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Specialised cells and root hair cells

1. What is a specialised cell?

A large organism, such as you or an oak tree, is made of many cells. The cells do not all do the same job. A **specialised cell** is a cell with a structure that suits it to one job. Its shape, and the sub-cellular structures inside it, help it to do that job. A feature that suits a cell to its job is an **adaptation**.

To explain an adaptation, use three parts:

feature → how it helps → job

- **Example:** a root hair cell has a long, thin extension (feature), which gives it a large surface area (how it helps), so it can take in more water and mineral ions from the soil (job).

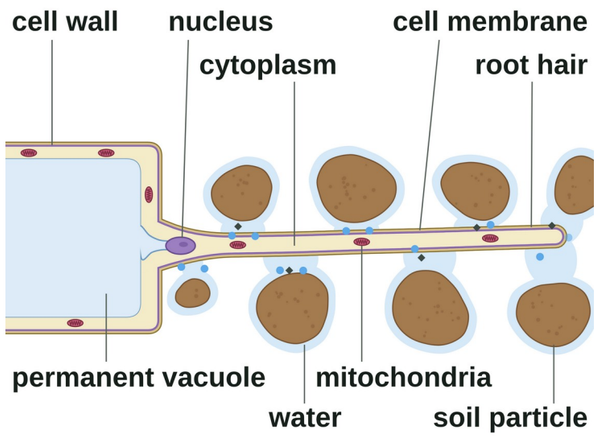
The six specialised cells you need to know, and their jobs, are in the table on page 2 (section 4).

Watch out: a list of features scores few marks. For each feature, say how it helps the cell do its job.

2. Root hair cells

A **root hair cell** is a cell on the surface of a root. Its job is to take in water and mineral ions from the soil.

- A **long, thin extension** (the root hair) reaches out between the soil particles. It gives the cell a large surface area touching the water in the soil, so it takes in more water and mineral ions.
- It has **no chloroplasts**. It grows underground, where there is no light, so it cannot photosynthesise.
- It has **many mitochondria**. They release energy, which the cell uses to take in mineral ions by active transport (B1 L10 Active transport and exchange surfaces).
- Water moves into the root hair cell by **osmosis** (B1 L9 Osmosis).



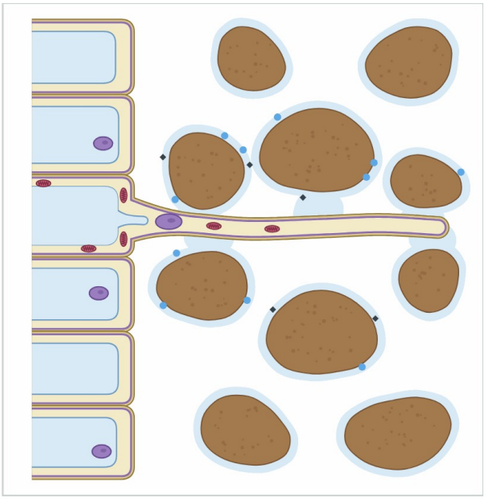
Blue dots = water. Grey diamonds = mineral ions. A diagram is simplified.

Watch out: not every plant cell is green. Root hair cells have no chloroplasts.

3. A real root and a diagram



A real root (painting)



A diagram

Each white hair is part of one root hair cell. Root hair cells have no chloroplasts.

If you look at the root of a young seedling through a hand lens, you see a white fuzz. The fuzz is thousands of **root hairs**. Each root hair is the long, thin extension of one root hair cell. Near the root tip there are no root hairs yet: the new cells there have not become root hair cells.

Exam pictures of a root hair cell are usually **diagrams**. A diagram is simplified on purpose:

- It shows one root hair cell. A real root has thousands of root hairs.
- It shows the whole cell, with its nucleus and vacuole. In the real root, each white hair is only part of one cell.
- It adds colours to show the parts. Real root hairs are white because they have no chloroplasts.
- It draws the cell much bigger than real life. A real root hair is up to about 1 mm long and far thinner than a hair on your head.
- It shows the hair between soil particles. The painted seedling grew on damp paper, so its hairs are easy to see.

Both show the long, thin extension that gives a large surface area for taking in water and mineral ions.

Watch out: a root hair is not a separate hair, and not a whole root. It is part of one root hair cell.

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Sperm, nerve and muscle cells, and the sizes of cells

4. The six specialised cells you need to know

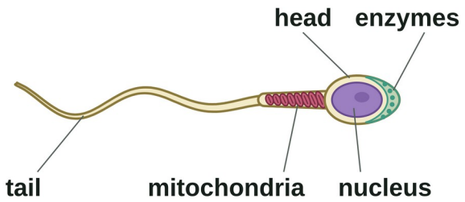
Animal cell	Job
sperm cell	swims to an egg cell and fertilises it
nerve cell	carries electrical impulses from one part of the body to another
muscle cell	contracts (gets shorter) to cause movement

Plant cell	Job
root hair cell	takes in water and mineral ions from the soil
xylem cells	carry water and mineral ions up the plant
phloem cells	carry dissolved sugars up and down the plant

5. Sperm cells

A **sperm cell** is the male sex cell. Its job is to swim to an egg cell and fertilise it.

- A long **tail** lashes from side to side, so the sperm cell can swim to the egg cell.
- **Many mitochondria**, packed just behind the head, release energy for swimming.
- **Enzymes** in the head digest a way through the outer layer of the egg cell.
- The **nucleus** carries half the genetic material of a body cell. It joins with the egg cell's nucleus at fertilisation (B6).

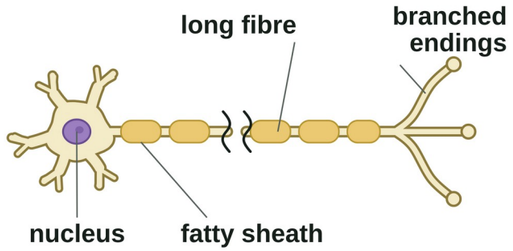


Watch out: mitochondria release energy. Never write that they make or produce energy.

6. Nerve cells

A **nerve cell** is a long cell that carries electrical impulses from one part of the body to another.

- It is **long**, so it can carry impulses a long way.
- **Branched endings** connect with many other cells, so impulses can pass to them.
- A **fatty sheath** insulates the long fibre, so impulses travel quickly.



Nerve cells are also called neurones. How impulses control the body is B5 Homeostasis and response.

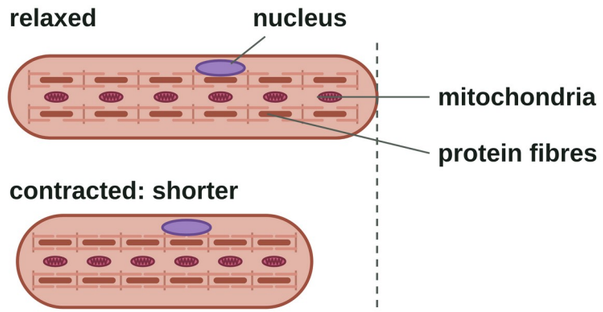
Watch out: nerve cells carry electrical impulses, not blood.

7. Muscle cells

A **muscle cell** is a cell that can contract (get shorter) to cause movement.

- It contains **protein fibres** that slide over each other, so the cell gets shorter.
- It has **many mitochondria**, which release the energy needed to contract.

Many muscle cells working together make muscular tissue (B2 L1 Cells, tissues and organs).



8. Comparing the sizes of cells

Cell	About how big
sperm cell	50 µm long
egg cell	0.1 mm (100 µm) across
root hair	up to 1 mm (1000 µm) long
nerve cell (the longest)	1 m long, from the bottom of the spine to the toes

To compare two sizes, change them into the **same unit** first: 1 mm = 1000 µm.

Worked example: how many times longer is a root hair 0.5 mm long than a sperm cell 50 µm long?

Step 1: change mm into µm: 0.5 × 1000 = 500 µm.

Step 2: divide: 500 ÷ 50 = 10.

Answer: **10 times** longer. Check: 10 × 50 µm = 500 µm = 0.5 mm.

Watch out: change both sizes into the same unit before you divide. mm → µm: multiply by 1000.

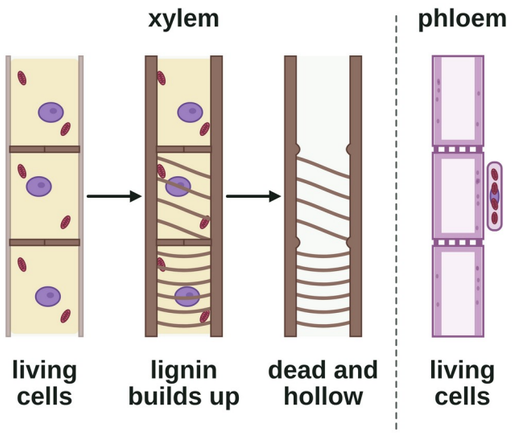
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Xylem and phloem cells, differentiation, and cells you have not met

9. Xylem cells

Xylem carries water and mineral ions from the roots up to the stem and leaves.

- Young xylem cells are living cells joined end to end.
- **Lignin** builds up in their walls, in rings and spirals. It strengthens the walls and helps to support the plant.
- Then the cells **die**. Their cytoplasm, nucleus and end walls break down.
- This leaves long, **hollow tubes** with no end walls, so water and mineral ions flow through with nothing in the way.



In the diagram, brown = xylem and purple = phloem. Real xylem and phloem are pale.

10. Phloem cells

Phloem carries dissolved sugars from the leaves to the rest of the plant, up and down.

- Phloem cells are **living** cells joined end to end in tubes.
- **Pores in the end walls** let cell sap, carrying dissolved sugars, move from one cell to the next.
- They have few sub-cellular structures. Small cells beside them supply the energy they need.

	Xylem cells	Phloem cells
living or dead?	dead	living
end walls	none: hollow tubes	end walls with pores
walls	strengthened with lignin	thin
carry	water and mineral ions	dissolved sugars
which way	up	up and down

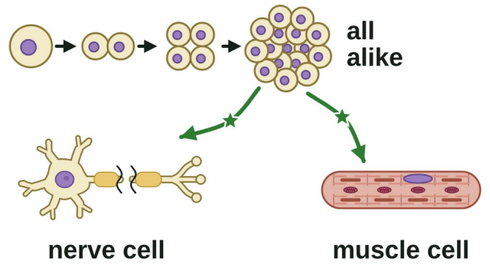
Watch out: the 'cell sap' in phloem is not a vacuole's cell sap (B1 L1 Animal and plant cells).

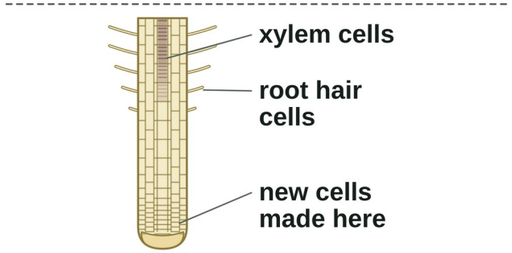
How the whole plant transports water and sugars is B2 L13 Plant transport: xylem and phloem.

11. Differentiation

Differentiation is the process by which a cell becomes specialised, gaining the sub-cellular structures it needs for its job.

- As an organism develops, its cells differentiate into different types of cell.
- **Most animal cells** differentiate at an **early stage**.
- In adult animals, cell division is mainly for **repair and replacement**, such as replacing skin cells.
- **Many plant cells** keep the ability to differentiate **throughout life**. That is why a plant can keep growing new roots, shoots and leaves.





Why it matters: a multicellular organism needs many types of cell to do different jobs. Specialised cells then work together in tissues (B2 L1 Cells, tissues and organs). Stem cells: B1 L7 Stem cells.

Watch out: differentiation is not division. A cell divides by mitosis (B1 L6 Cell division: mitosis) and becomes specialised by differentiating.

12. Answering "Explain how this cell is adapted"

In the exam you may meet a cell you have not studied. You will be given information about it.

Step 1: read the cell's job.

Step 2: find each feature in the picture or the text.

Step 3: for each feature, write feature → how it helps → job.

Model answer (a ciliated cell, which moves mucus away from the lungs): "The cell has tiny hairs called cilia, which beat together to sweep the mucus along, so it is moved away from the lungs. The cell has many mitochondria, which release energy for the cilia to keep beating."

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Key words, exam tips and check yourself

Key words

Adaptation: a feature that suits a cell or an organism to its job or to where it lives.

Differentiation: the process by which a cell becomes specialised, gaining the sub-cellular structures it needs for its job.

Lignin: a tough substance that strengthens the walls of xylem tubes.

Micrometre (µm): one thousandth of a millimetre (1 mm = 1000 µm).

Mineral ions: substances from the soil, such as nitrate, that a plant needs to stay healthy.

Mitochondria (one mitochondrion): the structures in the cytoplasm where aerobic respiration happens, releasing energy for the cell.

Muscle cell: a cell that can contract (get shorter) to cause movement.

Nerve cell: a long cell that carries electrical impulses from one part of the body to another.

Phloem: a plant tissue of tubes of elongated living cells that carries dissolved sugars from the leaves to the rest of the plant.

Root hair cell: a cell on the surface of a root, with a long, thin extension that gives a large surface area for taking in water and mineral ions.

Specialised cell: a cell with a structure that suits it to one job.

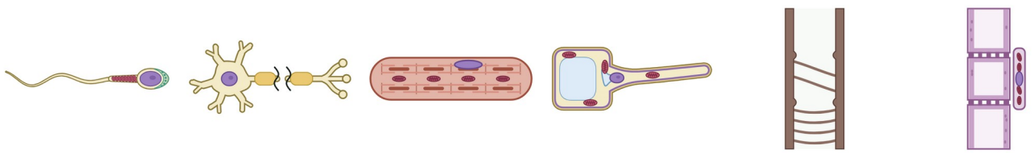
Sperm cell: the male sex cell, which swims to an egg cell and fertilises it.

Xylem: a plant tissue of hollow tubes strengthened by lignin that carries water and mineral ions from the roots to the stem and leaves.

Common mistakes

- **Wrong:** "Root hairs are tiny hairs on a root." **Right:** each root hair is part of one root hair cell.
- **Wrong:** "Mitochondria make energy." **Right:** they release energy.
- **Wrong:** "Xylem carries sugars." **Right:** xylem carries water and mineral ions; phloem carries dissolved sugars.
- **Wrong:** "Differentiation is when a cell divides." **Right:** it is when a cell becomes specialised.

The six cells at a glance



sperm cell: swims to an egg

nerve cell: carries impulses

muscle cell: contracts

root hair cell: takes in water

xylem: carries water up

phloem: carries sugars

Check yourself

Cover the answers, then check.

1. Give the job of a phloem cell.
2. How is a root hair cell adapted to take in water?
3. Name three ways a sperm cell is adapted to its job.
4. How does a fatty sheath help a nerve cell?
5. Why do muscle cells need many mitochondria?
6. Why are xylem cells hollow?
7. Describe what happens to a cell when it differentiates.
8. A root hair is 0.5 mm long. How long is it in micrometres?

Answers

1. It carries dissolved sugars up and down the plant.
2. It has a long, thin extension, which gives a large surface area, so it takes in more water.
3. A tail to swim; many mitochondria to release energy for swimming; enzymes in the head to digest a way into the egg cell.
4. It insulates the cell, so impulses travel quickly.
5. To release the energy the cell needs to contract.
6. The cells are dead, and their cytoplasm, nucleus and end walls have broken down, so water and mineral ions flow through with nothing in the way.
7. It becomes specialised: it gains the sub-cellular structures it needs for its job.
8. 0.5 × 1000 = 500 µm.

Exam tips

- Learn the job of each of the six cells and two or three features of each.
- For "explain how this cell is adapted", write feature → how it helps → job for each feature.
- With a cell you have not met, use the information given. Many mitochondria means energy is released for something: say what.
- Energy is **released** by respiration in mitochondria. Never write that energy is "made".
- Xylem: dead, hollow, lignin, water and mineral ions. Phloem: living, pores in end walls, dissolved sugars.
- In size questions, change both sizes into the same unit first, show your working and give the unit.