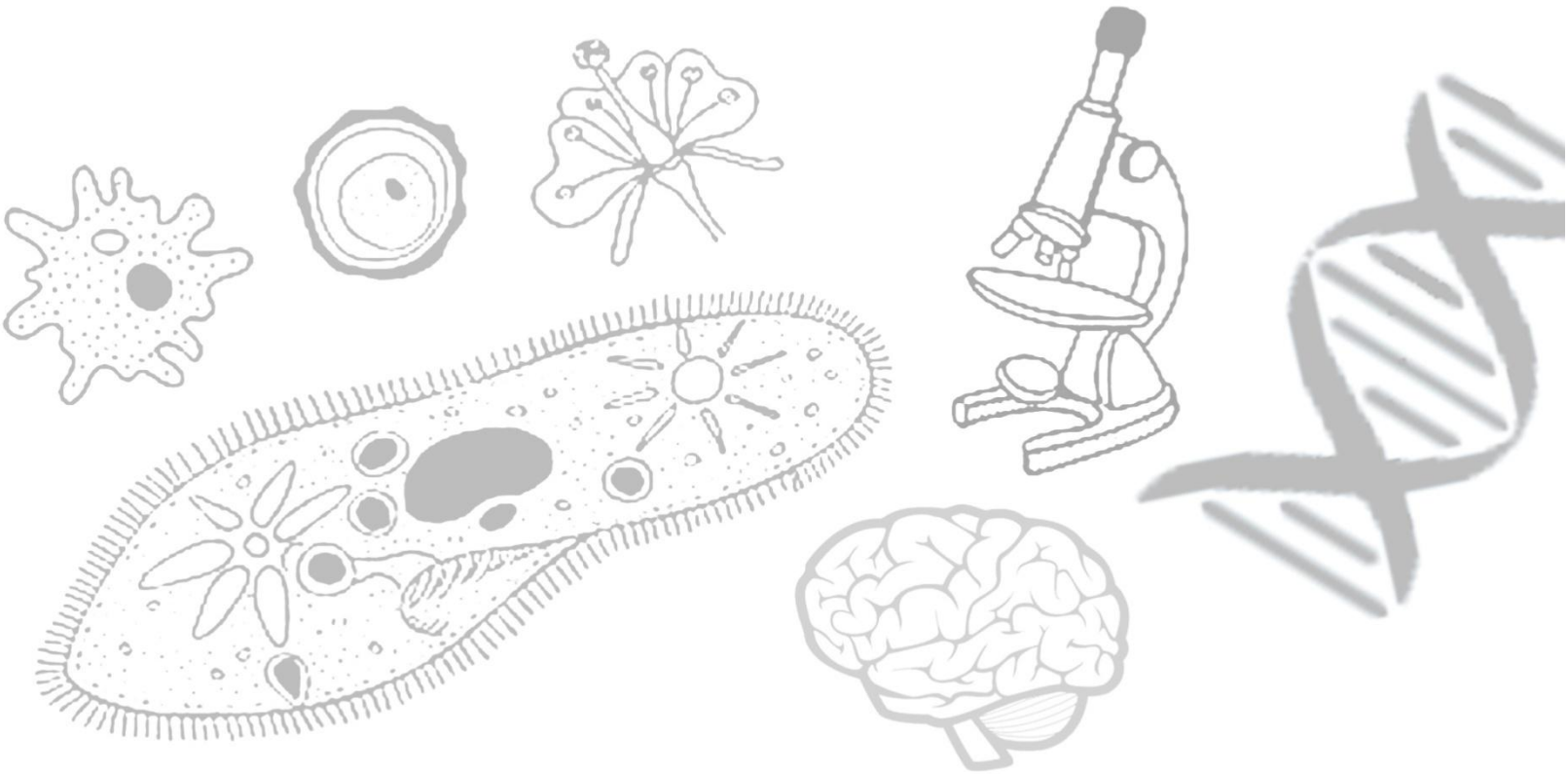
Chapter Notes

BIOLOGY



Phloem Transport: Mass Flow Hypothesis

Contents

Go to Top

Phloem Translocation

- The organic compounds such as glucose and sucrose produced during photosynthesis are translocated from the green cells to the non-green parts of plants through the phloem tissue.
- The transport of photosynthates from the leaves to the apices, roots, fruits, buds and tubers of the plant through the phloem is called translocation of organic solutes or long distance transport.
- Translocation occurs through the phloem in the upward, downward and radial directions from the leaves to the storage organs.
- The process of translocation requires expenditure of metabolic energy, and the solute moves at the rate of 100 cm/hr.
- Chemical analysis of the phloem sap reveals the presence of up to 90% sugars such as sucrose, raffinose, stachyose and verbascose.

FACT

Rabideau and Burr (1945) provided $^{14}CO_2$ to a leaf during photosynthesis (Tracer technique). Sugars synthesised in this leaf got labelled with ^{14}C (tracer). The presence of radioactively labelled sugars in the phloem revealed that the solutes are translocated through the phloem.

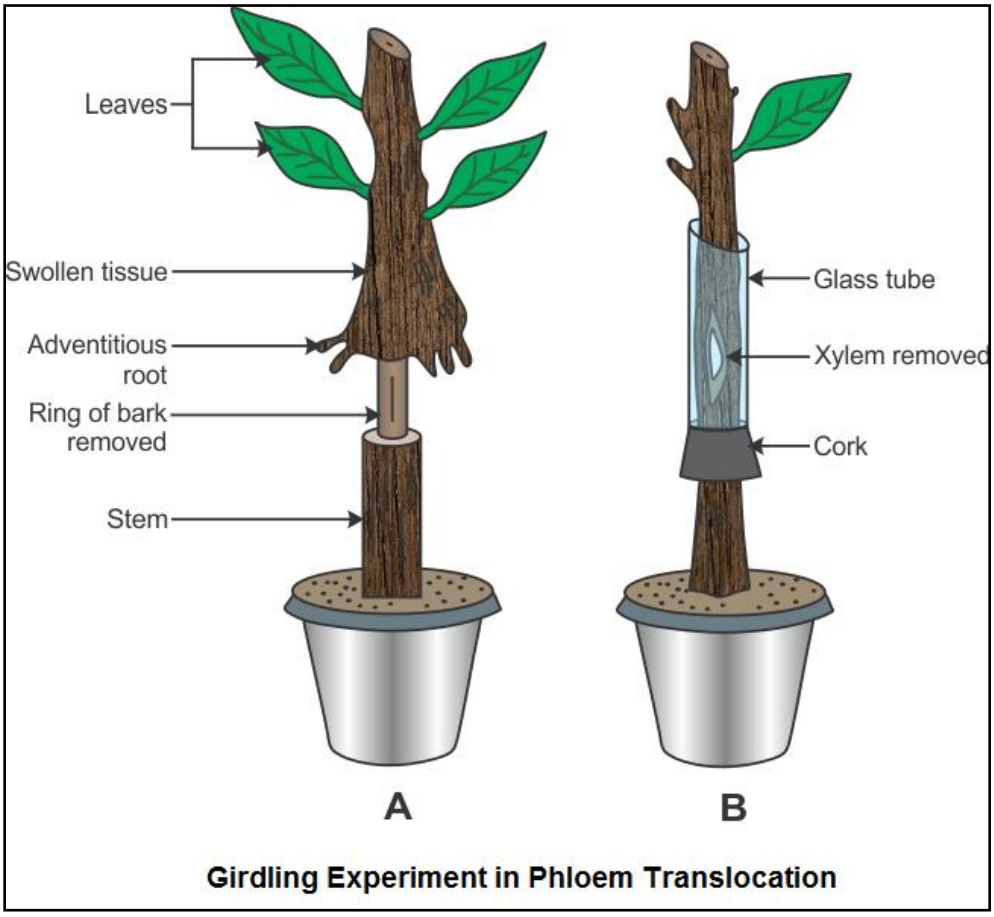
Evidences in Support of Phloem Translocation

- Some evidences which support that organic solutes are translocated through the phloem:

Ringing or Girdling Experiments

- To determine whether the xylem or phloem tissue is involved in translocation, it is possible to remove the cortex and the phloem of the stem in the form of a girdle.
- If the xylem is involved in transport, the roots found below the ring should not undergo any kind of modification because the xylem is intact in this experiment.
- However, the roots undergo swelling and sometimes show the formation of adventitious roots as they do not get adequate supply of food material because the phloem and cortex are removed.
- As a result, the food material accumulates at the edge of the ring, and with time, this region swells into a ridge.
- This experiment suggests that phloem elements are involved in the translocation of food materials.

Go to Top



Girdling Experiment in Phloem Translocation

Isotopic Studies

- If a leaf of a potted plant is illuminated in the presence of radioactive $^{14}CO_2$, it forms radioactive products of photosynthesis.
- These radioactive products are then transported to the stem.
- It was detected through autoradiography that these substances are translocated through the phloem mainly through the sieve tubes.

Chemical Analysis of Phloem Sap

- Chemical analysis of sieve tube sap proves to be a sweet, concentrated solution of sugar.
- This analysis supports the fact that the phloem tissue acts as the main channel in the translocation of organic solutes.

Go to Top

Factors Affecting Translocation of Solutes

Temperature	•Rate of translocation increases with increase in temperature
Light	•Translocation to root increases as compared to shoot when light intensity is increased
Metabolic inhibitors	•Carbohydrate translocation gets inhibited by metabolic inhibitors
Mineral deficiency	•Absorption and translocation of sucrose by a leaf are facilitated by boron
Hormones	•Translocation of sucrose is much more efficient in the presence of growth regulators

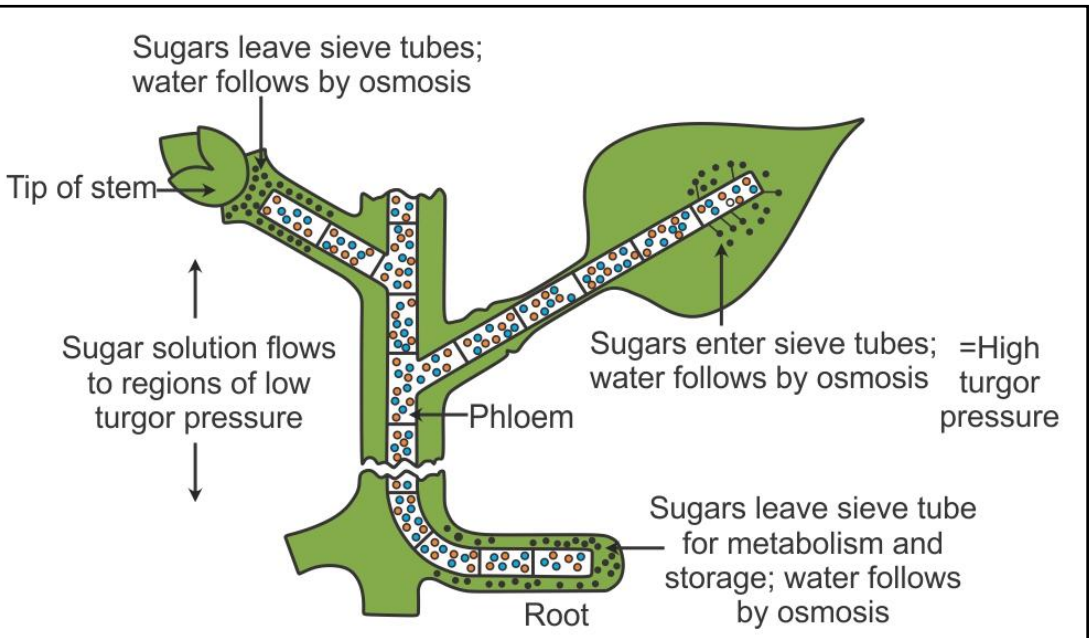
Go to Top

Mass Flow Hypothesis

- Several theories have been proposed to explain the mechanism of phloem translocation.
- Some of these theories:
  i. Diffusion hypothesis
  ii. Activated diffusion theory
  iii. Electro-osmotic theory
  iv. Interfacial flow hypothesis
  v. Munch hypothesis
- Among them, the Munch's mass flow hypothesis is the most widely accepted theory for translocation of solutes through the phloem.

Munch's Mass Flow Hypothesis

- The mass flow or pressure theory was first proposed by Munch (1930) and later elaborated by Crafts (1938).
- According to this theory, organic solutes are translocated en masse through the sieve tubes from the source (leaves) to the storage sites (roots, fruits and tubers).

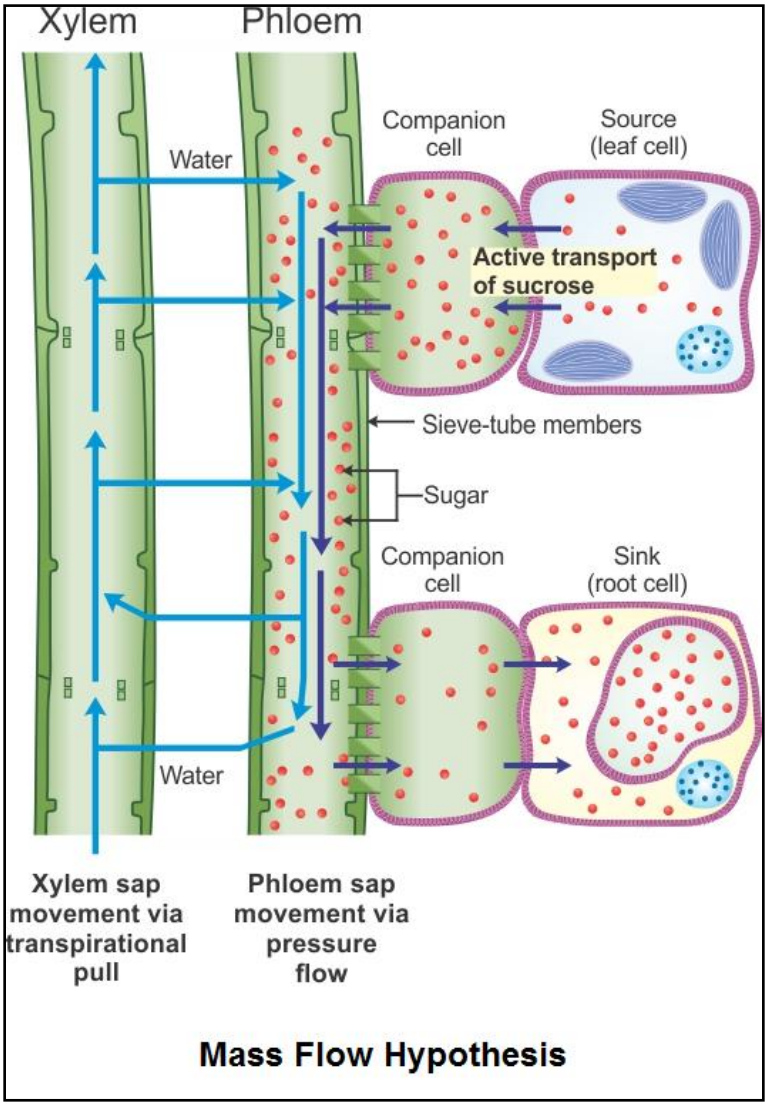


Diagrammatic representation of mechanism of translocation

- Mesophyll cells synthesise sugars during photosynthesis. As these get dissolved in the cell sap, the osmotic concentration and diffusion pressure deficit (DPD) of the mesophyll cells increase.
- Water enters the mesophyll cells from the xylem, and hence, the turgor pressure or pressure potential of the mesophyll cells increases.
- Sugars dissolved in water move from the mesophyll cells into the symplast system of the sieve tubes through the companion cells.
- Solutes are carried en masse through the symplast to finally reach the consumption centres.

Go to Top

- At the consumption end, food materials are either used up, as in roots, or are stored in an insoluble form, as in fruits and tubers. As a result, the osmotic concentration, and consequently, the turgor pressure in these cells are low.
- In this way, a continuous turgor pressure gradient is established across the symplast between the cells of the source and the cells of the sink.
- Water returns to the source through the apoplast system.



Instances Supporting Munch's Hypothesis

- When a woody plant is girdled, the sap containing high sugar content exudates from the cut end.
- The positive concentration gradient disappears when the plants are defoliated.
- Movement of viruses and growth hormones is rapid in illuminated leaves as compared to shaded leaves.

Objections to Munch's Hypothesis

- The hypothesis fails to explain bidirectional movement of metabolites which is common in plants.
- Osmotic pressure of mesophyll cells and that of root hair do not confirm the requirements.
- Munch hypothesis gives a passive role to the sieve tube elements and the protoplasm.

Go to Top