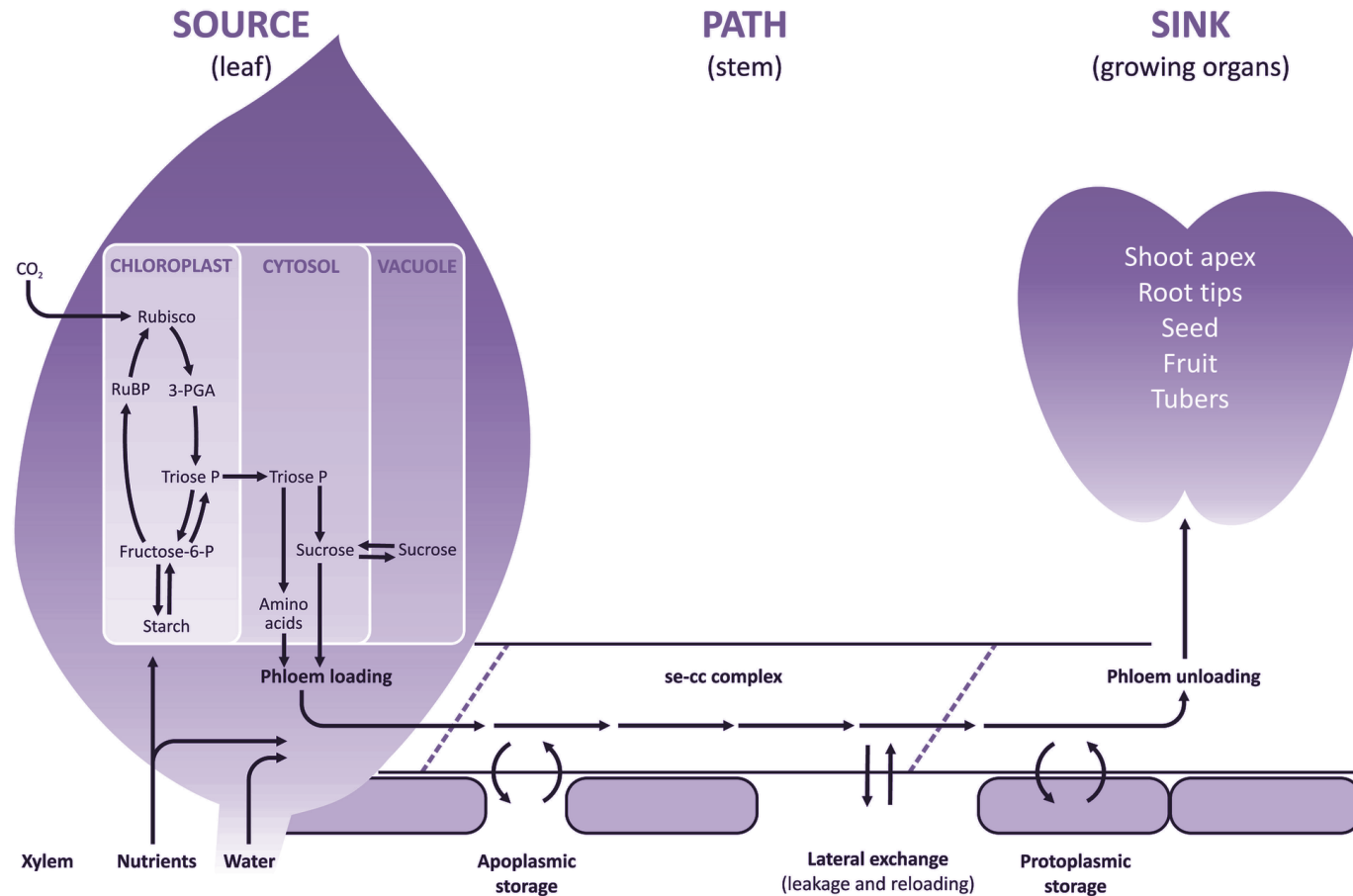


# Transport and Distribution of Assimilates in Plants



# Content

- ❖ **Transport of assimilates within the plant**
- ❖ **Loading and unloading of assimilates**
- ❖ **Allocation and partitioning of assimilates**
- ❖ **Regulation of assimilate transport and partitioning**

# Pathways for Assimilate Transport

## ❖ **Short-distance transport (短距离运输):**

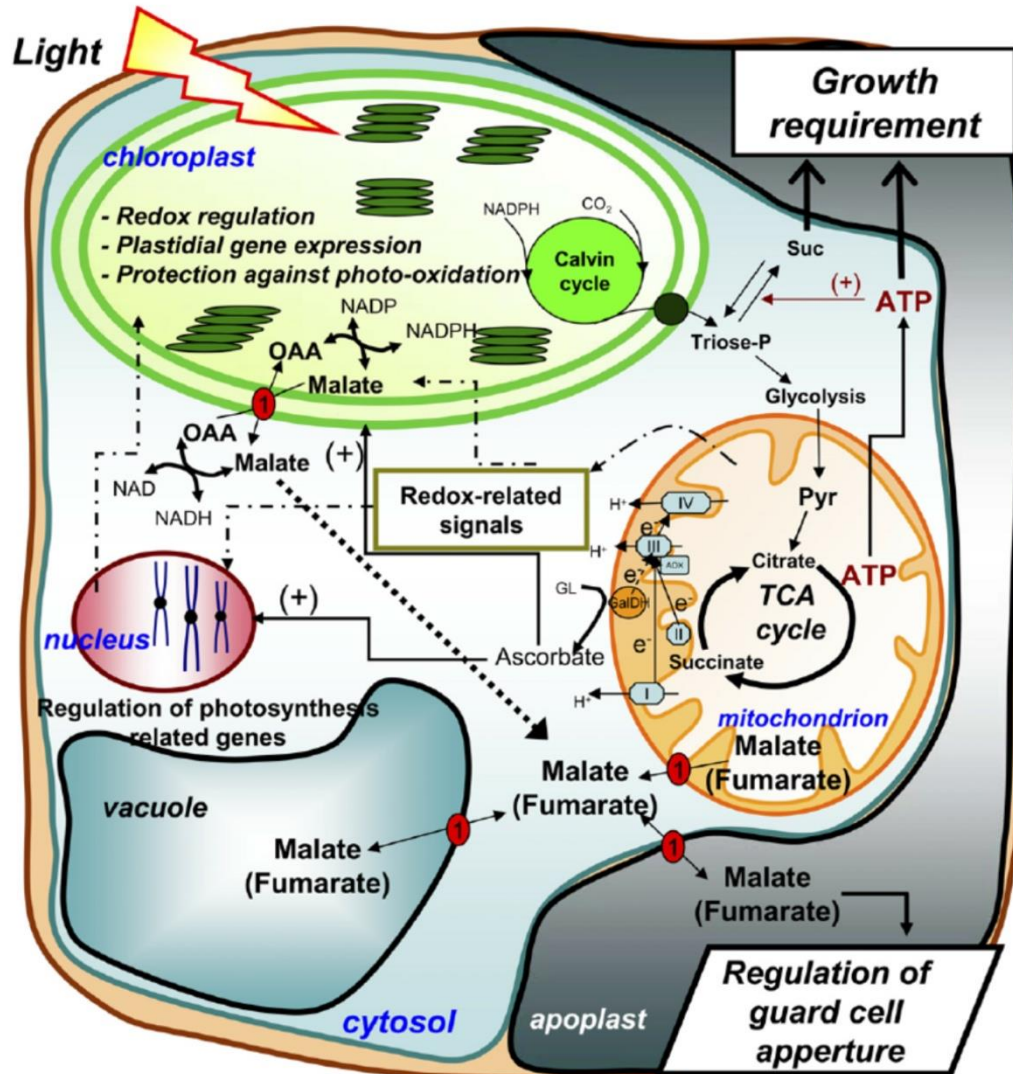
- Movement within cells and between neighboring cells.
- Includes symplastic transport, apoplastic transport, and transmembrane transport.

## ❖ **Long-distance transport (长距离运输):**

- Occurs mainly through the phloem.
- Moves sucrose and other assimilates from source organs to sink organs.

# Pathways for Assimilate Transport

## Short-Distance Transport Routes



Intracellular transport (胞内运输), movement among organelles and cellular compartments.

- ❖ Diffusion
- ❖ Cytoplasmic streaming (原生质环流)
- ❖ Exchange across organelle membranes (细胞器膜物质交换)
- ❖ Vesicle formation and secretion (囊泡形成与释放)

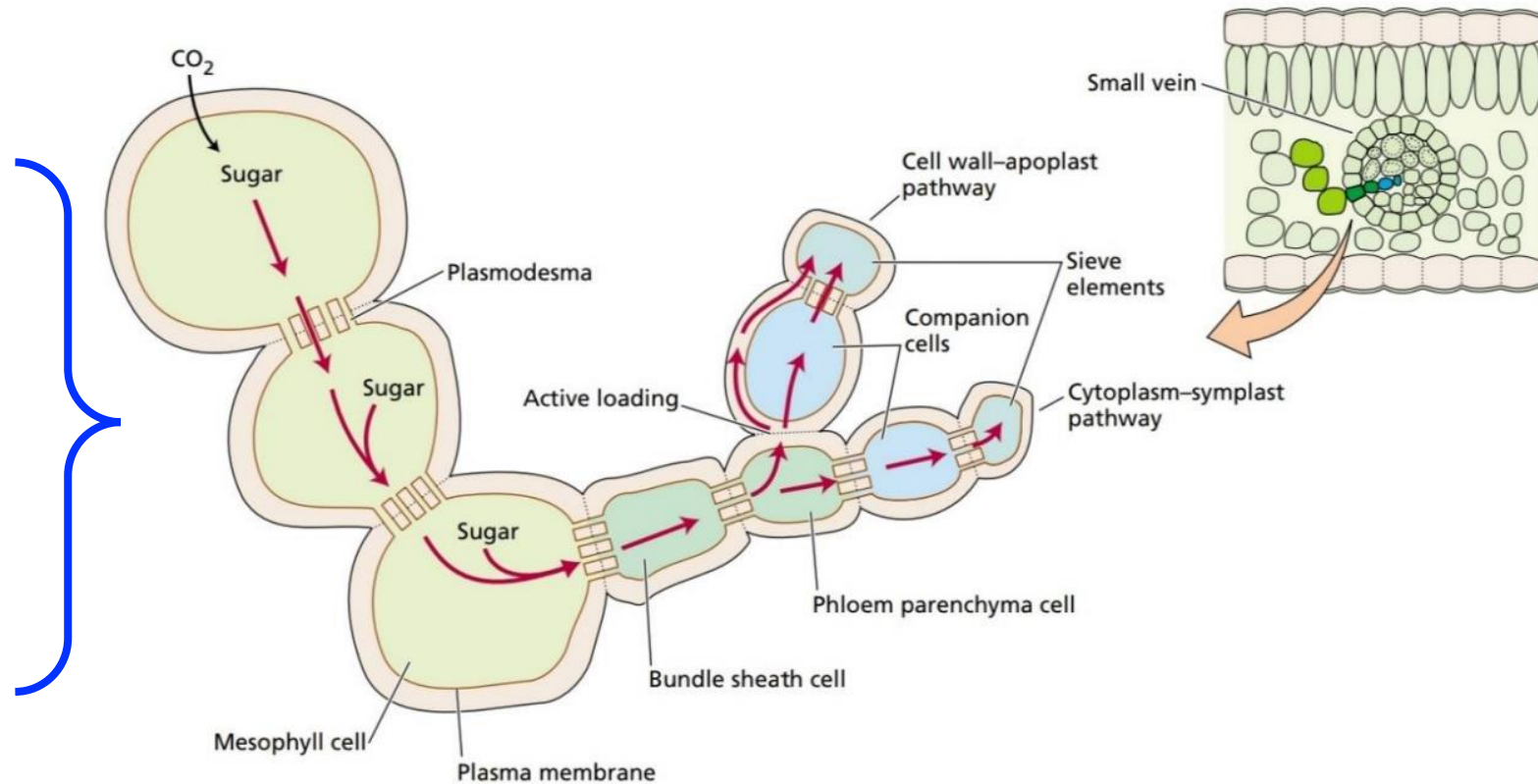
# Pathways for Assimilate Transport

## Short-Distance Transport Routes

Symplastic transport

Apoplastic transport

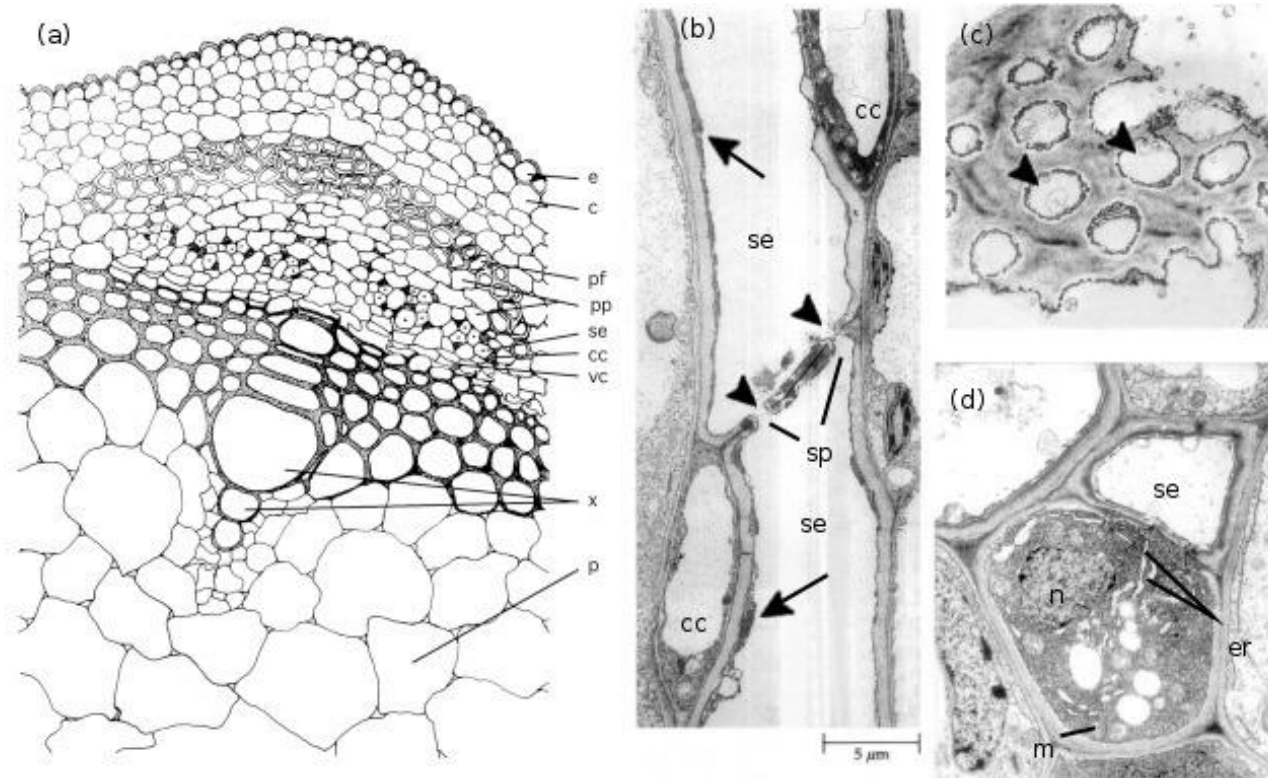
Transmembrane transport



# Pathways for Assimilate Transport

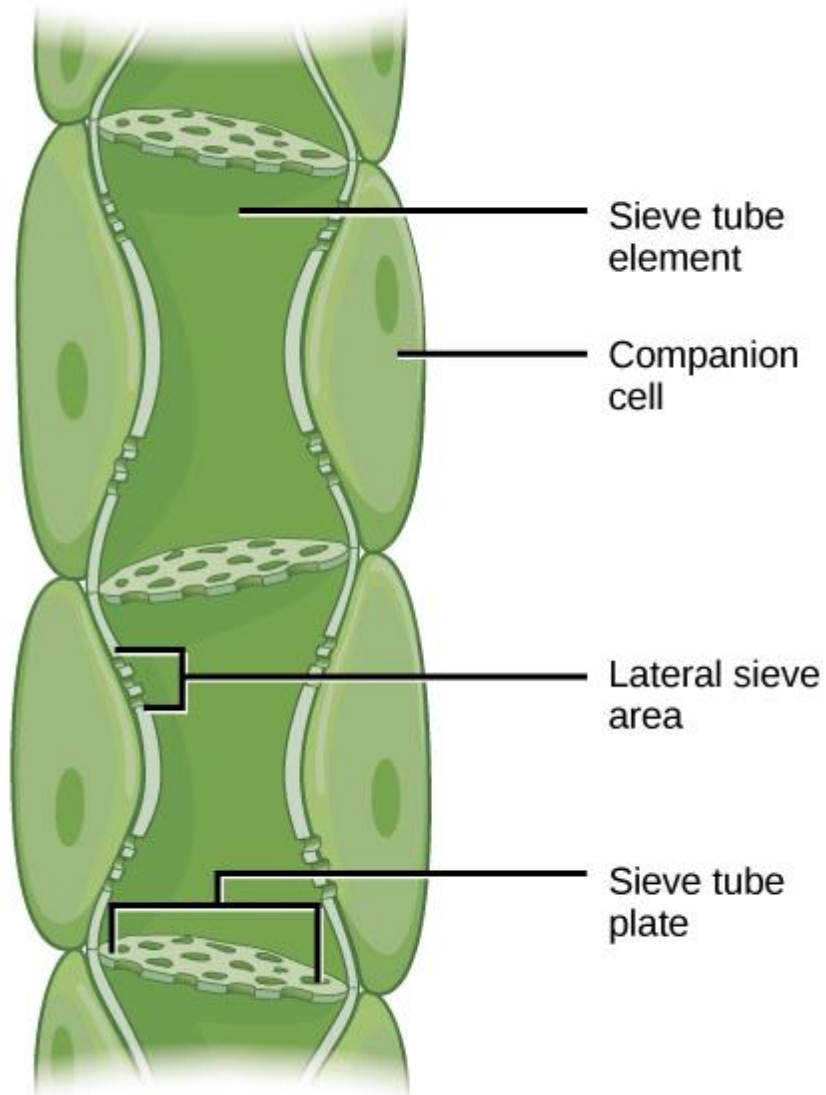
Long-distance assimilate transport occurs mainly in the **phloem (韧皮部)**.

The transport tissue is composed of the **sieve element–companion cell complex (筛管分子-伴胞复合体, SE–CC complex)**.



# Pathways for Assimilate Transport

## Long-Distance Transport in the Phloem



- ❖ **Sieve tube elements (筛管分子):**
  - ✓ Specialized cells that conduct phloem sap.
  - ✓ Mature sieve elements contain little cytoplasm and lack a nucleus.
- ❖ **Companion cells (伴胞):**
  - ✓ Metabolically active cells closely associated with sieve elements.
  - ✓ Support sieve element function and participate in phloem loading and unloading.

# Research Methods for Assimilate Transport

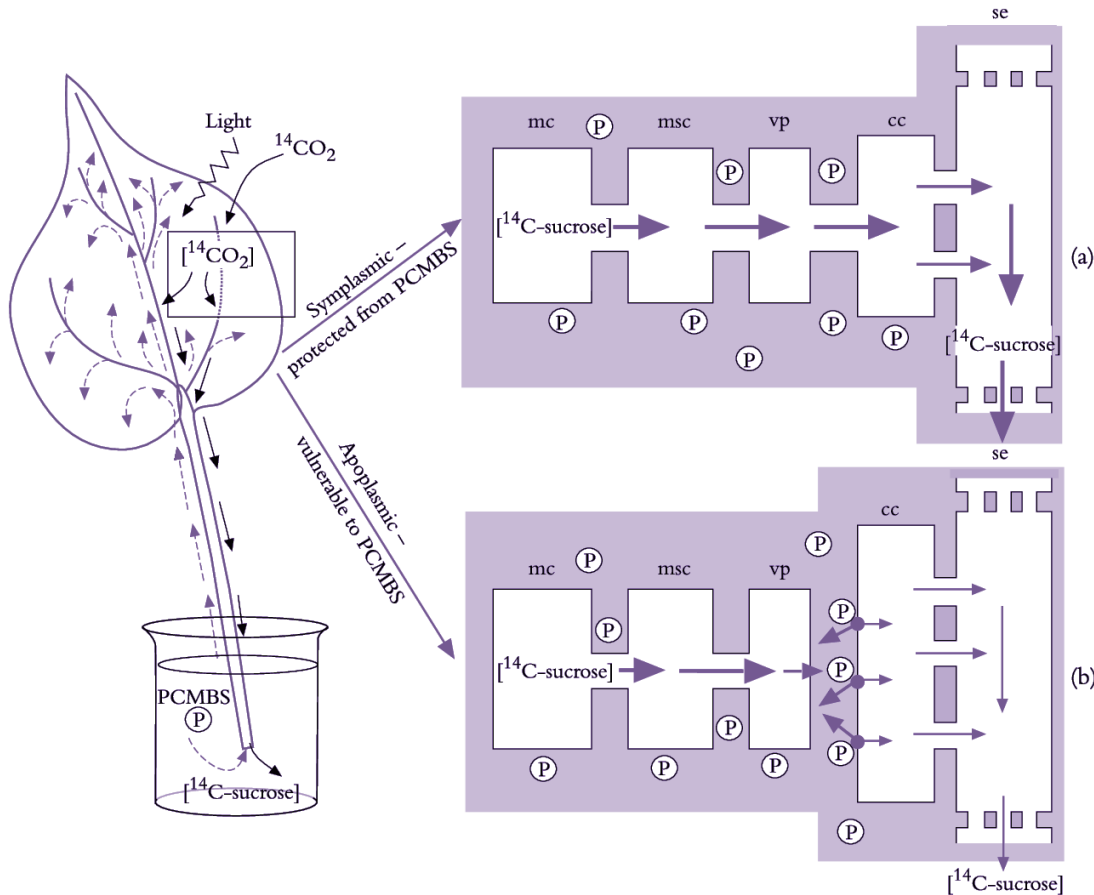
## 1. Girdling treatment (环割处理)



- ❖ A ring of bark/phloem is removed from the stem or branch.
- ❖ This blocks phloem transport while xylem water flow may continue.
- ❖ Accumulation of sugars above the girdle indicates downward assimilate transport through phloem.
- ❖ Used to study **source–sink** relationships and **assimilate allocation**.

# Research Methods for Assimilate Transport

## 2. Tracer Methods for Assimilate Transport



❖ Roots can be labeled with radioactive phosphate, such as  $^{32}\text{P}$  or  $^{35}\text{S}$

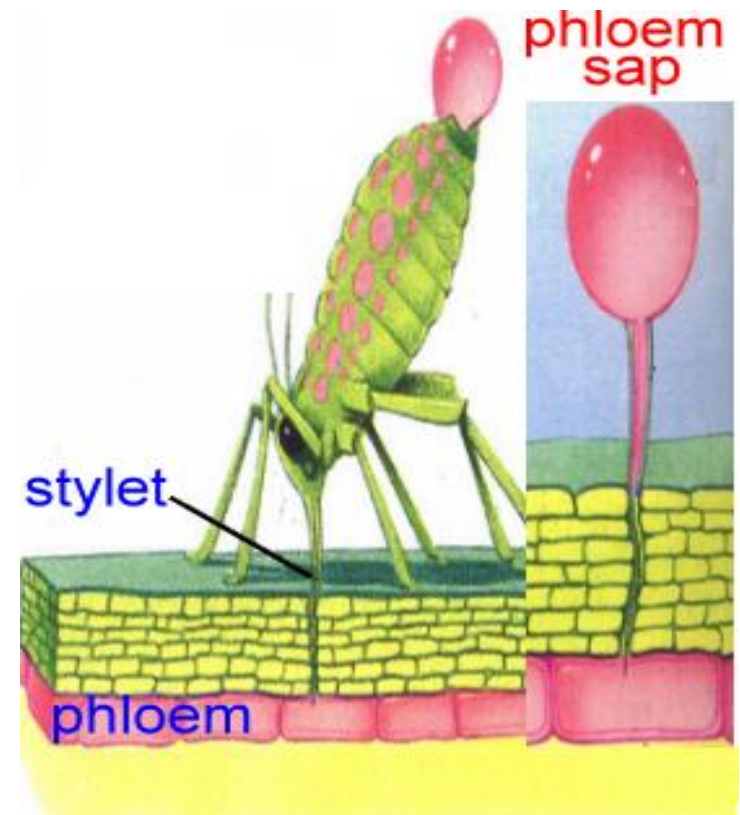
❖ Leaves can be labeled with  $^{14}\text{CO}_2$  to trace photosynthetic carbon assimilation.

❖ Labeled sugars or organic compounds can also be introduced into specific tissues.

# Research Methods for Assimilate Transport

## 3. Aphid stylet technique (蚜虫口针法)

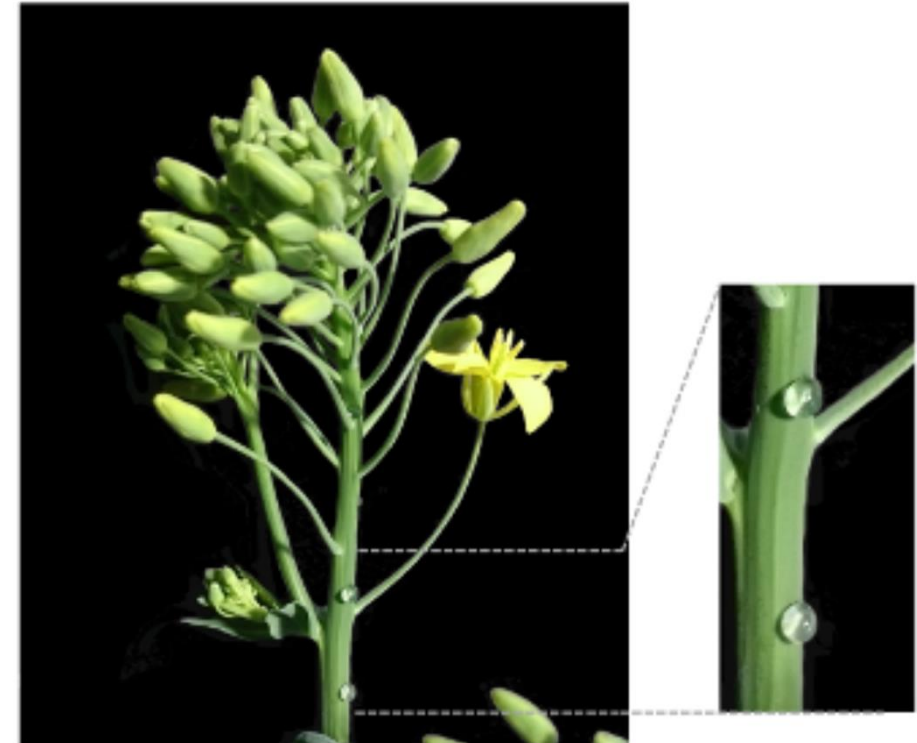
Use aphid stylets to collect phloem sap directly from sieve tubes.



# Research Methods for Assimilate Transport

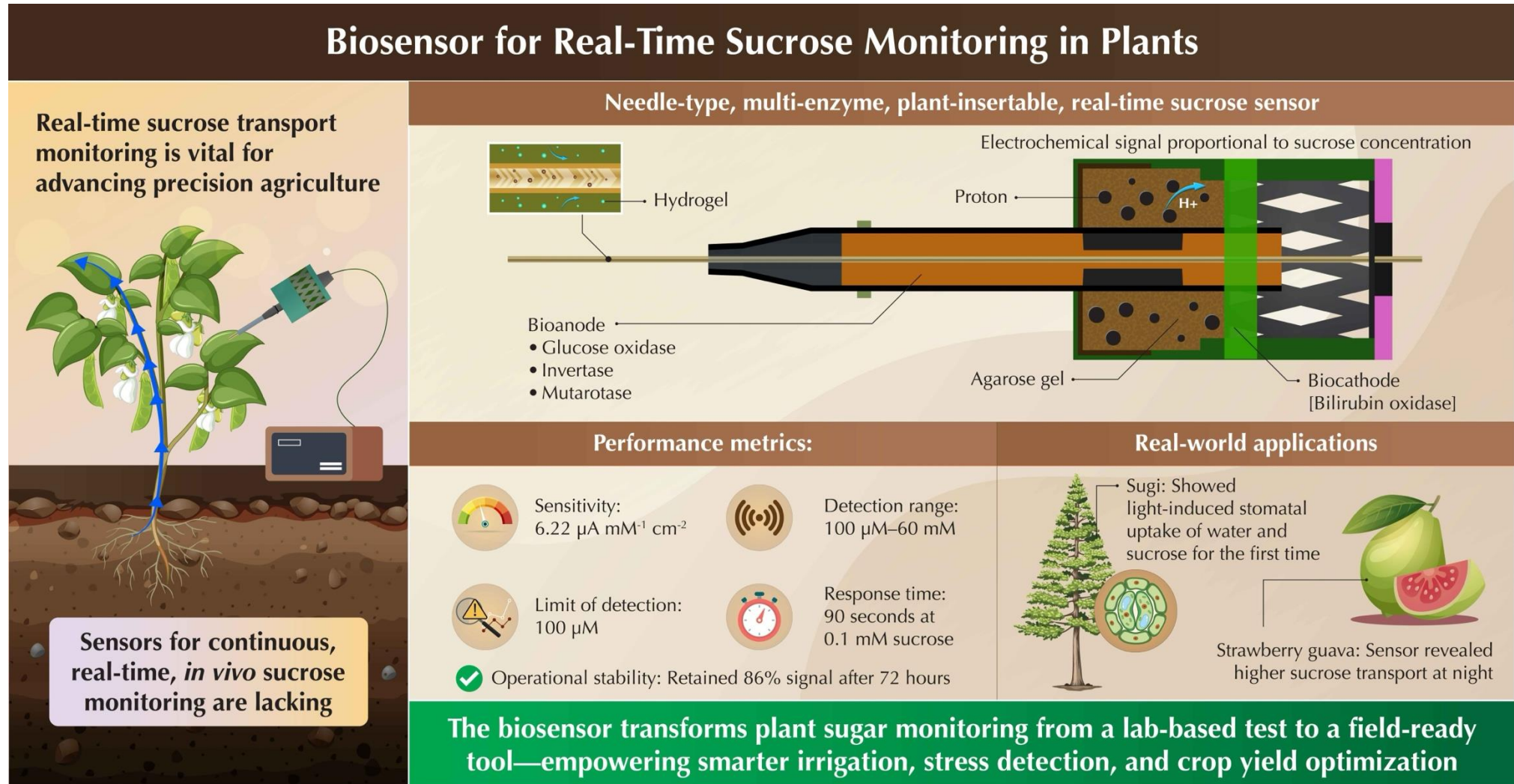
## 4. Phloem exudate collection

Collect sap from cut stems or petioles to analyze sugars, amino acids, hormones, and signaling molecules.



# Research Methods for Assimilate Transport

## 4. Biosensors



# Direction and Velocity of Assimilate Transport

- ❖ Assimilates (同化产物) are transported mainly from **source tissues (源组织)** to **sink tissues (库组织)**.
- ❖ Transport can be bidirectional at the whole-plant level, but movement within a single sieve tube is usually one-way.
- ❖ Typical transport velocity is about **100 cm h<sup>-1</sup>**, but it varies with:
  - Plant species
  - Developmental stage
  - Environmental conditions
  - Type of assimilate transported (*sugars are faster than amino acids*)

# Direction and Velocity of Assimilate Transport

Specific mass transfer rate (比集转运速率, SMTR) describes the amount of assimilate transported per unit phloem cross-sectional area per unit time.

$$\text{SMTR} = \frac{W}{S \times t} = V \times C$$

**W:** Mass of the transported assimilate (usually in grams of dry matter).

**S:** Cross-sectional area of the phloem (typically cm<sup>2</sup>).

**t:** Time period over which translocation is measured (typically hours).

**v:** The speed of mass flow. High pressure gradients increase velocity, significantly boosting SMTR.

**C:** The amount of solute (sugar) per unit volume. Denser sap carries more mass at the same speed.



**Giant pumpkins (Cucurbitaceae) exhibit some of the highest recorded SMTR values in nature.**

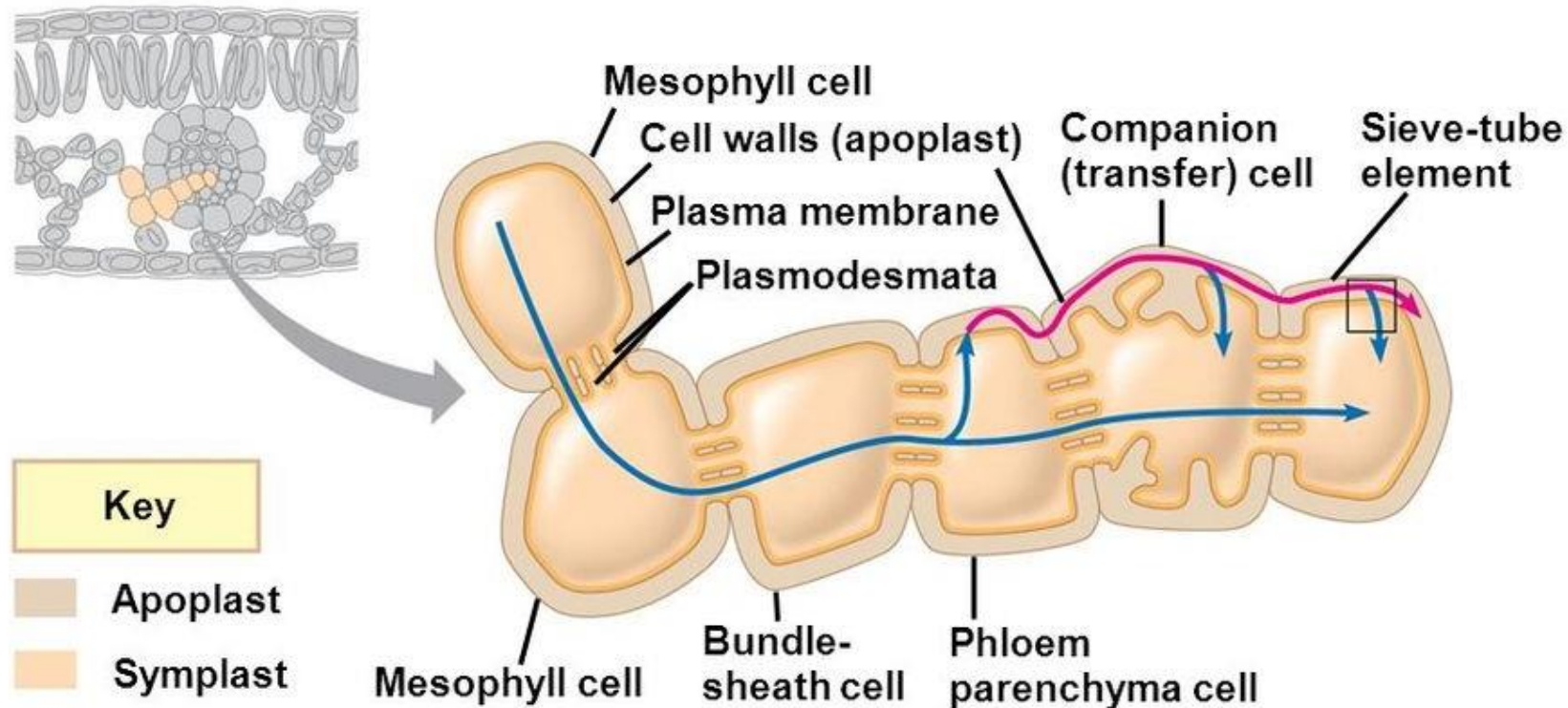
| Parameter                                 | Slow System (e.g. Willow) | Active System (e.g. Maize) | Peak System (e.g. Pumpkin) |
|---|---------------------------|----------------------------|----------------------------|
| SMTR ( $\text{g cm}^{-2} \text{h}^{-1}$ ) | ~2.0                      | ~10.0                      | ~13.0+                     |
| Velocity ( $\text{cm h}^{-1}$ )           | 30 - 50                   | 80 - 120                   | 150 - 200                  |
| Conc. (% Sucrose)                         | 15% - 20%                 | 18% - 25%                  | 20% - 30%                  |

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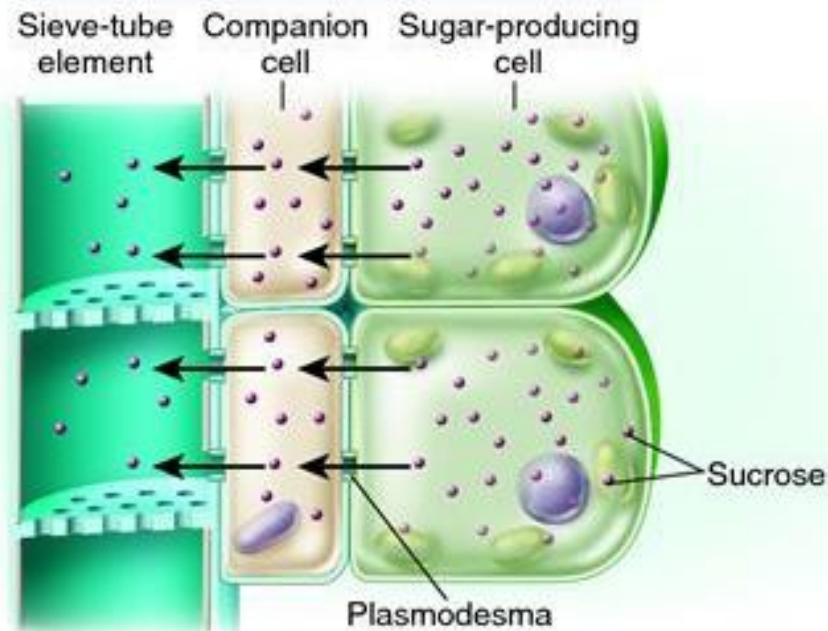
# Phloem Loading of Assimilates

- ❖ Phloem loading (韧皮部装载) is the movement of assimilates from mesophyll cells into the sieve element–companion cell complex.
- ❖ Main transported sugar: **sucrose** (蔗糖).

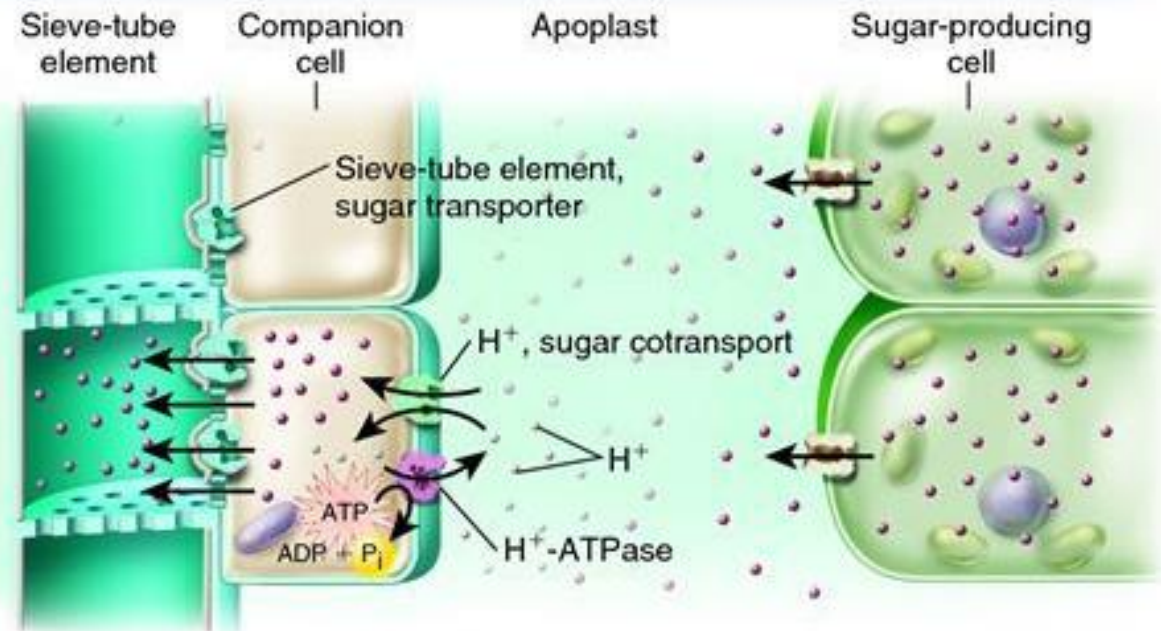


# Phloem Loading of Assimilates

- ❖ Symplastic pathway: Sucrose moves cell-to-cell through plasmodesmata (胞间连丝).
- ❖ Apoplastic pathway : an active, energy-dependent process



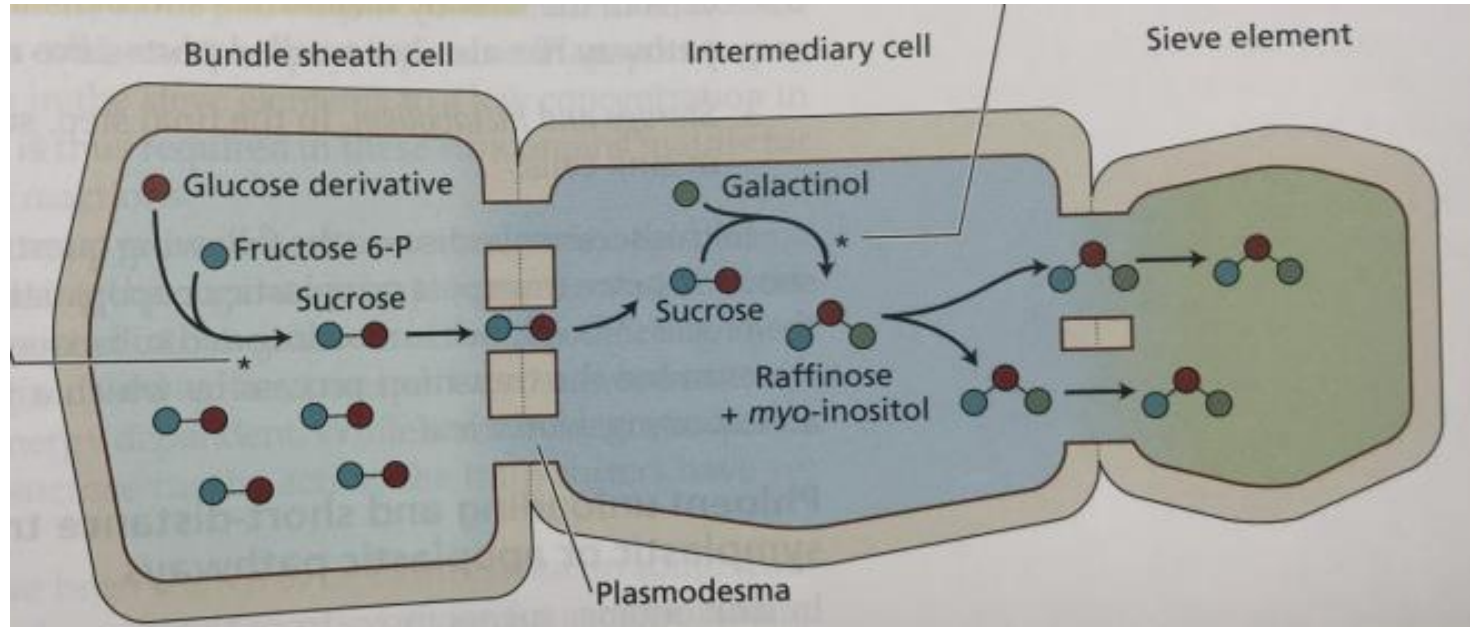
(a) Symplastic phloem loading



(b) Partly apoplastic phloem loading

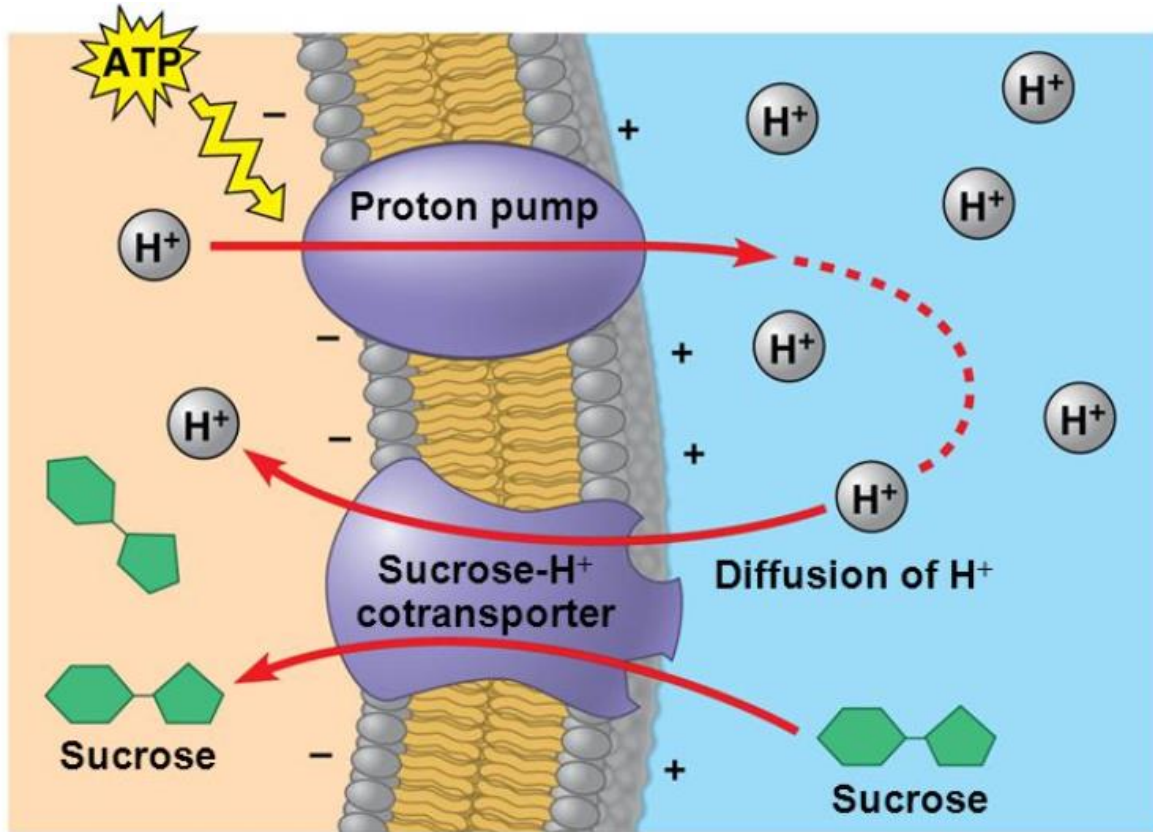
# Polymer-Trapping Model

The polymer-trapping model (聚合物陷阱模型) is for **symplastic phloem loading**



**Sucrose enters intermediary cells (中间细胞) through plasmodesmata. Sucrose is converted into larger sugars, such as raffinose (棉子糖) and stachyose (水苏糖).**

# Apoplastic loading Mechanism



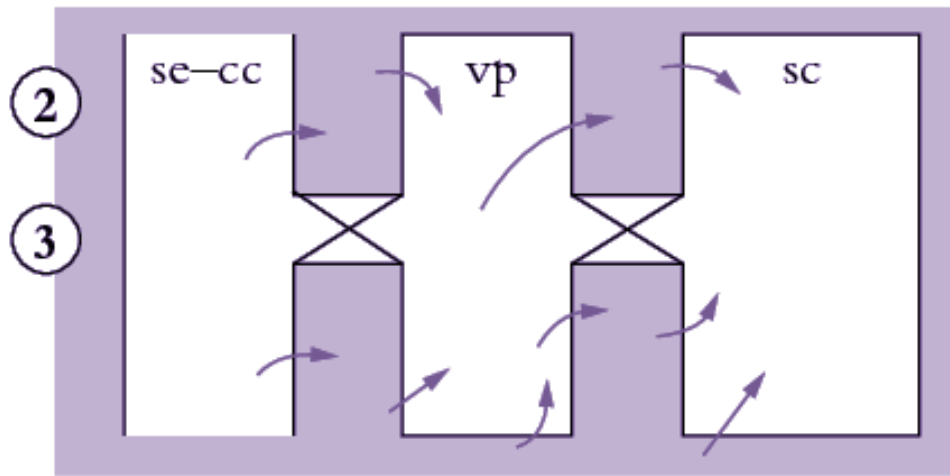
1. H<sup>+</sup>-ATPase pumps protons out of the cell.
2. Sucrose-proton symporters (蔗糖-质子同向转运蛋白, SUT/SUC) use proton gradient to import sucrose

- H<sup>+</sup>-ATPase
- sucrose-proton symporter

# Phloem Unloading at Sink Tissues

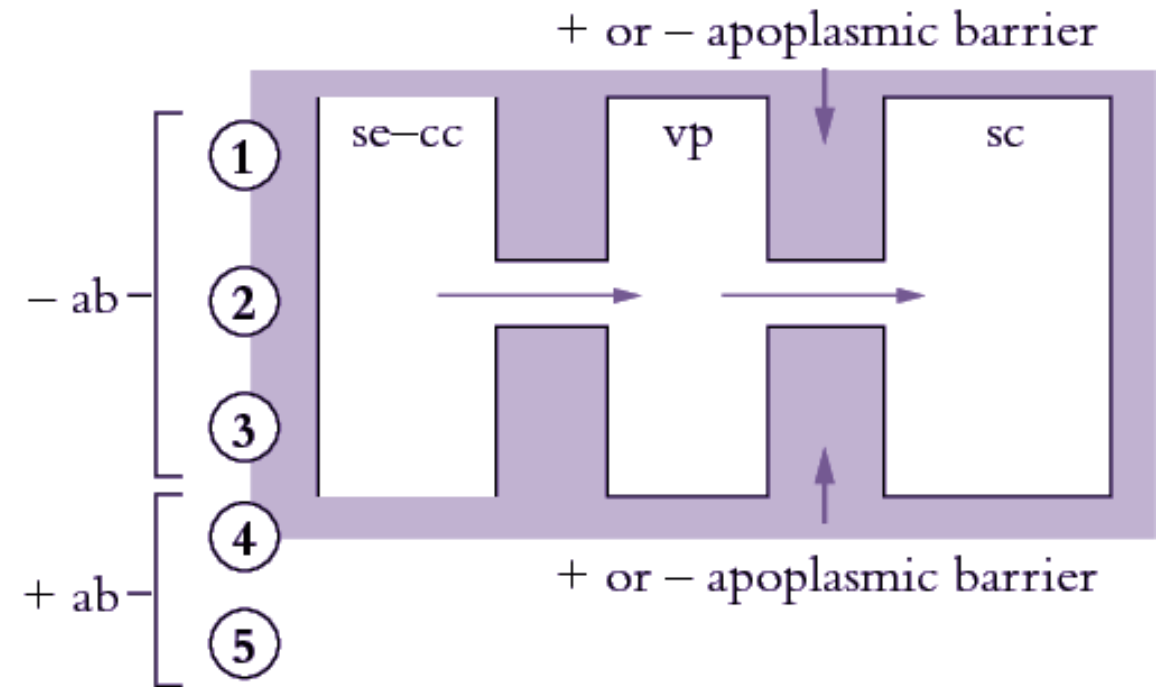
Phloem unloading moves assimilates from the SE–CC complex into sink cells.

(a) Apoplastic pathway



Sucrose exits the phloem into the apoplast.

(b) Symplasmic pathway



Assimilates move through plasmodesmata

# Pressure Flow Hypothesis

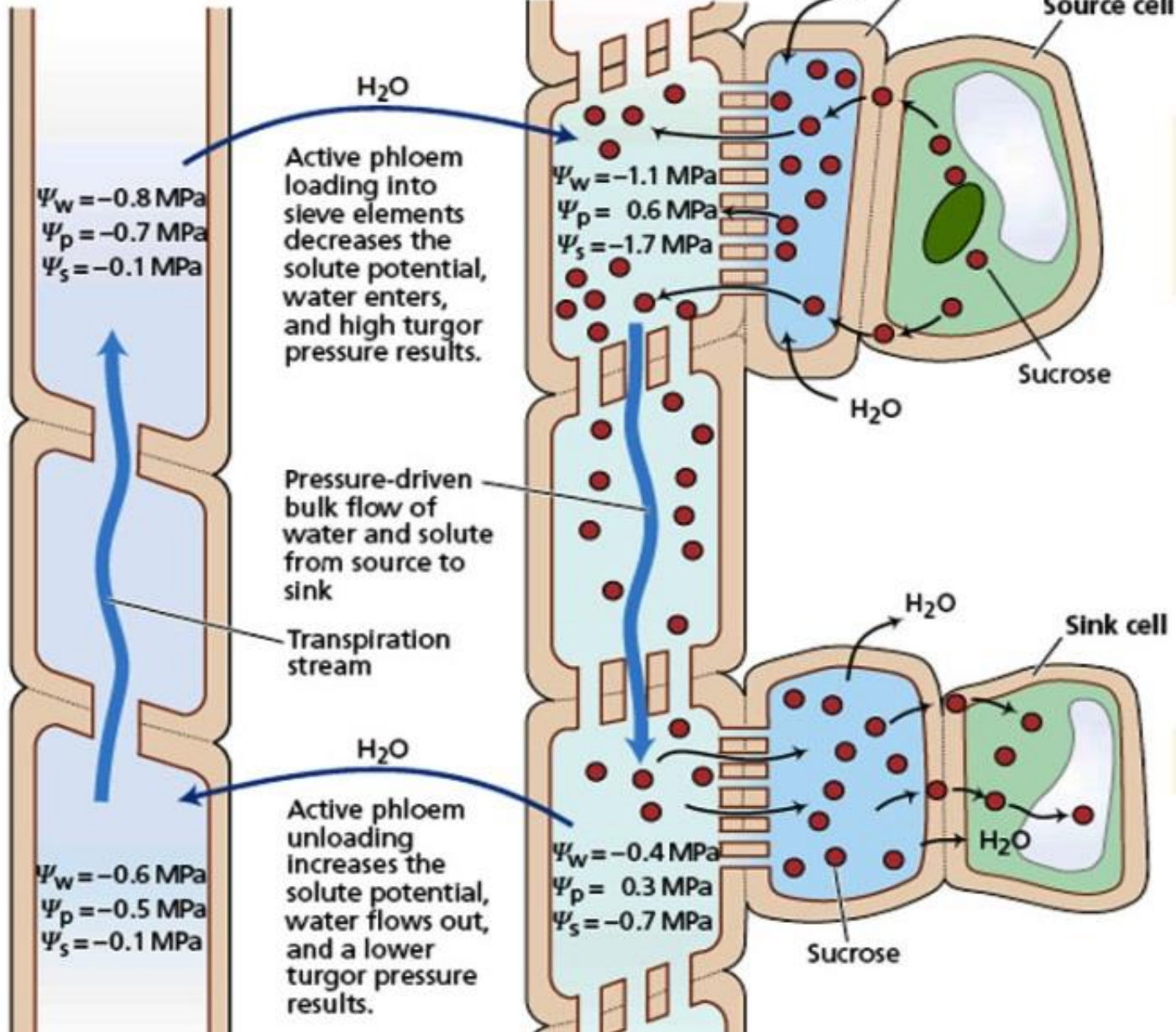
The pressure flow hypothesis (压力流动学说) explains long-distance transport in the phloem.

- ❖ Proposed by Ernst Münch in 1930.
- ❖ Assimilates, mainly sucrose, move through sieve tubes by mass flow.
- ❖ Flow is driven by a pressure gradient between:
  - ✓ Source tissues, where sucrose is loaded.
  - ✓ Sink tissues, where sucrose is unloaded.
- ❖ Water enters the phloem at the source and exits at the sink, generating bulk flow.

Xylem vessel elements

Phloem sieve elements

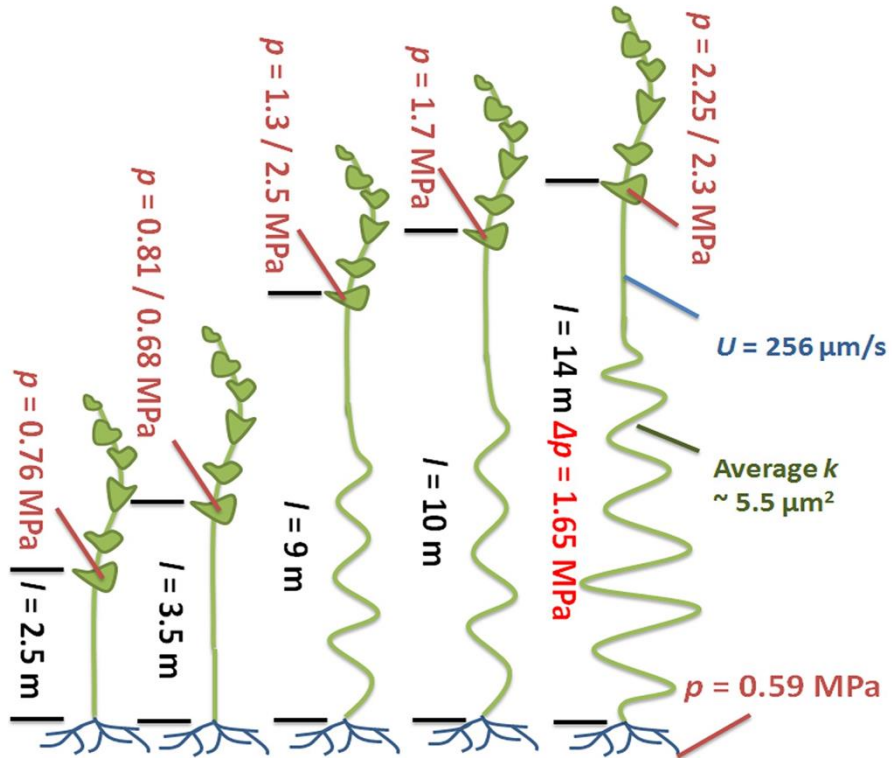
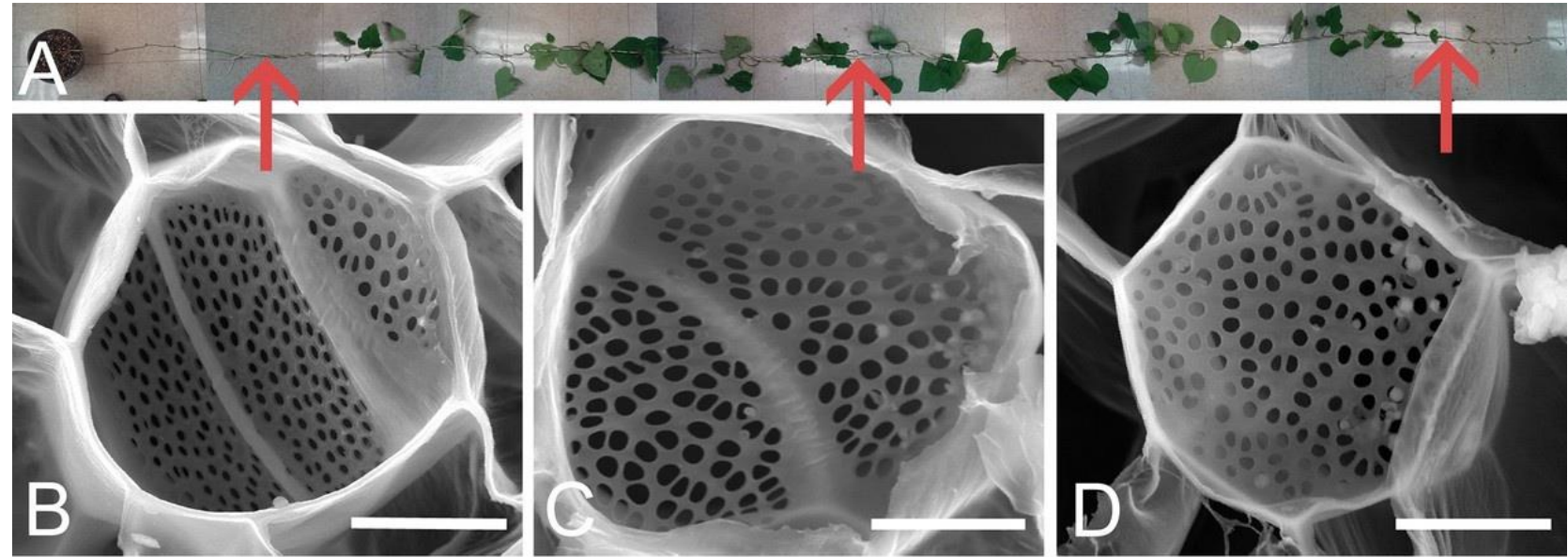
Companion cell



**Source loading → water entry → high pressure → mass flow → sink unloading → water exit**

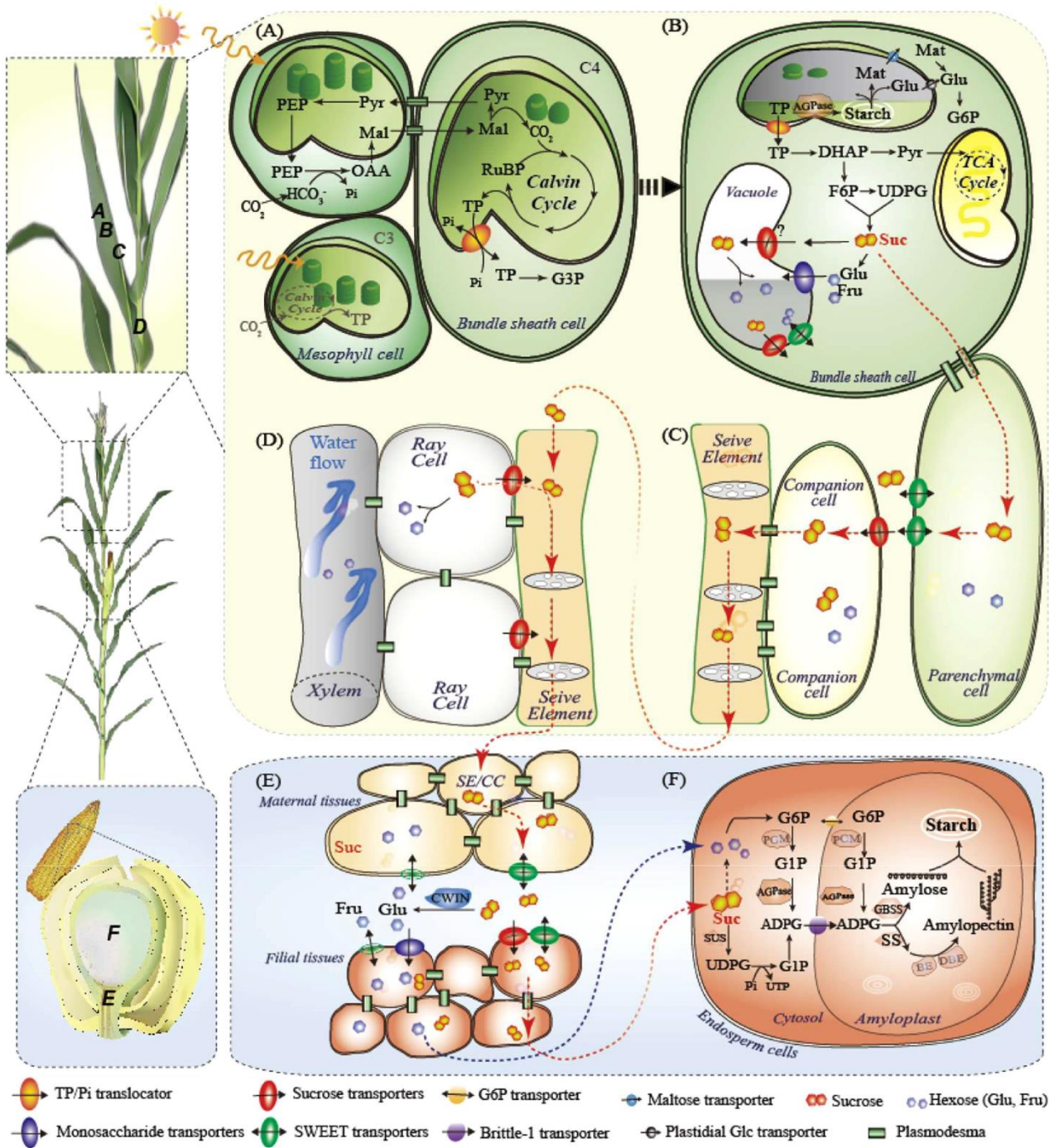
# Testing the Münch hypothesis of long distance phloem transport in plants

Michael Knoblauch<sup>1\*</sup>, Jan Knoblauch<sup>1,2</sup>, Daniel L Mullendore<sup>1</sup>, Jessica A Savage<sup>2,3</sup>, Benjamin A Babst<sup>4†</sup>, Sierra D Beecher<sup>1</sup>, Adam C Dodgen<sup>1</sup>, Kaare H Jensen<sup>5</sup>, N Michele Holbrook<sup>2</sup>



# Content

- ❖ Transport of assimilates within the plant
- ❖ Loading and unloading of assimilates
- ❖ Allocation and partitioning of assimilates**
- ❖ Regulation of assimilate transport and partitioning**

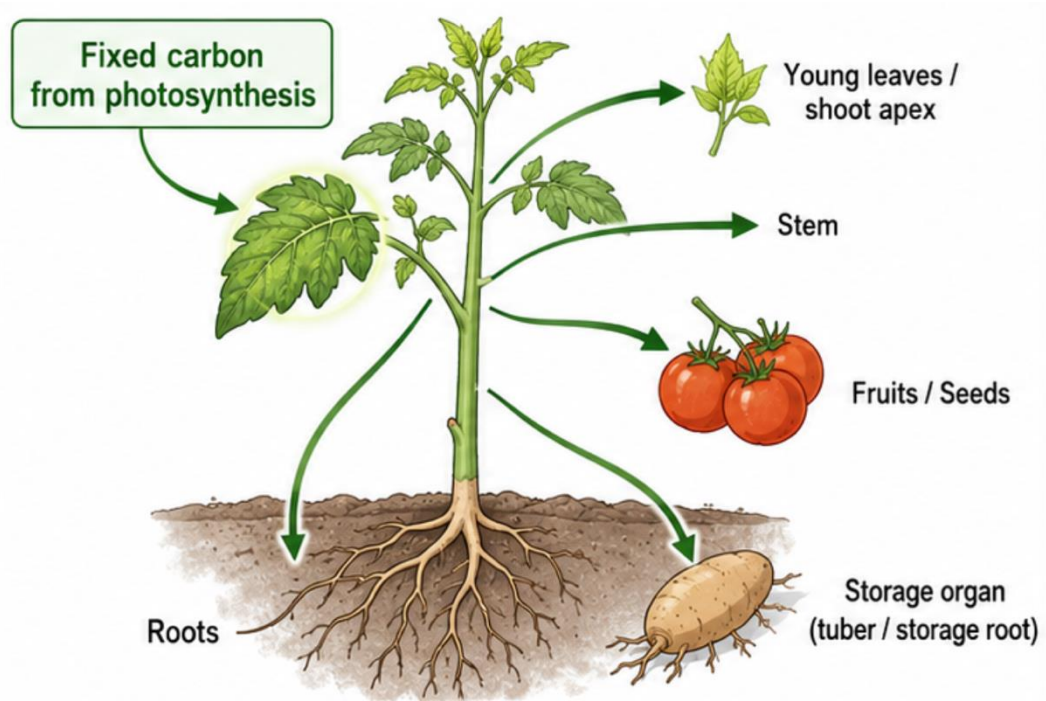


# Allocation and Partitioning of Assimilates

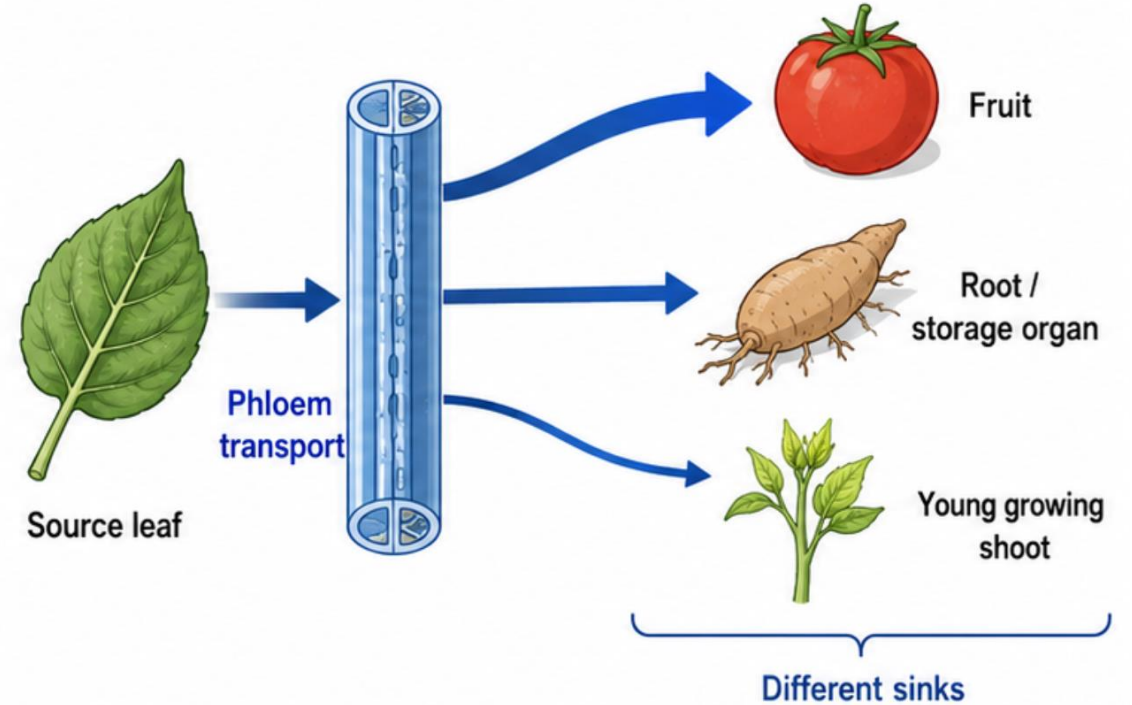
- ❖ **Assimilate allocation** (同化物配置) refers to how fixed carbon is distributed among plant organs.
- ❖ **Assimilate partitioning** (同化物分配) refers to the distribution of transported assimilates among different sinks.
- ❖ **Source tissues** produce and export assimilates.
- ❖ **Sink tissues** import and use or store assimilates.
- ❖ **Source–sink relationships** determine plant growth, yield formation, and harvest index.

# Allocation and Partitioning of Assimilates

## Assimilate allocation



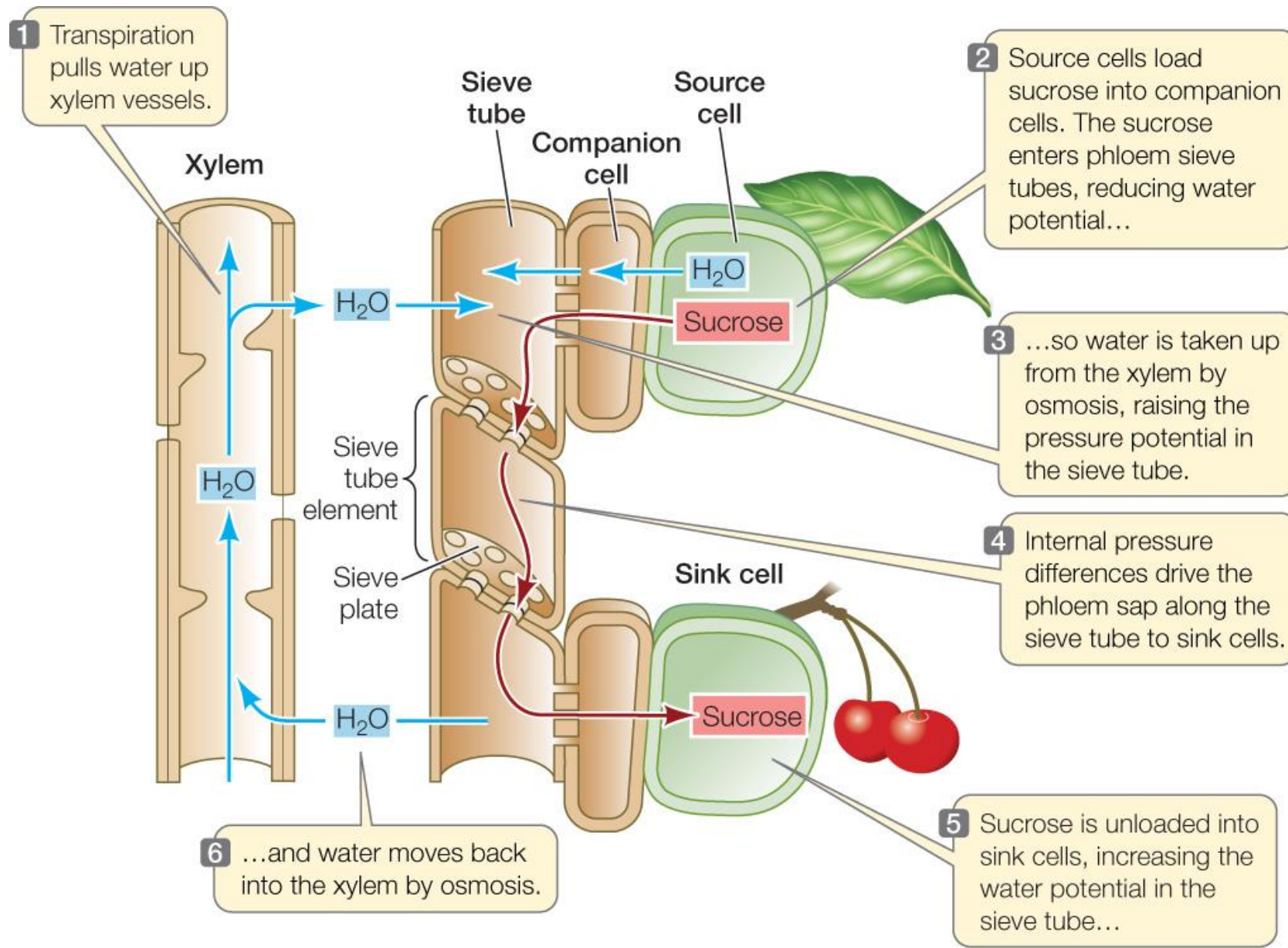
## Assimilate partitioning



# Sources, Sinks, and Flow

- ❖ **Source (源):** organ that produces and exports assimilates, usually mature leaves.
- ❖ **Sink (库):** organ that imports and consumes or stores assimilates, such as roots, young leaves, fruits, seeds, and storage organs.
- ❖ **Flow (流):** transport pathway connecting sources and sinks through the phloem (韧皮部).
- ❖ **Source–sink unit (源-库单位):** a functional system formed by sources, sinks, and the transport pathway between them.

# Source-sink unit



# Features of Assimilate Partitioning

- ❖ Assimilates are preferentially supplied to strong growth centers. **优先供应生长中心**
- ❖ Nearby sinks often receive assimilates first. **就近供应, 同侧运输**
- ❖ Leaves and sinks can show functional supply relationships. **功能叶之间无同化物供应关系**
- ❖ Assimilates and nutrients can be redistributed and reused. **同化物和营养元素的再分配与再利用**

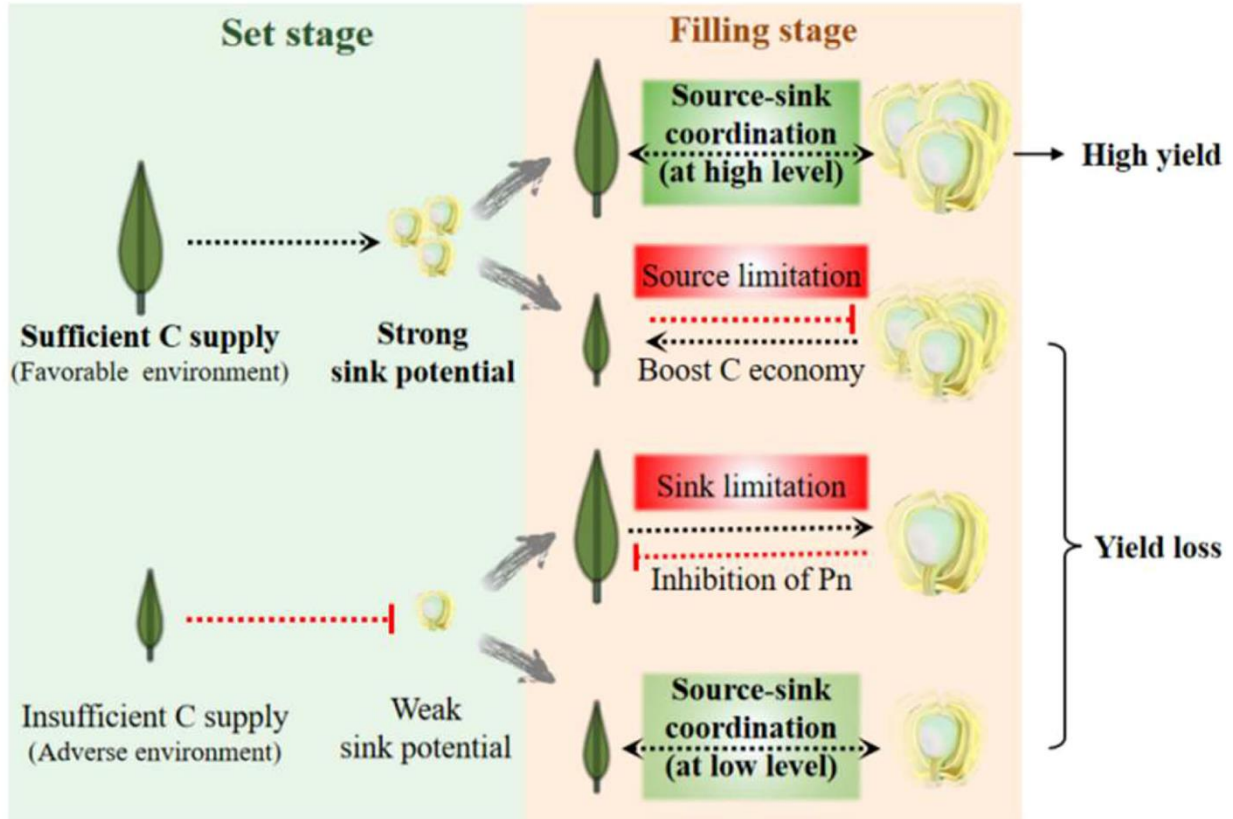
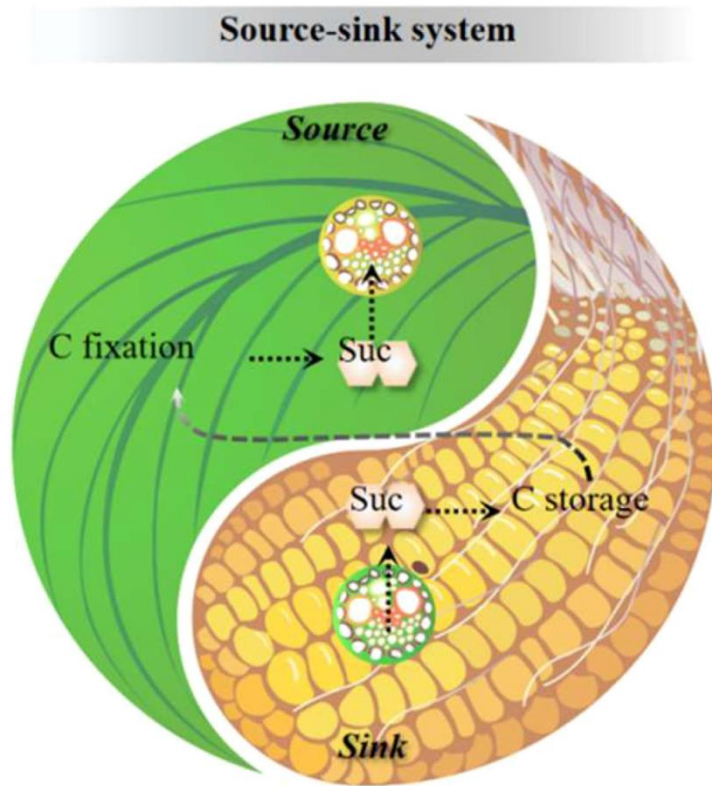
# Assimilate Partitioning and Yield Formation

- ❖ **Yield depends on three major factors:**
  - **Source strength (源强):** ability to produce assimilates.
  - **Sink strength (库强):** ability to import, use, and store assimilates.
  - **Transport capacity (运输能力):** efficiency of phloem connection between source and sink.
- ❖ **Yield may be limited by source capacity, sink capacity, or coordination between source and sink.**
- ❖ **High yield requires balanced source production, sink demand, and transport efficiency.**

# Source-Limited, Sink-Limited, and Coordinated Yield

- ❖ **Source-limited type (源限制型):** yield is limited by insufficient photosynthetic supply.
- ❖ **Sink-limited type (库限制型):** yield is limited by weak storage or reproductive sink capacity.
- ❖ **Source–sink coordinated type (源库互作型):** yield is improved when source supply and sink demand are well matched.

# Source-Limited, Sink-Limited, and Coordinated Yield



**Crop management should aim to increase both assimilate production and sink utilization.**

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- ❖ Transport of assimilates within the plant
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# Regulation of Assimilate Partitioning

## ❖ **Metabolic regulation:**

- Changes in sucrose concentration within cells regulate assimilate movement.
- Sugar metabolism affects source export and sink utilization.

## ❖ **Plant hormones regulate** assimilate partitioning by affecting:

- Sink growth
- Leaf senescence
- Storage organ development
- Fruit and seed filling

# Regulation of Assimilate Partitioning

## ❖ **Temperature:**

- Affects transport rate and direction.
- Phloem transport is often most active around 20–30°C.

## ❖ **Light:**

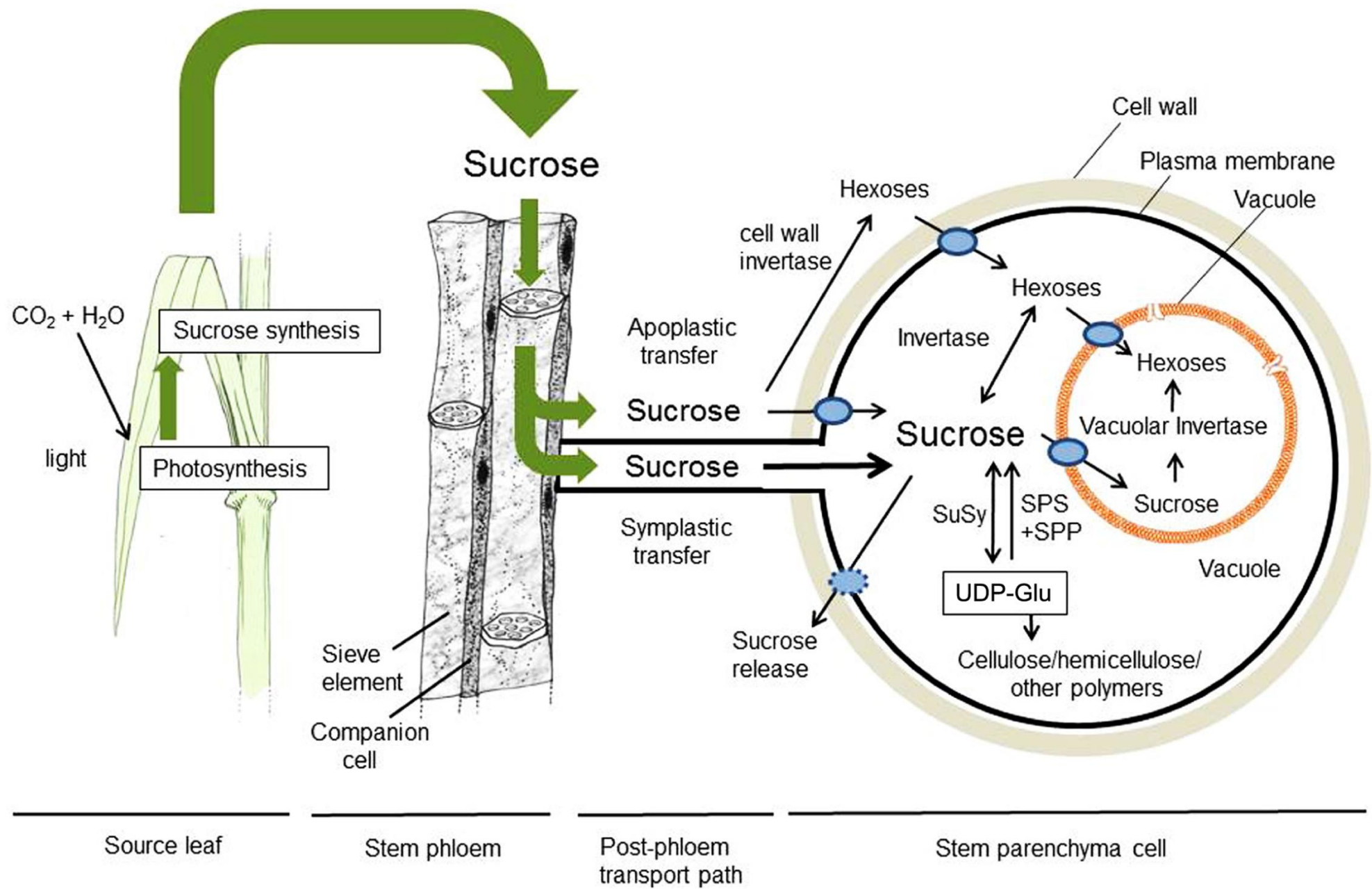
- Promotes photosynthesis and increases assimilate supply.
- Also enhances source activity and phloem loading.

## ❖ **Water status:**

- Drought reduces phloem transport and accelerates senescence.
- Water availability affects pressure-driven mass flow.

## ❖ **Mineral nutrients:**

- Nitrogen, phosphorus, potassium, and boron influence assimilate production, transport, and sink development.



# Homework Assignments

**Topic:** Tuber/root enlargement in potato, sweet potato, or sugar beet

**Your task:**

- ❖ Identify the main source (源), sink (库), and transport pathway.
- ❖ Explain what limits yield: source strength, sink strength, or transport capacity.
- ❖ Discuss one regulator: sugar metabolism, hormones, temperature, light, water, or mineral nutrients.
- ❖ Propose one management strategy to improve assimilate allocation.

**Challenge:**

Design a simple experiment to test your explanation. Include treatment, control, and predicted result.