

A plant runs a team too, with its own organs and transport tissues:

- The **roots** take up water and dissolved minerals from the soil.
- The **leaves** make the plant's food — a simple sugar — by photosynthesis (subtopic 8B).
- Two transport tissues link the parts (subtopic 8C teaches them in detail): the water-carrying tissue takes water up from the roots to the rest of the plant, and the **phloem** carries sugar from the leaves to every part that needs food — including the roots, which cannot make their own.

Organ systems enable survival: every cell and every part gets supplied



Animal and plant organ systems drawn as teams: on the animal side, the respiratory, digestive, urinary and circulatory systems each labelled with their job; on the plant side, roots taking up water, leaves making sugar, water carried up from the roots and sugar carried down by the phloem

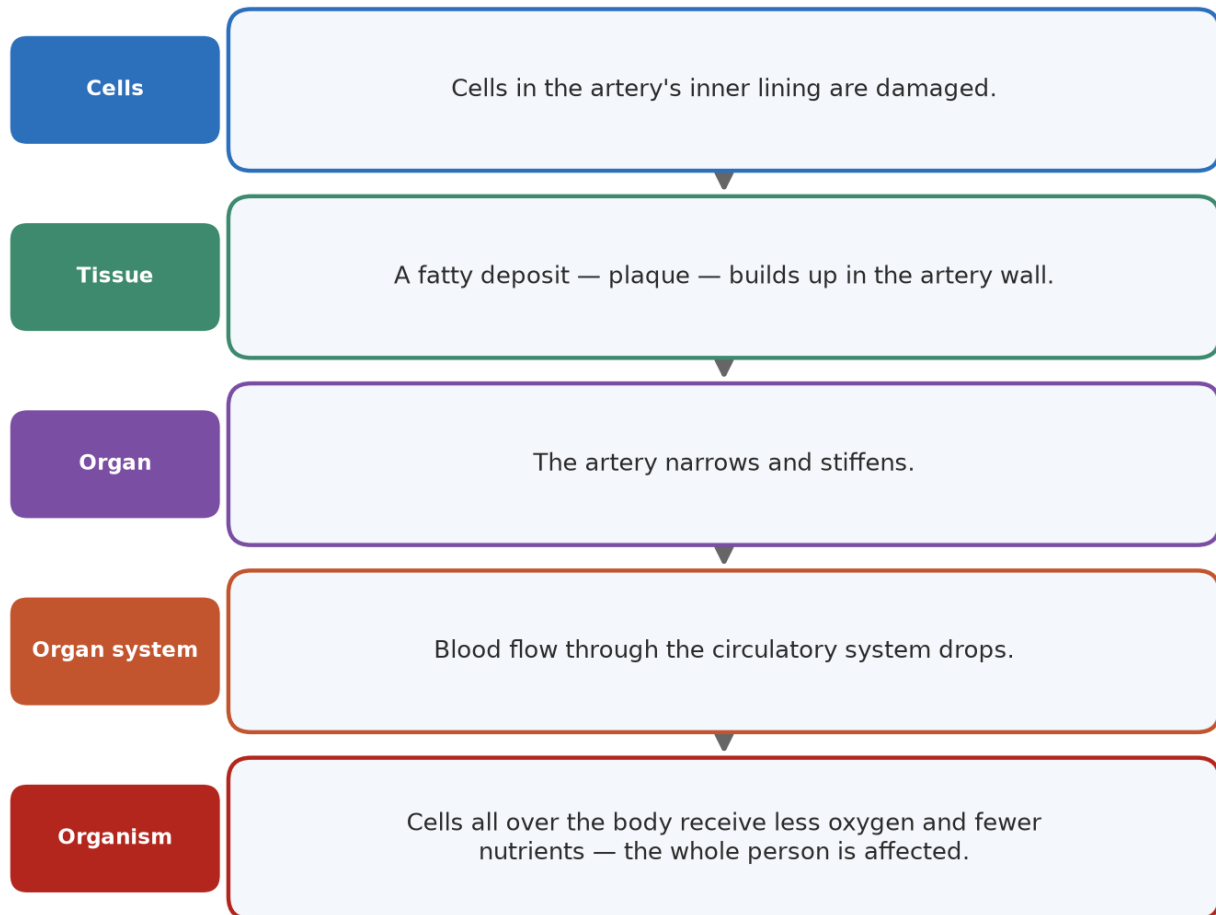
What survival needs

Every cell of every organism has the same basic deal: supplies in, wastes out. An animal cell needs a steady supply of oxygen, food substances and water, and it must get rid of carbon dioxide and other waste substances. A plant cell needs light, carbon dioxide, water and minerals. No single cell can fetch these for itself — the organ systems do the fetching and the clearing. An organism survives for as long as that supply-and-removal work keeps going, and it is in trouble as soon as the work stops in any part of the team.

What is a disorder?

A **disorder** is a condition in which part of an organism stops working as it should (see the Word watch above). A disorder can start at any level of the ladder — in some cells, in a tissue or in a whole organ. Because the levels are nested, the trouble does not stay where it began. A disorder in cells damages the tissue the cells belong to; a damaged tissue lets down the organ it is part of; a struggling organ lets down the whole system; and a struggling system lets down the organism. The figure below shows that climb.

One disorder, rippling up the levels of organisation



The disorder starts at one level — here, the cells of the artery wall — and its effects climb the levels until the whole organism feels them.

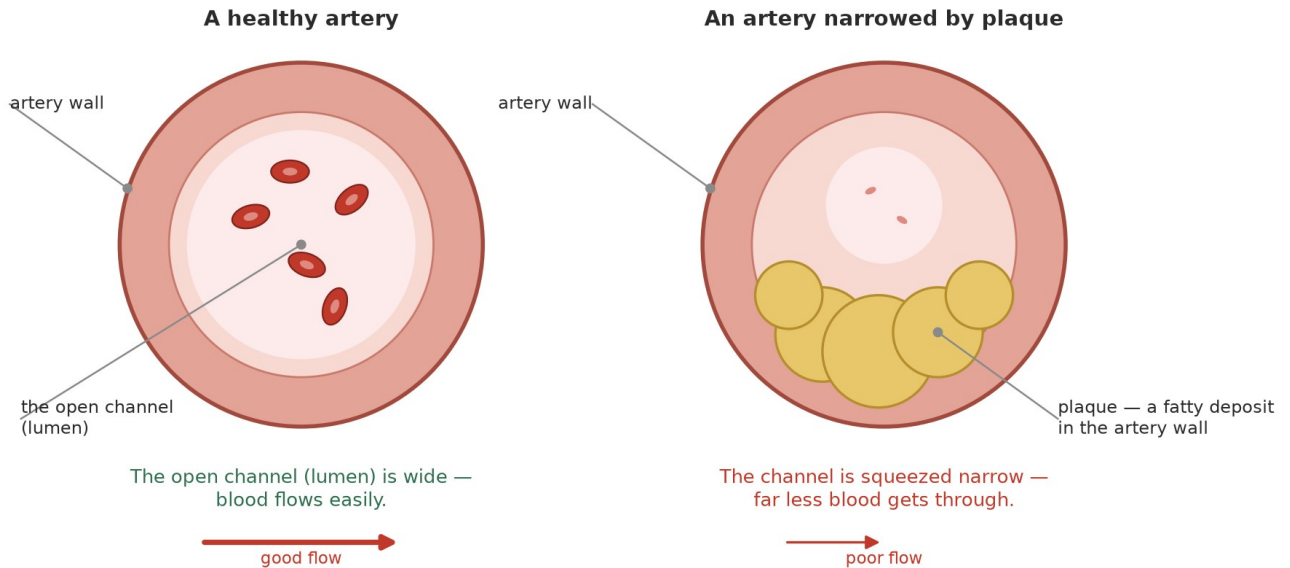
A disorder climbing the levels of organisation: a problem in cells ripples up to tissue, organ, organ system and finally the whole organism

The rest of the Theory section is four disorder studies — two in animals, two in plants — each one following the climb from a small beginning to the whole organism.

An animal tissue disorder: hardening of the arteries (VC2S8U03.E04)

Arteries are the blood vessels that carry blood away from the heart. An artery's wall is made of tissue, and its inside is an open channel called the **lumen**. In some people, fatty substances slowly build up inside the artery wall over many years. The build-up is called **plaque**. As plaque grows, the wall thickens and hardens, and the lumen gets narrower and narrower. This is the **hardening of the arteries** that VC2S8U03.E04 names.

Arteries: a healthy open channel against one narrowed by plaque



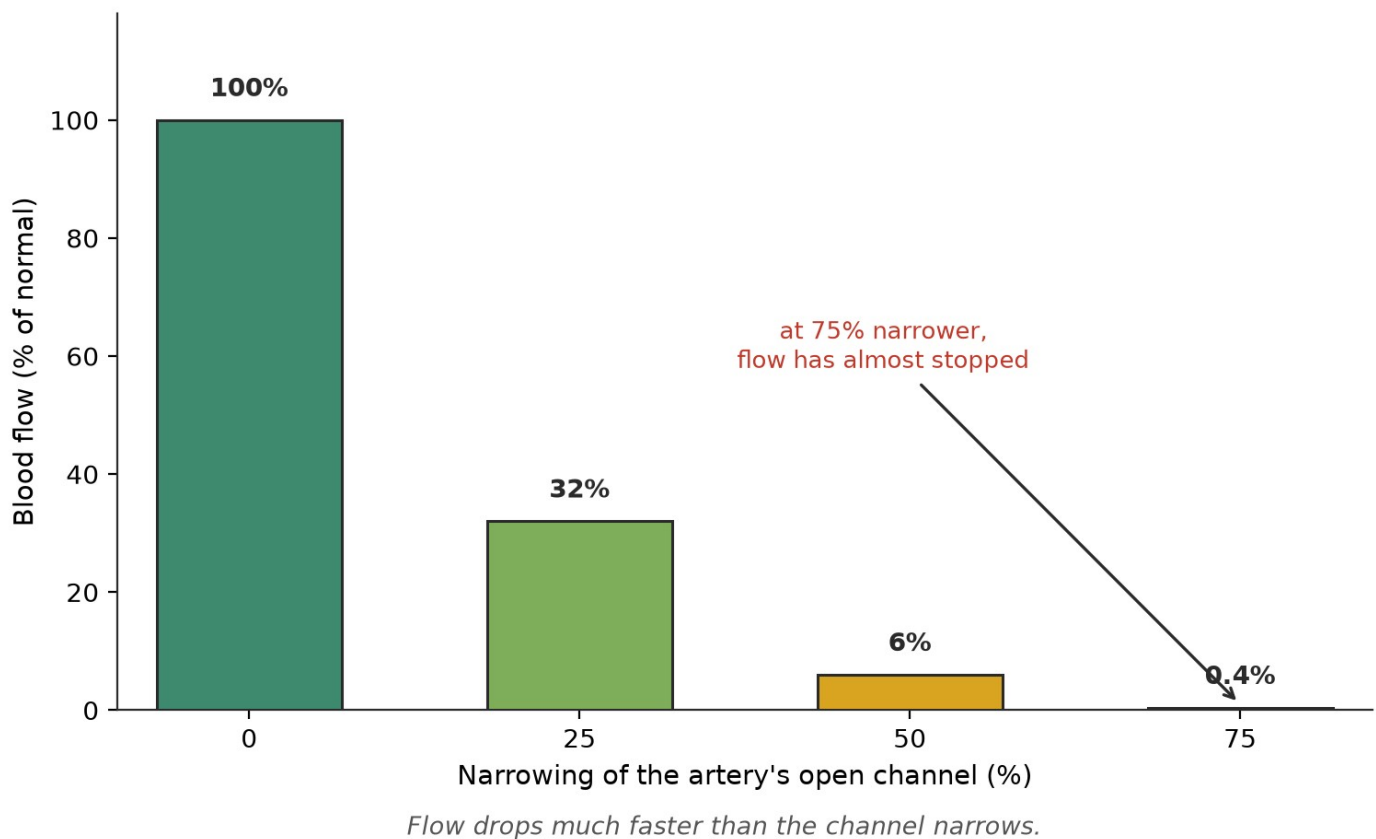
A healthy artery and a hardened artery side by side: the healthy artery has a wide open lumen; the hardened artery has plaque built up in its wall and a much narrower lumen

The effects climb the ladder. A narrow lumen lets less blood through, so the tissues fed by that artery get less oxygen and fewer food substances — that is **poor circulation**. The heart must push harder to force blood through the narrowed channel, and a heart that works too hard for too long can itself become diseased — that is one way hardening of the arteries leads to **heart disease**. If the blood supply to part of the heart muscle is cut off altogether, that muscle cannot do its work and the heart can stop.

Reading the flow data (subtopic 4C)

The bar graph below shows how the blood flow through an artery changes as the lumen narrows. (*Simulated data for practice.*)

What narrowing does to flow — simulated data for practice



A bar graph of simulated data: blood flow as a percentage of normal against narrowing of the artery, falling from 100% at no narrowing to 32% at 25% narrower, 6% at 50% narrower, and 0.4% at 75% narrower, where flow has almost stopped

Read the graph the way subtopic 4C teaches — shape and trend, no number-crunching:

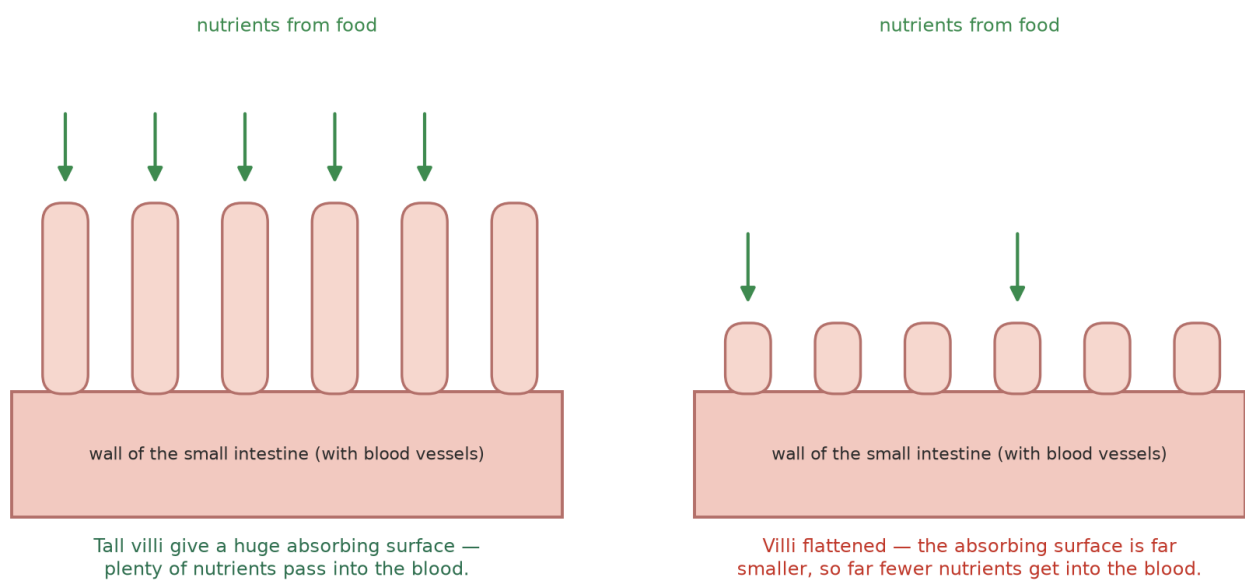
- At 25% narrower, the flow is already down to about 32% of normal — nearly a third.
- At 50% narrower, only about 6% gets through.
- At 75% narrower, the flow is about 0.4% — for the body's purposes, it has almost stopped.

The trend is clear: the more the artery narrows, the less blood flows — and the drop gets much bigger with each extra step of narrowing. A small build-up of plaque is not a small problem: even a quarter narrower already cuts the flow by more than half.

Another animal tissue disorder: flattened villi

The **small intestine** is the organ where digested food substances pass into the blood. Its inner wall is covered in millions of tiny finger-like projections called **villi** (one is a **villus**). The villi give the wall a very large surface, and food substances pass through that surface into the blood — the process is **absorption**.

Villi in the small intestine — a tissue-level disorder (coeliac disease)



Tall healthy villi and flattened villi side by side: the tall villi give a large surface for absorption; in coeliac disease the villi are flattened and far less food passes into the blood

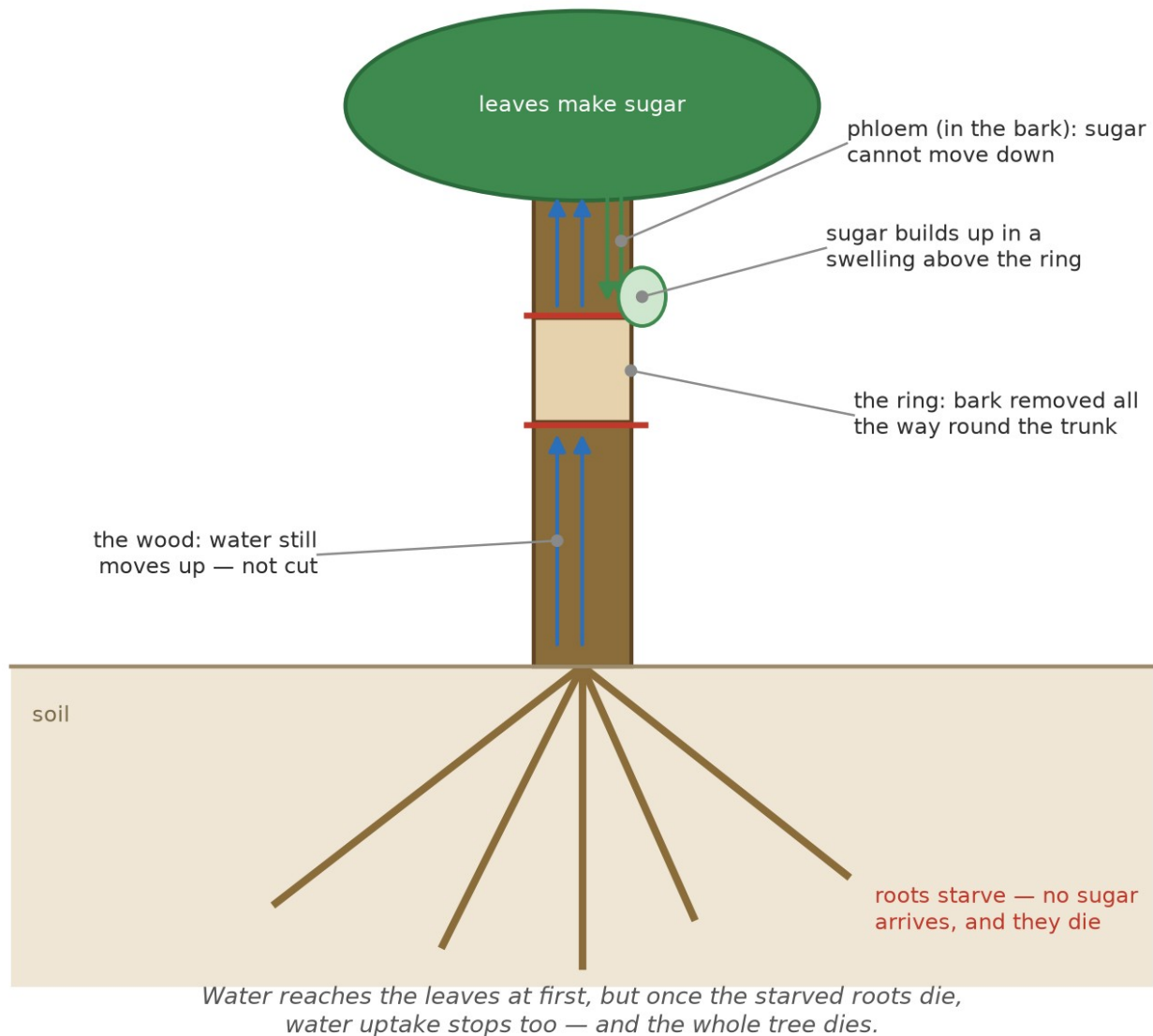
In **coeliac disease**, the body reacts wrongly to a protein found in wheat and some other grains. That reaction damages the villi and flattens them. Flattened villi give a much smaller surface, so far less food is absorbed. The effect on the organism is surprising: the person can eat plenty of food and still miss out on the food substances their cells need — not growing well, feeling tired and losing weight. Structure and function, again: change the structure of the villi and you change the job they can do.

Plant disorders count too: ringbarking

The achievement standard asks for a plant as well as an animal, so here is the plant side. Remember from the team figure: the phloem in a tree's bark carries sugar down from the leaves, and the water-carrying tissue in the wood carries water up.

Ringbarking is the removal of a band of bark all the way around a trunk. The cut goes through the phloem but leaves the water-carrying tissue in the wood untouched. Sugar from the leaves can no longer travel down — it collects in a swelling just above the ring. Water can still travel up for a while, so the leaves may stay green at first — but the roots, starved of sugar, stop working and die. Once the roots die, no water comes up at all, and the whole tree dies. A cut in one tissue, in one place, kills an entire tree.

Ring-barking: cutting the phloem kills a tree

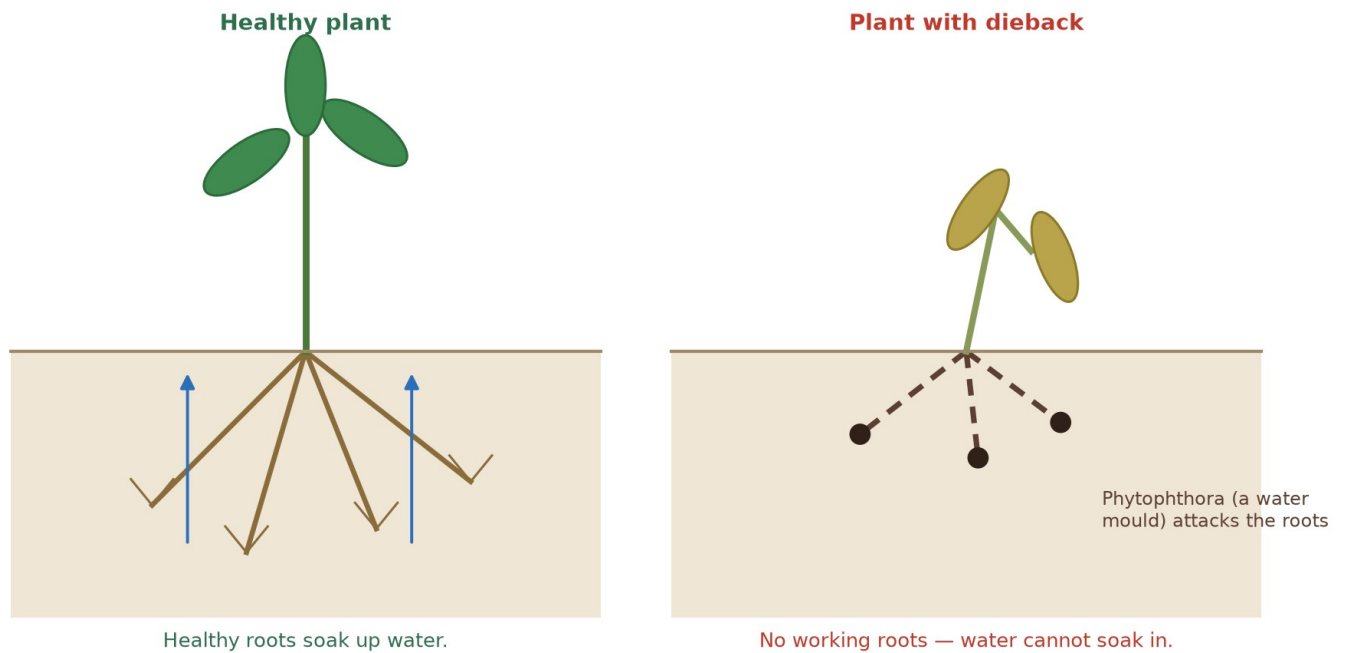


A ringbarked tree: a band of bark removed around the trunk, the phloem cut and sugar swelling above the ring while water still moves up through the wood, and the roots below starving of sugar

Plant disorders count too: dieback from root rot

Dieback describes a plant dying back from its tips, and a common cause in Australian bushland and gardens is root rot. An organism that lives in the soil — *Phytophthora*, a water mould, not a fungus — infects the roots and rots them.

Dieback: a disorder of root tissue kills the whole plant



A healthy plant and a dieback-affected plant side by side: healthy roots on the left, rotted roots attacked by Phytophthora on the right, with the plant above wilting and dying back from the tips

Rotted roots cannot take up water or minerals. The rest of the plant wilts and dies back from the tips — even when the soil is wet, because the supply line itself is destroyed. Notice the climb once more: the disorder starts in the cells of the roots, ruins the root tissue, and the whole plant dies from the top down.

Vital and non-vital organs (VC2S8U03.E07)

Some organs are **vital** — the organism cannot live without them. The heart, the brain, the liver and the lungs are vital organs. Others are **non-vital**: a person can live without them, because the rest of the body manages the loss.

VC2S8U03.E07 lists examples, and the effects of losing each:

- **One kidney.** The other kidney does the work of two, and the person lives well — but must look after the kidney they have.
- **The spleen.** Other organs take over most of its jobs; the person needs extra care against infections.
- **The gall bladder.** It stores **bile**, a liquid that helps break down fatty food in the small intestine; without it, bile still reaches the small intestine and the body copes.
- **The appendix.** A small pouch on the large intestine; removing it changes little.
- **The tonsils.** Defence tissue at the throat; without them, the body defends itself in other ways.

The loss of one of the reproductive organs works the same way: the body manages. “Non-vital” never means “does nothing” — each of these organs has a job; the body simply has ways of managing when the job is lost.

Which organs can the body live without?

Organs the body cannot live without	Organs the body can live without
The heart pumps blood to every cell in the body	One kidney the other kidney grows and does the work of both
The brain controls and coordinates the body's work	The spleen other organs take over its jobs; infections need extra care
The liver cleans the blood and makes substances the body needs	The gall bladder stores bile; the body copes without it
The lungs you can live with one, but you need at least one	The appendix a pouch on the large intestine; removal changes little
	The tonsils defence tissue at the throat; the body defends itself in other ways

Vital means the body cannot live without it. A non-vital organ has a job, but the body can manage — sometimes differently — after it is removed.

Vital organs and non-vital organs in two columns: heart, brain, liver and lungs, which a person cannot live without, against one kidney, spleen, gall bladder, appendix and tonsils, which a person can live without, each with a short note

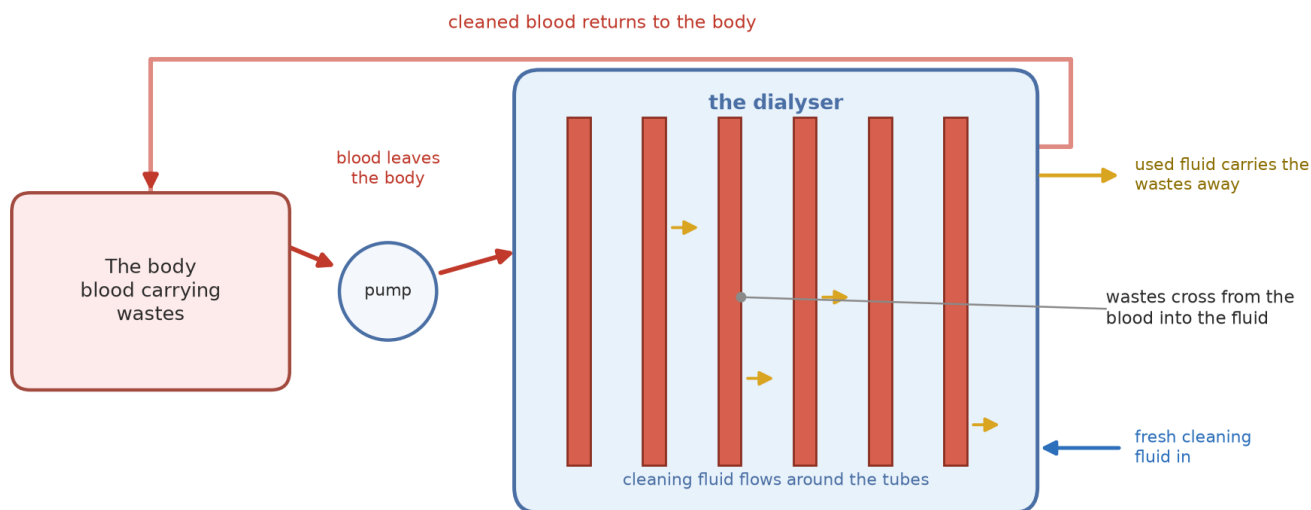
Artificial organs: mimicking or helping a real organ (VC2S8U03.E06)

An **artificial organ** is a man-made device that does part or all of the job of a real organ. The clearest example is the **kidney dialysis machine**, used when a person's kidneys have stopped working. The machine mimics the kidneys' filtering job:

1. Blood is pumped out of the body and through tubes in a filter called the **dialyser**.
2. Waste substances and extra water cross from the blood, through the tube walls, into a special fluid.
3. The cleaned blood returns to the body.

The person sits connected to the machine for hours at a time, several times a week. The machine mimics the filtering job of the kidneys — but not everything the kidneys do, and it works only while the person is connected to it. Other artificial parts include artificial heart valves, which keep blood flowing the right way, and artificial hip joints, which let a person walk again.

A dialysis machine mimics the kidneys' cleaning job



The machine does outside the body what healthy kidneys do inside it: wastes leave the blood, and the cleaned blood goes back.

A kidney dialysis machine: blood pumped from the body into the dialyser, where wastes and extra water cross into the fluid, and cleaned blood returning to the body

Modelling a filter — a simple activity (VC2S8U03.E06)

The kidneys' filtering job can be modelled with filter paper. Mix a spoon of sugar and a handful of coarse sand into a beaker of water, and pour the mixture through filter paper in a funnel.

- **What happens:** the sand — the large grains — stays on the paper, while the sugar water passes through. Large things are kept back; dissolved things pass.
- **Shows well:** the idea of separating by size — as the kidney's filter keeps blood cells in the blood while dissolved substances pass.
- **Falls short (subtopic 5A):** filter paper cannot choose *which* dissolved substances pass — a real kidney keeps the useful ones and lets the wastes go. And the model is a one-off pour, while a kidney filters all day, every day.
- **Risk (subtopic 3B):** nothing here is harmful, but do not taste anything made in the lab, carry the beaker with two hands, and wipe up spills at once so nobody slips. Plan and run the activity with the risk-management guidance from Science ASSIST (see Sources).

Organ transplantation: ethical questions to discuss (VC2S8U03.E05)

A **transplant** replaces a failing organ with a healthy organ from another person, the **donor**. Transplants save lives — but they raise **ethical questions**, questions about what is right and fair. These are live questions with more than one reasonable view; in class, the job is to give reasons and to listen to reasons, not to “win”. Four questions worth discussing:

1. **Not enough organs.** There are far more people waiting for a transplant than there are donor organs. Who should get one first — the sickest, the longest waiting, the best match? What makes one way of choosing fairer than another?
2. **Consent.** Should donation be something each person opts into while alive — and should the family's wishes still be heard at the time? Where should the final say sit, and why?
3. **Living donors.** A person can give one kidney and live well with the other. Is it right for a healthy person to take on surgery and risk for someone else? Should family members be asked, or should they offer?

4. **Buying and selling.** In Australia it is against the law to buy or sell human organs. What is the argument for that rule — and can students think of any argument against it? (Think about what would happen if organs went to the highest bidder.)
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Putting it together

Organ systems enable survival because they keep every cell supplied and cleared. A disorder of a cell, tissue or organ threatens survival because the levels are nested: the trouble climbs the ladder to the whole organism. The pattern held for both sides of the living world — hardened arteries and flattened villi in animals, ringbarking and root rot in plants — and it is why medicine works the way it does: transplanting organs, building artificial ones, and treating disorders low on the ladder before they reach the top.

Words to know in 8D

Word	What it means here
organ system	a group of organs working together at one big job
disorder	a condition in which part of an organism stops working as it should
vital organ	an organ the organism cannot live without
non-vital organ	an organ the organism can live without, because the rest of the body manages
lumen	the open channel inside a blood vessel
plaque	a build-up of fatty substances inside an artery wall
villi (villus)	tiny finger-like projections lining the small intestine, through which food substances pass into the blood
absorption	the passing of food substances (or other substances) into the blood
phloem	the transport tissue in a plant that carries sugar from the leaves to the rest of the plant
ringbarking	the removal of a band of bark all the way around a trunk or stem
dieback	the dying back of a plant from its tips, here caused by root rot
dialysis	the cleaning of the blood by a machine that does part of the kidneys' filtering job
artificial organ	a man-made device that does part or all of the job of a real organ
transplant	an operation replacing a failing organ with a healthy organ from a donor
donor	the person an organ for a transplant comes from

Worked examples

Example 1 — scaffolded

Four descriptions each name one level of organisation. Name the level in each case.

Working	Comment
1. "A group of similar cells working together at one job" — a tissue .	Cells group into tissues; that is the second level of the ladder.

Working	Comment
2. “The heart” — an organ .	The heart is built from several tissues working together, which is what makes it an organ.
3. “The heart, the blood and all the blood vessels, working together” — an organ system (the circulatory system).	A group of organs at one big job — here, transport — is an organ system.
4. “The whole person” — the organism .	All the organ systems together make the whole organism: the top of the ladder.

Example 2 — scaffolded

Follow the hardening of the arteries up the levels of organisation. State what changes at each level.

Working	Comment
1. Cells and tissue: plaque builds up in the artery wall; the wall thickens and hardens.	The disorder starts in the tissue of the artery wall.
2. Organ: the artery’s lumen gets narrower, so less blood can pass.	A tissue problem has changed the organ — the artery now does its job less well.
3. Organ system: the circulatory system delivers less blood to the tissues that artery feeds.	The struggling artery lets the whole transport team down.
4. Organism: the person may tire easily; the heart pushes harder and can itself become diseased.	The climb ends at the whole organism — poor circulation, and in time heart disease.

Example 3 — unscaffolded

A person with untreated coeliac disease eats plenty of food but still does not grow well and feels tired. Explain why, linking the structure of the villi to their job.

The villi are tiny finger-like projections lining the small intestine, and their job is absorption — letting digested food substances pass into the blood. Tall villi give the wall a very large surface for that job. In coeliac disease the villi are flattened, so the surface is much smaller and far less food is absorbed. ∴ even though the person eats plenty, too little food reaches the blood and the cells — growth is poor and the person feels tired. Changing the structure changed the function.

Example 4 — unscaffolded

A gardener removes a band of bark all the way around an apple tree’s trunk. A friend says, “*The tree will be fine — water can still travel up the trunk.*” Explain why the friend is wrong, even though water does still travel up for a while.

The bark carries the phloem, and the phloem’s job is carrying sugar down from the leaves to the rest of the plant, including the roots. Ringbarking cuts the phloem, so sugar can no longer reach the roots and collects in a swelling above the ring. The water-carrying tissue in the wood is untouched, so water does still travel up at first — that part of the friend’s claim is true. But the roots, starved of sugar, stop working and die; once the roots are dead, no water is taken up at all, and the whole tree dies. ∴ the tree dies not from losing its water supply at once, but from losing its food supply first — the friend is wrong.

Practice questions

Scaffolded

Q1. Define each of the following, as the words are used in this subtopic: (a) organ system; (b) disorder; (c) vital organ; (d) absorption.

Q2. The levels of organisation. (a) Name the five levels of organisation, from smallest to largest. (b) For the circulatory system, give one example of each level, as the figure in the Theory section shows.

Q3. What each system does. (a) State the job of the respiratory system. (b) State the job of the digestive system. (c) State the job of the circulatory system. (d) State the job of the urinary system. (e) In a plant, state what each of the two transport tissues carries: the phloem, and the water-carrying tissue.

Q4. Hardening of the arteries. (a) Name what builds up inside the artery wall. (b) State what happens to the lumen. (c) State one effect on the tissues fed by that artery. (d) State one effect on the whole person.

Q5. Vital and non-vital organs. (a) What is a vital organ? (b) Name two vital organs. (c) Name two non-vital organs. (d) State what happens when a person loses one kidney.

Q6. The flow bar graph in the Theory section shows simulated data. (a) State the blood flow through an artery at 25% narrowing. (b) Describe the trend shown by the graph. (c) State at which narrowing the flow has almost stopped. (d) Why does the book label the data as simulated?

Unscaffolded

Q7. Explain why a person with flattened villi can miss out on food substances even when they eat plenty of food.

Q8. Explain why ringbarking kills a tree even though the water-carrying tissue is untouched.

Q9. A plant whose roots have been rotted by *Phytophthora* wilts even when the soil is wet. Explain why.

Q10. The kidney dialysis machine. (a) Name the job of the kidneys that the machine mimics. (b) Name the two things that cross from the blood into the fluid in the dialyser. (c) State what returns to the body. (d) State one way the machine is not as good as a real kidney.

Q11. Organ transplantation raises ethical questions. State **two** of the questions discussed in the Theory section, and give one reason why people might hold different views about each.

Q12. A student says: “*A disorder in one organ only affects that organ.*” Evaluate this claim, using one example from this subtopic.

Q13. A person says: “*I had my tonsils removed and nothing changed, so tonsils do not have a job.*” Evaluate this claim.

Q14. Choose **one animal disorder** and **one plant disorder** from this subtopic. For each, explain how a problem that starts at one level of organisation ends up threatening the survival of the whole organism.

Answers

Q1. (a) A group of organs working together at one big job. (b) A condition in which part of an organism stops working as it should. (c) An organ the organism cannot live without. (d) The passing of food substances into the blood. **Q2.** (a) Cell, tissue, organ, organ system, organism. (b) A heart muscle cell; heart muscle tissue; the heart; the circulatory system; the whole person. **Q3.** (a) Brings oxygen into the body and removes carbon dioxide. (b) Breaks down food into small dissolved food substances the body can use. (c) Carries oxygen and food substances to every cell and carries waste substances away. (d) Removes some waste substances from the blood and keeps the amount of water in the body right. (e) The phloem carries sugar; the water-carrying tissue carries water up from the roots. **Q4.** (a) Plaque — a build-up of fatty substances. (b) It gets narrower. (c) They get less oxygen and fewer food substances (poor circulation). (d) Any one: the person may tire easily; the heart pushes harder and can become diseased; the heart can stop if its own blood supply is cut off. **Q5.** (a) An organ the organism cannot live without. (b) Any two of: heart, brain, liver, lungs. (c) Any two of: one kidney, spleen, gall bladder, appendix, tonsils. (d) The other kidney does the work of two, and the person lives well but must look after the kidney they have. **Q6.** (a) About 32% of normal. (b) The more the artery narrows, the less blood flows — and the drop gets much bigger with each extra step of narrowing. (c) 75% narrower. (d) Because the numbers were made up for practice; the pattern they show is real, the exact numbers are not measured data. **Q7.** Villi give the small intestine a large surface for absorption; flattened villi give a much smaller surface, so far less food passes into the blood — the cells miss out even when plenty of food is eaten. **Q8.** The bark carries the phloem, and ringbarking cuts it, so sugar can no longer reach the roots; the roots starve and die, and once the roots are dead no water is taken up and the whole tree dies — even though the untouched water-carrying tissue kept water moving for a while. **Q9.** Rotted roots cannot take up water or minerals; with the supply line destroyed, the rest of the plant wilts and dies back from the tips no matter how wet the soil is. **Q10.** (a) Filtering waste substances and extra water out of the blood. (b) Waste substances and extra water. (c) The cleaned blood. (d) Any one: it does not do everything the kidneys do; it works only while the person is connected to it, hours at a time, several times a week. **Q11.** Any two of the four discussed — not enough organs (who gets one first: the sickest, the longest waiting, the best match); consent (opting in, and the family's wishes); living donors (a healthy person taking on risk for someone else); buying and selling (the law against it, and fairness). One sensible reason on each side is enough. **Q12.** The claim is wrong: the levels of organisation are nested, so a disorder climbs the ladder — e.g. plaque in the artery wall (a tissue) narrows the artery (an organ), lets down the circulatory system, and ends in poor circulation or heart disease in the whole person. **Q13.** The claim is wrong: tonsils are defence tissue at the throat and do have a job; “nothing changed” because the body defends itself in other ways — the tonsils are non-vital, not useless. **Q14.** Animal, e.g. hardening of the arteries: plaque in the artery wall (tissue) narrows the lumen (organ), cuts blood flow in the circulatory system, and starves the body's cells of oxygen — threatening survival. Plant, e.g. ringbarking: the phloem is cut (tissue), sugar can no longer reach the roots, the roots starve and die, and without roots the whole tree dies. Any pair from the subtopic, correctly climbed, earns the marks.

Fully-worked solutions

Q1. (a) An **organ system** is a group of organs working together at one big job (1 mark). (b) A **disorder** is a condition in which part of an organism stops working as it should (1 mark). (c) A **vital organ** is an organ the organism cannot live without (1 mark). (d) **Absorption** is the passing of food substances into the blood (1 mark).

Q2. (a) **Cell, tissue, organ, organ system, organism** — all five, in order (2 marks). (b) One example per level, from the figure: **a heart muscle cell** (cell), **heart muscle tissue** (tissue), **the heart** (organ), **the circulatory system** (organ system), **the whole person** (organism) (4 marks — one each).

Q3. (a) The respiratory system **brings oxygen into the body and removes carbon dioxide** (1 mark). (b) The digestive system **breaks down food into small dissolved food substances the body can use** (1 mark). (c) The circulatory system **carries oxygen and food substances to every cell and carries waste substances away** (1 mark). (d) The urinary system **removes some waste substances from the blood and keeps the amount of water in the body right** (1 mark). (e) Sugar travels in the **phloem**; water travels up from the roots through the **water-carrying tissue** (2 marks — one each).

Q4. (a) **Plaque** — a build-up of fatty substances — builds up inside the artery wall (1 mark). (b) The lumen **gets narrower** (1 mark). (c) The tissues fed by that artery get **less oxygen and fewer food substances** — poor circulation

(1 mark). (d) Any one (1 mark): the person **may tire easily**; the heart **pushes harder and can itself become diseased**; the heart **can stop** if its own blood supply is cut off.

Q5. (a) A vital organ is **an organ the organism cannot live without** (1 mark). (b) Any two of **heart, brain, liver, lungs** (2 marks — one each). (c) Any two of **one kidney, spleen, gall bladder, appendix, tonsils** (2 marks — one each). (d) **The other kidney does the work of two**, and the person lives well but **must look after the kidney they have** (1 mark).

Q6. (a) At 25% narrowing the flow is **about 32% of normal** (1 mark). (b) **The more the artery narrows, the less blood flows**, and the drop gets much bigger with each extra step of narrowing (1 mark). (c) At **75% narrower**, where the flow is about 0.4% — almost nothing (1 mark). (d) The book labels the data as simulated because **the numbers were made up for practice** — the pattern they show (flow falling fast as the channel narrows) is real behaviour, but the exact numbers are not measured data (1 mark).

Q7. Villi are tiny finger-like projections lining the small intestine, and their job is **absorption — letting digested food substances pass into the blood**; tall villi give a **very large surface** for that job (2 marks). Flattened villi give a **much smaller surface**, so **far less food is absorbed** — the cells miss out on food substances even when the person eats plenty (2 marks).

Q8. The bark carries the **phloem**, and ringbarking **cuts the phloem**, so **sugar can no longer travel down** from the leaves to the roots (2 marks). The roots, **starved of sugar, stop working and die**; once the roots are dead, **no water is taken up at all**, and the whole tree dies (2 marks) — even though the untouched **water-carrying tissue** kept water moving for a while.

Q9. *Phytophthora* rots the roots, and **rotted roots cannot take up water or minerals** (2 marks). With the supply line destroyed, the rest of the plant **wilts and dies back from the tips** — the soil being wet makes no difference, because the water cannot get into the plant (2 marks).

Q10. (a) The machine mimics the kidneys' job of **filtering waste substances and extra water out of the blood** (1 mark). (b) **Waste substances and extra water** cross from the blood into the fluid (2 marks — one each). (c) **The cleaned blood** returns to the body (1 mark). (d) Any one (1 mark): the machine **does not do everything the kidneys do**; it works **only while the person is connected to it** — hours at a time, several times a week.

Q11. Any two of the four questions, each with a sensible reason on each side (2 marks per question — 1 for the question, 1 for the reason): **not enough organs** — who gets one first, and why one way of choosing is fairer; **consent** — opting in while alive, and whether the family's wishes should still be heard; **living donors** — whether a healthy person should take on surgery and risk for someone else; **buying and selling** — the argument for the rule against it (organs should not go only to the rich) and any argument a student can think of against it.

Q12. The claim is **wrong** (1 mark). The levels of organisation are **nested**, so a disorder does not stay where it begins — it **climbs the ladder** from cells and tissue, to organ, to system, to the whole organism (1 mark). Example, e.g.: **plaque builds up in the artery wall** (a tissue), the **lumen narrows** (the artery as an organ), the **circulatory system delivers less blood**, and the whole person ends up with **poor circulation or heart disease** (2 marks).

Q13. The claim is **wrong** (1 mark). The tonsils **are defence tissue at the throat — they do have a job** (1 mark). “Nothing changed” because the tonsils are **non-vital**: without them, **the body defends itself in other ways** — non-vital never means “does nothing” (2 marks).

Q14. One animal disorder and one plant disorder, each correctly climbed (3 marks each — 1 for the starting level, 1 for the climb, 1 for the threat to the whole organism). Animal, e.g. **hardening of the arteries**: plaque in the artery wall (tissue) → the lumen narrows (organ) → the circulatory system delivers less blood → the body's cells are starved of oxygen, the heart works harder and can fail — survival is threatened. Plant, e.g. **ringbarking**: the phloem is cut (tissue) → sugar can no longer reach the roots → the roots starve and die → without roots the whole tree dies. (Flattened villi and dieback work equally well, climbed the same way.)

Sources

Web sources below were retrieved 2026-08-21.

- Science ASSIST (Australian Science Teachers' Association), "Risk management", n.d. asta.edu.au

The flow bar graph in the Theory section is **simulated data for practice**; the pattern it shows — blood flow falling fast as the artery's open channel narrows — is the real behaviour of a fluid in a narrowing tube.

Elaboration contexts used: VC2S8U03.E04 (hardening of the arteries leading to poor circulation or heart disease), VC2S8U03.E05 (ethical issues arising from organ transplantation), VC2S8U03.E06 (a kidney dialysis machine as an artificial organ that mimics the kidneys' filtering job) and VC2S8U03.E07 (the loss of non-vital organs such as one kidney, the spleen, the gall bladder, the appendix, the tonsils or a reproductive organ, and the effects on body systems).