Plant structure and function

Plant cell ultrastructure, starch and cellulose, xylem, phloem and sclerenchyma, uses of plant fibres, mineral ions, and the related core practicals.

Plant cells

Plant cells have the organelles of animal cells (nucleus, mitochondria, ribosomes, ER, Golgi) and some extra structures.

Structure	Description and function
Cell wall	Made of **cellulose** microfibrils; **strong**, prevents bursting, gives support
Middle lamella	A layer of **pectin** that glues neighbouring cells together
Plasmodesmata	Channels of cytoplasm through the cell walls that link adjacent cells, allowing transport and communication
Pits	Thin areas of the cell wall (without secondary thickening) where substances can pass between cells
Chloroplast	Double membrane, **thylakoids** in **grana**, **stroma**; site of **photosynthesis**
Amyloplast	Stores **starch** grains
Vacuole and tonoplast	A large sap-filled **vacuole**, bounded by the membrane called the **tonoplast**; stores solutes and keeps the cell **turgid**

Comparing plant and animal cells

Plant cells have a cell wall, chloroplasts, a large permanent vacuole and plasmodesmata, and they store **starch**. Animal cells have **centrioles** and store **glycogen**, and they have no cell wall or chloroplasts.

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Starch and cellulose

	Starch	Cellulose
Monomer	**α-glucose**	**β-glucose**
Bonds	1,4 (and 1,6) glycosidic bonds	**1,4 glycosidic bonds** between β-glucose, where each glucose is **inverted** relative to its neighbour
Shape	Coiled helix (amylose) or branched	**Straight, unbranched chains**
Role	**Energy store**	**Structural** (cell walls)

Hydrogen bonds form between the parallel cellulose chains, linking about 60–70 chains into **microfibrils**, which group into **fibres**. The many hydrogen bonds give high **tensile strength**, though each bond is weak.

Support and transport tissues

The arrangement of **cellulose microfibrils** and **secondary thickening** (the deposition of **lignin**) makes cell walls strong and rigid.

Tissue	Structure	Position in stem	Function
Sclerenchyma fibres	Long, dead cells with thick walls **lignified**, no cell contents, tapered ends	Outside the vascular bundle (and in the stem cortex)	**Support** and strength
Xylem vessels	Dead, hollow tubes with **lignified** walls (**annular, spiral and pitted** thickening); no end walls; **pits**	Inside the vascular bundle (towards the centre)	Transport **water and mineral ions** up the plant, and **support**
Phloem	**Sieve tube elements** (living, with perforated end walls, **sieve plates**, and few organelles) and **companion cells** (many mitochondria; load sugars)	Outside the xylem in the vascular bundle	**Translocation** of organic solutes (sucrose) in both directions

Lignin makes xylem waterproof and strong; the lack of end walls and cell contents gives an unobstructed tube for cohesion–tension to pull a column of water upwards.

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Uses of plant fibres and starch

Sclerenchyma fibres (flax, hemp, jute) are used for **rope, textiles and paper**. They are strong, renewable and biodegradable. Plant fibres and starch can contribute to **sustainability** by replacing **oil-based plastics**, for example in biodegradable packaging made from starch or poly(lactic acid), reducing the use of **non-renewable** oil and reducing waste and carbon emissions.

Water and mineral ions

- **Water** is needed for **turgidity** (support), photosynthesis, transport and cooling, and as a solvent.
- **Nitrate** is needed to make **amino acids, proteins, nucleotides and chlorophyll**. A deficiency causes **stunted growth** and **yellow leaves (chlorosis)** from the older leaves.
- **Calcium** is needed to make the **middle lamella** (calcium pectate) and for membrane structure. A deficiency causes poor growth.
- **Magnesium** is a component of **chlorophyll**. A deficiency causes **yellow leaves** (chlorosis), starting between the veins.

Core practicals

Core Practical 7: plant tissues under the microscope

- Cut thin **transverse sections** of a root, stem and leaf, stain with **toluidine blue** (lignin turns blue-green) or phloroglucinol (red with lignin).
- Draw a **plan diagram**: outlines of tissues only, **no individual cells**, labelled, with drawn proportions.
- Draw and label **cells** in detail from a small region.
- Identify **xylem vessels** (large, with lignified walls), **phloem** (sieve tubes next to small companion cells) and **sclerenchyma fibres** (thick-walled, in groups).

Core Practical 8: tensile strength of plant fibres

1. Fix fibres of equal length and diameter to a clamp, and attach a **mass hanger**.
2. Add masses until the fibre **breaks**, and record the mass (the **breaking force** $F = mg$).
3. Repeat several times for each type of fibre and take a mean.

Control the length, the thickness, the humidity and the temperature. Compare the mean breaking force, or the **tensile strength** (breaking force divided by the cross-sectional area).

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