Transport in plants

A-Level Biology

The two transport tissues

Plants move substances through two transport **tissues** 组织:

- **xylem** 木质部 carries water and dissolved **mineral ions** 矿物离子 up from the roots.
- **phloem** 韧皮部 carries dissolved foods (called **assimilates** 同化物, mainly sugars) to wherever they are needed.

In a **transverse section** 横切面 (a cut straight across) of a **dicotyledonous plant** 双子叶植物:

- in the **stem**, xylem and phloem sit together in bundles near the outside, with xylem on the inside of each bundle.
- in the **root**, the xylem is in the centre, often in a star shape, with phloem between the arms.
- in the **leaf**, both are found in the veins.

When you draw a plan diagram, you draw only the outlines of the tissues, not the single cells.

The wood of a tree trunk is xylem; each ring is one year of growth

Image: Vijayanrajapuram, CC BY-SA 4.0 (commons.wikimedia.org)

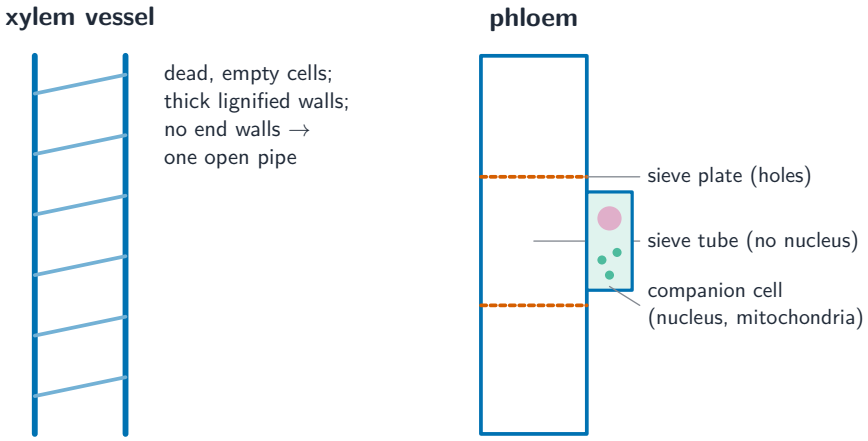
Xylem vessels

Xylem water-carrying tubes are called **vessels** 导管. They are made of dead, empty cells joined end to end, with the end walls gone, so they form one long open pipe. Their walls are thickened and waterproofed with **lignin** 木质素. So the structure suits the job: the hollow, open tube with no contents lets water flow fast, and the lignin gives strength and support.

Phloem sieve tubes and companion cells

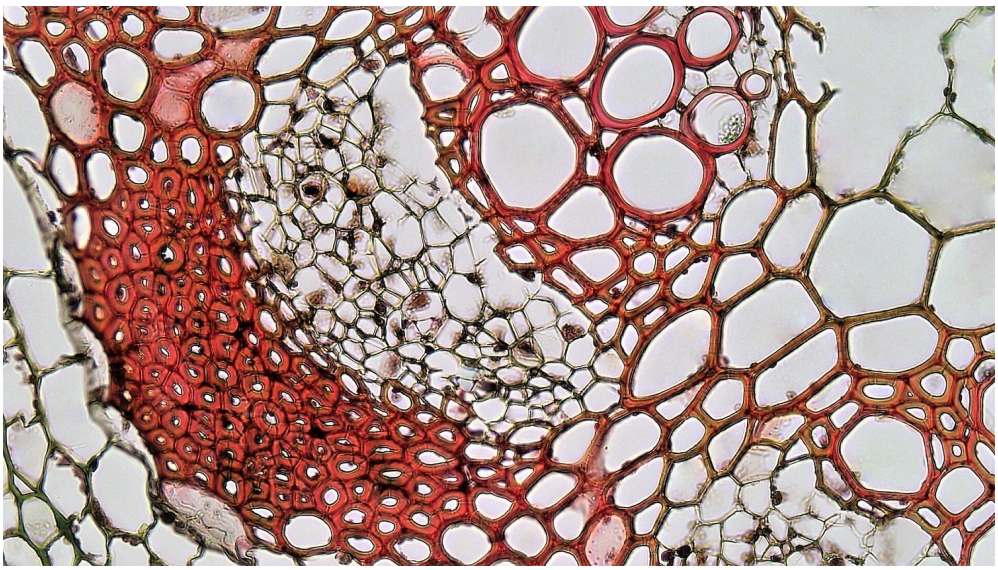
Phloem food-carrying tubes are called **sieve tubes** 筛管. They are living cells joined end to end, but their end walls are not gone —they become **sieve plates** 筛板 with many holes that sap flows through. To leave room for flow, a sieve tube cell loses most of its contents and has no nucleus.

Beside each sieve tube is a **companion cell** 伴胞. It keeps its **nucleus** 细胞核 and has many **mitochondria** 线粒体. It does the living work for the sieve tube and loads sugars into it.



Xylem 木质部 *is a dead, open pipe; phloem* 韧皮部 *is living sieve tubes* 筛管 *with sieve plates* 筛板 *and companion cells* 伴胞

This is what a real **vascular bundle** 维管束 looks like under the microscope, in a stained section of a young sunflower stem:



A real ***vascular bundle*** 维管束 *in section: the big red cells are xylem* 木质部 *vessels (thick lignified* 木质化 *walls); the smaller cells above are phloem* 韧皮部

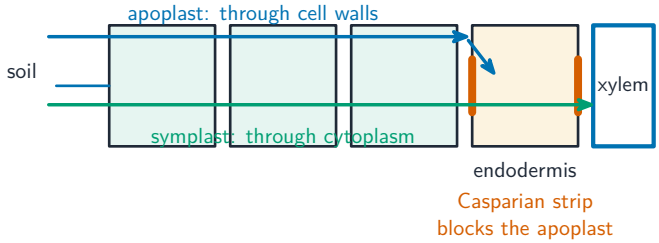
Image: Berkshire Community College Bioscience Image Library, CC0 (commons.wikimedia.org)

Water from the soil to the xylem

Water enters a **root hair cell** 根毛细胞 by **osmosis** 渗透, because the root hair has a lower water potential than the soil water. Water then crosses the root to the xylem by two pathways:

- the **apoplast pathway** 质外体途径—water moves through the **cell walls** 细胞壁 (made of **cellulose** 纤维素) and the spaces between cells, without entering the cytoplasm. This is fast.
- the **symplast pathway** 共质体途径—water moves through the cytoplasm of cells, passing from cell to cell through the **plasmodesmata** 胞间连丝.

At a ring of cells called the **endodermis** 内皮层, the apoplast pathway is blocked by the **Casparian strip** 凯氏带, a waterproof band of **suberin** 木栓质. This forces all the water through the cell membranes, which lets the plant control what enters the xylem.



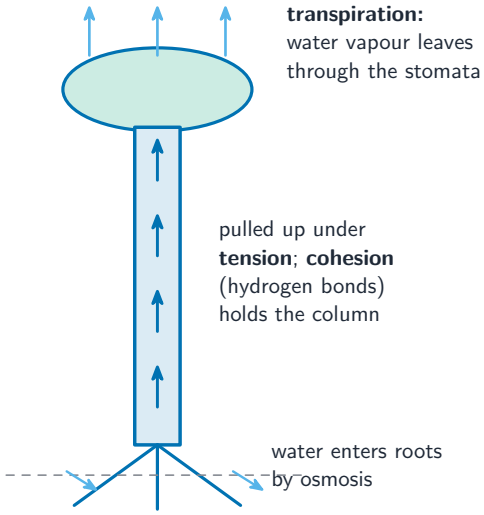
The apoplast 质外体 *goes through the walls, the symplast* 共质体 *through the cytoplasm; the Casparian strip* 凯氏带 *blocks the apoplast at the endodermis*

Transpiration and the movement of water up the xylem

Transpiration 蒸腾作用 is the loss of water vapour from a plant. Water **evaporates** (turns to vapour) from the wet cell surfaces inside the leaf —this is **evaporation** 蒸发. The **water vapour** 水蒸气 then **diffuses** 扩散 out through the **stomata** 气孔 into the **atmosphere** 大气.

This loss at the top pulls water up the xylem in a continuous column. It works because of hydrogen bonding between water molecules:

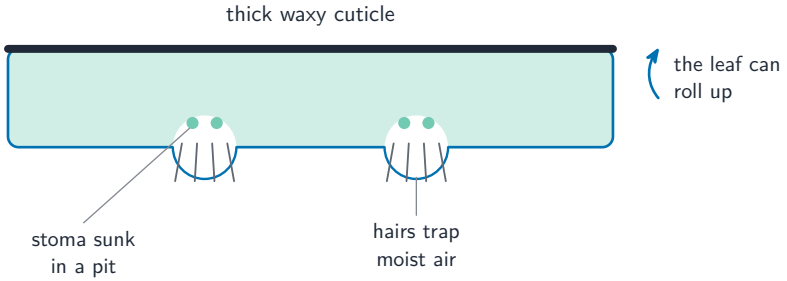
- water molecules attract each other through **hydrogen bonds** 氢键, so they stick together. This sticking is **cohesion** 内聚力, and it lets the whole column be pulled up under **tension** 张力 (the cohesion–tension idea).
- water molecules also stick to the cellulose of the cell walls. This is **adhesion** 附着力, which helps hold the column in place.



Transpiration 蒸腾 *at the leaf pulls the whole water column up the xylem; cohesion* 内聚力 *(hydrogen bonds) keeps it together*

Xerophytes

A **xerophyte** 旱生植物 is a plant **adapted** 适应 to live where water is scarce. Its leaves reduce water loss by transpiration in several ways: a thick waxy **cuticle** 角质层, **stomata** sunk in pits, hairs that trap moist air, and leaves that can roll up. You should be able to draw a labelled leaf section showing these features.



Xerophyte 旱生植物 *leaves cut water loss: a thick cuticle* 角质层*, sunken stomata* 气孔*, trapped moist air and rolling up*

Translocation: moving assimilates in the phloem

Assimilates such as **sucrose** 蔗糖 and **amino acids** 氨基酸 are carried in the phloem from a **source** 源 to a **sink** 库.

- a **source** is where the assimilate is made or released (for example a photosynthesising leaf).
- a **sink** is where it is used or stored (for example a growing root).

Loading at the source

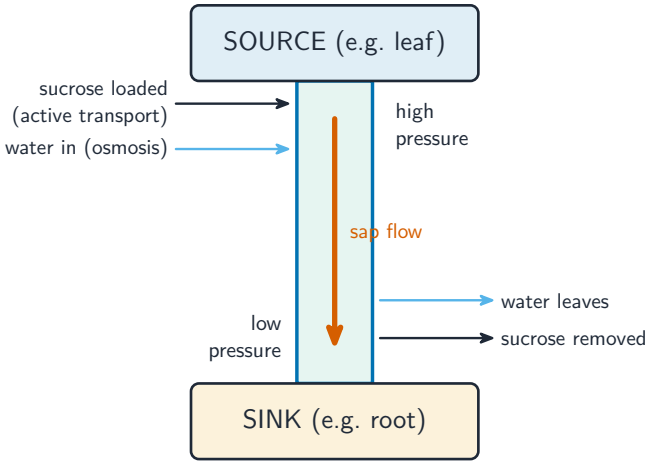
Companion cells load sucrose into the sieve tubes against its concentration gradient. They use **proton pumps** 质子泵 to pump hydrogen ions out, then **cotransporter proteins**

协同运输蛋白 bring sucrose back in together with those ions. This is a form of **active transport** 主动运输.

Loading sucrose lowers the **water potential** 水势 inside the sieve tube, so water follows by osmosis. This raises the **hydrostatic pressure** 静水压 there.

Mass flow

At the sink, sucrose is removed, so the water potential rises, water leaves, and the pressure falls. The result is a pressure difference between source (high) and sink (low). Sap flows from high to low pressure down this gradient. This pressure-driven flow is called **mass flow** 集流.



Loading sucrose at the source 源 *raises the pressure; sap then flows by mass flow* 集流 *to the sink* 库