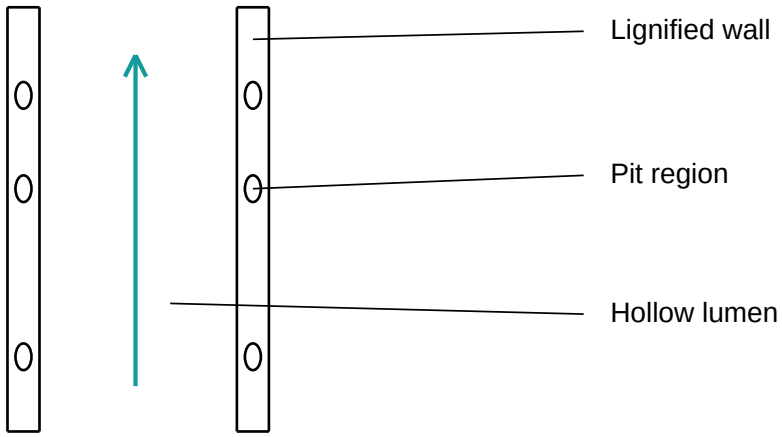
Xylem: an open, reinforced pathway

Water and mineral ions move through xylem vessels. Each vessel is a series of vessel elements joined end to end; their structure provides both a transport route and mechanical support.

1. FOLLOW THE WATER PATH



Longitudinal cutaway, not to scale. Arrow shows an example of upward water flow; the open ends connect with other vessel elements.

2. DEAD, HOLLOW ELEMENTS REDUCE RESISTANCE

Loss of the protoplast leaves no cytoplasm or organelles obstructing the lumen. Openings in the end walls connect adjacent elements, allowing water to flow along the vessel.

3. LIGNIN RESISTS COLLAPSE

Lignified secondary walls strengthen the vessel and help it resist inward collapse when water is under tension. Lignification also reduces wall permeability. The wall supports the conduit; it does not actively pump water.

4. PITS PROVIDE LATERAL CONNECTIONS

At pits, secondary-wall thickening is absent and a thin primary-wall barrier remains. Water can move sideways between adjacent conducting elements or into surrounding tissue; a pit is not a sieve plate.

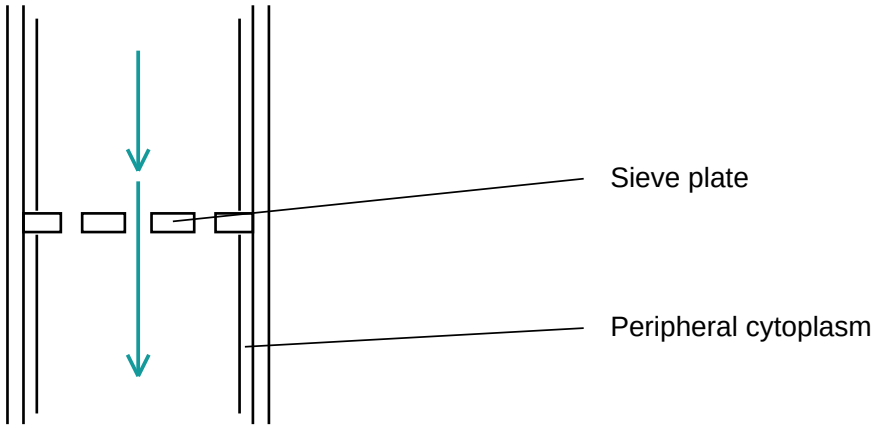
Vessel structure and pits: OpenStax Biology 2e, section 30.2.

Scope: Cambridge Biology 9700 syllabus, section 7.1, outcome 4, p. 26.

Sieve tubes: a living flow pathway

Sieve tube elements carry phloem sap containing sucrose, amino acids and other solutes. Their reduced contents and porous end walls allow mass flow while the cells remain alive.

1. SAP PASSES THROUGH SIEVE-PLATE PORES



Two elements in longitudinal section. The arrow passes through a pore, not through solid wall. The direction shown is one example, not a rule that phloem always flows down.

2. REDUCED CONTENTS LEAVE ROOM FOR FLOW

Mature sieve tube elements lack a nucleus and have few organelles with a thin peripheral layer of cytoplasm. This reduces obstruction, but they retain a plasma membrane and are not dead, empty xylem cells.

3. SIEVE PLATES CONNECT THE ELEMENTS

Pores in the shared end wall allow phloem sap to pass between consecutive elements. The plate remains part of the wall; it is not an entirely missing end wall. Sieve plates still contribute resistance to flow.

4. SUPPORT COMES FROM COMPANION CELLS

Reduced cellular machinery limits the sieve element's independence. Adjacent companion cells help maintain its metabolism and exchange substances with it through cytoplasmic connections.

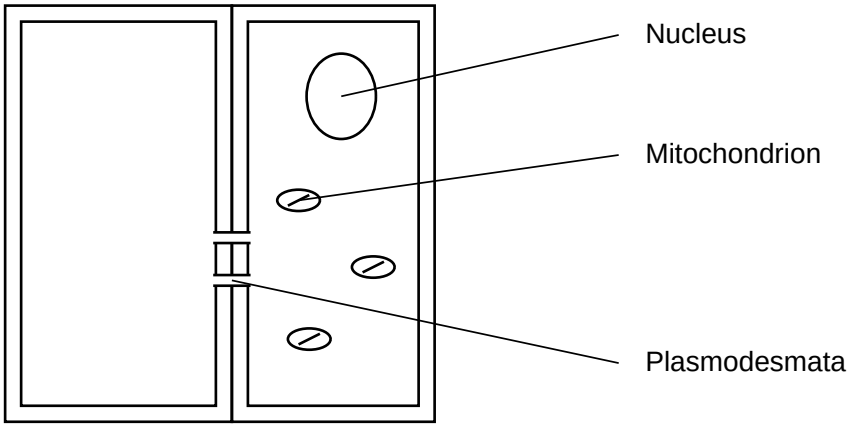
Sieve elements and pore function: Kalmbach & Helariutta (2019).

Scope: Cambridge Biology 9700 syllabus, section 7.1, outcome 4, p. 26.

Companion cells: metabolic support

A companion cell is a separate living cell closely associated with a sieve tube element. It retains the machinery needed for metabolism and supports the functioning of the phloem transport system.

1. LINK THE CELL MACHINERY TO ITS JOB



Simplified cell pair. Short channels across the shared wall represent plasmodesmata; the ovals with an internal line represent mitochondria.

2. MANY MITOCHONDRIA SUPPLY ATP

Aerobic respiration supplies ATP for energy-requiring processes. Where phloem loading is active, ATP powers membrane proton pumps; the resulting gradient can drive sucrose uptake. ATP is not a direct motor pushing sap along the tube.

3. NUCLEUS AND RIBOSOMES MAINTAIN METABOLISM

The nucleus supports gene expression, and ribosomes make proteins needed for cell activity. This retained machinery helps the companion cell support a mature sieve element that lacks its own nucleus.

4. PLASMODESMATA CONNECT THE PARTNERS

These cytoplasmic channels cross the shared cell wall, permitting exchange of substances and communication. The cells remain distinct: do not draw the companion-cell nucleus inside the sieve tube.

Companion cells: OpenStax Biology 2e, section 30.2.
Active loading and pressure-driven flow: OpenStax Biology 2e, section 30.5.

Scope: Cambridge Biology 9700 syllabus, section 7.1, outcome 4, p. 26.