Load sucrose at the source

Companion cells help transfer assimilates into phloem sieve tubes. Sucrose illustrates how two membrane proteins work together to achieve active loading.

1. FOLLOW THE APOPLASTIC LOADING ROUTE

APOPLAST
Sucrose outside the companion cell

→

COMPANION CELL
Sucrose enters by cotransport

→

SIEVE ELEMENT
Sucrose passes through plasmodesmata

Source tissues supply sucrose to the cell-wall space, the apoplast. Loading transfers it into the living companion cell and then into the sieve tube element. Diagram shows a route, not relative cell sizes.

2. WHY COMPANION CELLS MATTER

A companion cell has a nucleus, dense cytoplasm and many mitochondria. Respiration supplies ATP needed for proton pumping. The associated mature sieve tube element lacks a nucleus and depends on metabolic support.

3. TWO DIFFERENT CONNECTIONS

Plasmodesmata are cytoplasmic connections between the companion cell and sieve tube element. Sieve plates connect successive sieve tube elements along a tube. Do not label the companion-cell connection as a sieve plate.

This is the proton-pump/cotransporter model required here. Loading routes vary among plants; some use symplastic pathways. The diagram does not mean that every species loads all assimilates in the same way.

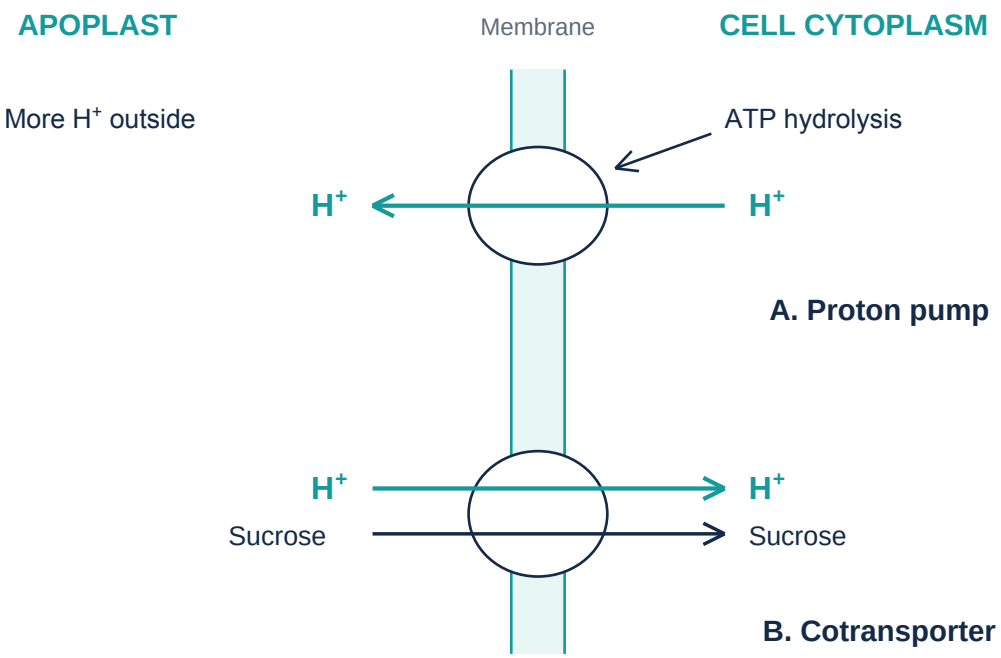
Mechanism reference: OpenStax Biology 2e, section 30.5.

Scope: Cambridge Biology 9700 syllabus, section 7.2, outcome 7, p. 26.

Pump out, bring sucrose in

H^+ is a proton. The pump moves protons out using ATP; their return through a different protein is coupled to sucrose entry. Keep the two directions distinct.

1. COMPANION-CELL MEMBRANE: TWO PROTEINS



Simplified membrane section; one H^+ symbol denotes proton movement, not a measured concentration.

2. BUILD AN ELECTROCHEMICAL GRADIENT

The proton pump hydrolyses ATP and moves H^+ out against its electrochemical gradient. This creates a difference in proton concentration and electrical potential across the membrane.

3. USE THE GRADIENT TO LOAD SUCROSE

H^+ returns down its electrochemical gradient through a sucrose-H^+ cotransporter. Coupling allows sucrose to enter against its concentration gradient. Both substances cross in the same direction: this is symport.

Mechanism reference: OpenStax Biology 2e, section 30.5.

Scope: Cambridge Biology 9700 syllabus, section 7.2, outcome 7, p. 26.

Trace the energy to the outcome

ATP powers the proton pump directly. Sucrose uptake uses the proton gradient that the pump establishes: this is secondary active transport, not direct ATP hydrolysis by the cotransporter.

1. COMPARE THE TWO MEMBRANE PROTEINS

	PROTON PUMP	COTRANSPORTER
Cargo	H^+	H^+ with sucrose
Direction	Out of companion cell	Into companion cell
Direct driver	ATP hydrolysis	H^+ gradient
Effect	Establishes gradient	Accumulates sucrose

2. LOADING PREPARES THE SOURCE FOR FLOW

Sucrose accumulation lowers the solute potential and initially lowers the water potential of the sieve tube. Water enters by osmosis from nearby xylem, raising hydrostatic pressure. This links loading to the mass-flow mechanism in the next lesson.

3. PREDICT WHAT HAPPENS IF ATP SUPPLY FALLS

Less ATP limits proton pumping. As the H^+ gradient dissipates, it can support less sucrose cotransport and loading. Do not claim uptake must stop instantly: an existing gradient can temporarily continue to drive transport.

Keep the processes separate: the pump moves ions, the cotransporter couples solute movements, and osmosis moves water. None of these should be described as sucrose moving by osmosis.

Mechanism reference: OpenStax Biology 2e, section 30.5.

Scope: Cambridge Biology 9700 syllabus, section 7.2, outcome 7, p. 26.