Transport In Plants

Transport In Plants

Plants → No circulatory system

In Flowering Plants

- Water
- Mineral Nutrients
- Organic nutrients
- Plant growth regulator

Need to be transported

Transport

- Over short distance
  - by diffusion & cytoplasmic streaming
- Over long distance
  - By vascular system (translocation)

Xylem → Unidirectional (water + mineral + some organic nitrogen + hormones) → from root to stem

Phloem → Multidirectional → from leaves to root
↳ In spring, from lower end to buds of tree.

Phloem sap → water + sucrose (alkaline)

Means Of Transport

- Diffusion
- Facilitated diffusion
- Active Transport

Diffusion : (1) Passive (2) Over short distance

(3) No energy expenditure

(4) High conc. to lower conc.

(5) Slow process

(6) Not dependent on living system

(7) Obvious in gases & liquid (only mean of gaseous transport in plant)

(8) Rate → Conc. gradient, permeability of membrane, temp. and pressure.

Facilitated Diffusion :

(1) For substance having hydrophillic moiety.

(2) Special proteins

(3) No energy expenditure

(4) Transports saturates

(5) Specific (6) Sensitive to Inhibitor

(7) Porins → Proteins → forms large pores in outer membrane

Plastids

Mitochondria

Some bacteria

Aqua porins → Water channels → 8 different proteins

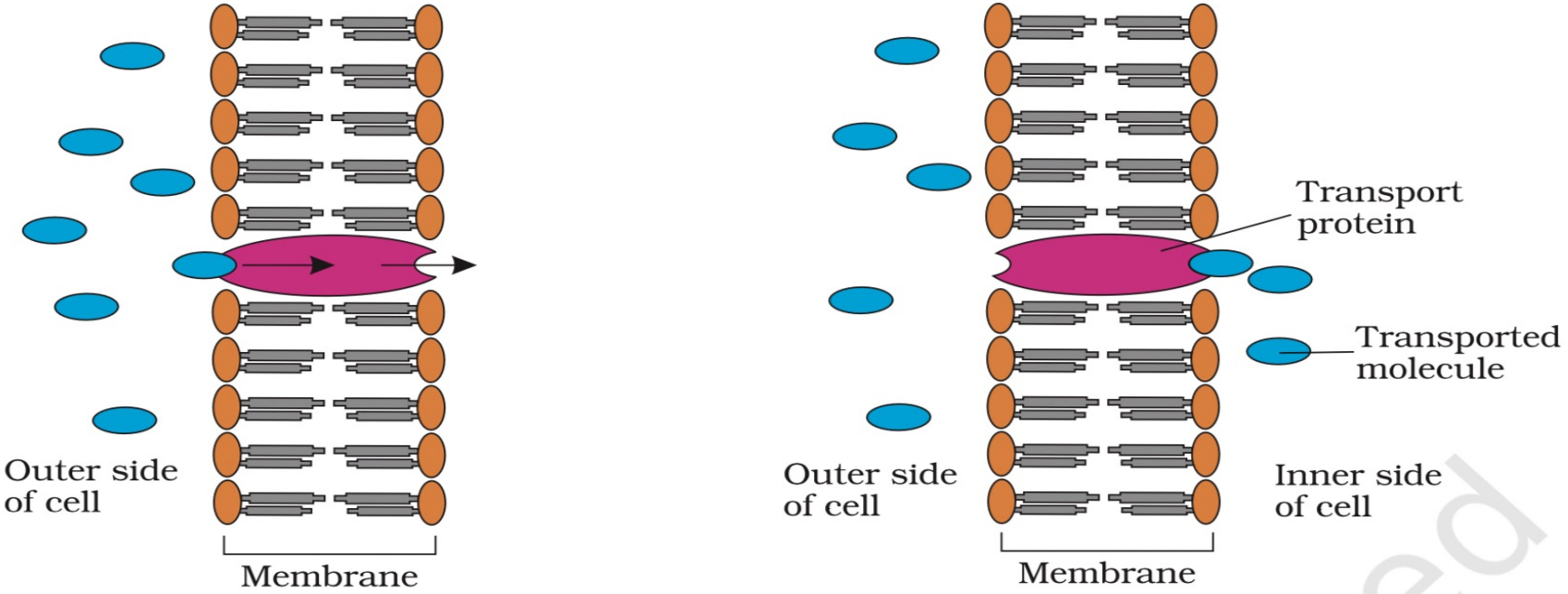


Figure 11.1 Facilitated diffusion

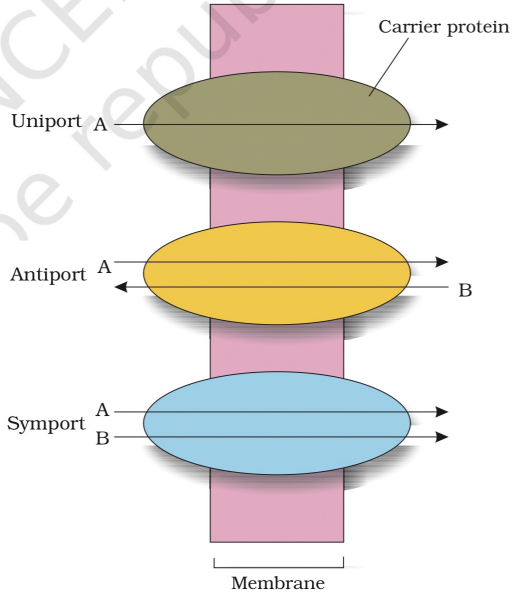


Figure 11.2 Facilitated diffusion

Symport → Both molecules cross the membrane in same direction

Antiport → " " " " " in different direction.

Uniport → " " " " " independent of other molecules.

Active Transport :

(1) Specific membrane protein

(2) Uphill transport (low conc. → high conc.)

(3) Saturates

(4) Very Specific

(5) Sensitive to inhibitors

(6) Requires ATP energy

TABLE 11.1 Comparison of Different Transport Mechanisms

Property	Simple Diffusion	Facilitated Transport	Active Transport
Requires special membrane proteins	No	Yes	Yes
Highly selective	No	Yes	Yes
Transport saturates	No	Yes	Yes
Uphill transport	No	No	Yes
Requires ATP energy	No	No	Yes

Plant Water Relations

Watermelon → 92% water

Most herbaceous plants → 10-15% of its fresh wt.

Mature corn plant → absorbs almost 3L in a day.

Mustard plant → absorbs water equal to its own weight in 5 hrs.

Water → Limiting factor

- Growth
- Productivity

Water Potential

Solute Potential (Ψ_s) | Pressure Pot. (Ψ_p)

Water molecules → Possess Kinetic Energy

Water conc. ↑, KE ↑ or water Pot. ↑

Pure water → Greatest water pot.

↳ at standard temp. (not under any pressure)

water pot. → 0

All solution → lower water pot. than pure water

↓

Ψ_s → Always −ve

Pressure applied > Patm → water pot. ↑

ψ_p → Usually +ve (though in plant −ve pot. → Plays imp. role)

$$\psi_w = \psi_s + \psi_p$$

Osmosis

Determinants of movement of molecule

- Cell Membrane
- Tonoplast (Vacuole Memb.)

Osmosis → High conc. to low conc. → via differentially or selectively permeable membrane

More solute conc. ↑ → more pressure required. to prevent water from diffusing

Osmotic Pressure → +ve
Osmotic Pot. → −ve

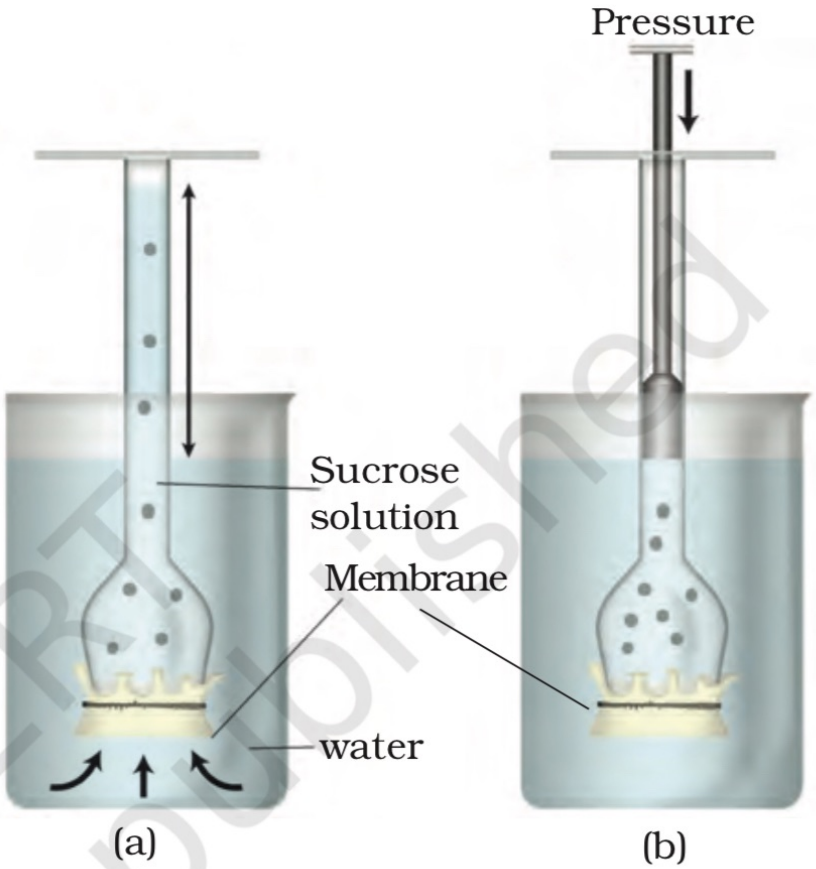


Figure 11.4 A demonstration of osmosis. A thistle funnel is filled with sucrose solution and kept inverted in a beaker containing water. (a) Water will diffuse across the membrane (as shown by arrows) to raise the level of the solution in the funnel (b) Pressure can be applied as shown to stop the water movement into the funnel

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Plasmolysis

Isotonic ~ External solution equals osmotic pressure of cytoplasm

Hypotonic ~ external sol. more dilute → Cell swells

Hypertonic ~ external sol. more conc. → Cell shrinks

Plasmolysis ~ water moves out of cell → Cell memb. shrinks

↓

Usually reversible

Flaccid → Isotonic solution (equilibrium)

Turgor pressure → Hypotonic cond.

- Cell enlargement
- Cell extension growth

Imbibition : water absorbed by solid-colloids

causing them increase in volume

- water absorption in seed
- emerge out of seedlings

Long Distance Transport Of Water

Movement of molecule → 50 µm in 2.5s

Positive hydrostatic pressure gradient → Root Pressure

Negative hydrostatic pressure gradient → Transpiration

Q. How do plants absorb water ??

Root hairs → absorption of water + Mineral

↳ Increases surface area.

Apoplast → Adjacent cell wall → continuos except casparian strips (endodermis)

↓

Doesn't involve crossing cell membrane

↳ Intercellular spaces + Walls of cells

↓

Mass flow due to adhesive & cohesive property of water

Symplast → Interconnected Protoplast

↓

Neighbouring cells are connected through cytoplasmic strand through Plasmodesmata

↓

Movement is slower

Cytoplasmic streaming → Hydrilla leaf

Movement of water → Ultimately Symplastic

Mycorrhiza: Symbiotic association → Fungus + Root of Plant

↓ Pinus

Fungus → provides minerals + water

Root → Sugar and N- containing compounds

Root Pressure

Guttation → Evaporation low → excess water near grass blades and herbaceous plants.

↓

Observable at night & early morning

Donot play major role in water movement.

Transpiration

Xylem → 15m/hr rate

< 1% water → used in photosynthesis.

Stomata → loss of water → Transpiration
↓
$CO_2 + O_2$ exchange

→ Often during day
Close during night

Opening of stomata → Turgidity of guard cells

Inner wall of guard cells → Stomatal aperture
↓
Thick and elastic

Cellulose microfibril → Oriented radially

Dicot leaf → Lower surface → more stomata

Monocot

> equal stomata → both surface

> Transpiration affected by :

- Temp
- Light
- Humidity
- Wind speed
- No. of stomata
- Distribution of stomata
- Canopy structure, etc.

Cohesion : Mutual attraction b/w water molecules

Adhension : Attraction of water molecules to polar surface

Surface tension: Water molecules are attracted to each other in liq. phase more than to water in gas phase.

Tensile Strength: Ability to resist pulling force.

Capillarity: Ability to rise in tuber.

Transpiration: Create pressure to lift 130 m high.

Uptake of Mineral Ions

1. Mineral → charged particle → cannot move through cell memb.
2. Conc. of mineral in soil → lower than in root.

Therefore, active absorption.
Some ions → Passively in epidermal cells.

Note: Root epidermis because of suberin layer has the ability to actively transport ion in one direction only.

Mechanism of Translocation

Chief Sink : Growing region of plant

- Apical Meristem
- Lateral Meristem
- Young leaves
- Flower, Fruits, Seeds, Storage Organ

Elements readily mobilised → P, N, S, K

Elements not readily mobilised → Ca

Pressure Flow or Mass Flow Hypothesis

Translocation of sugars from SOURCE → SINK

1. Process of loading at source → hypertonic cond. in Phloem

↓

2. Water in adjacent xylem moves into phloem by osmosis.

↓

3. Osmotic pressure builds up, phloem sap move to area of lower pressure

↓

4. Active transport to move sucrose out of phloem sap & into cell → sugar into energy, starch or cellulose.

↓

↓

5. As sugar removed, osmotic pressure ↓es and water moves out of the phloem.

Girdling experiment: Shows phloem is the tissue responsible for translocation of food.

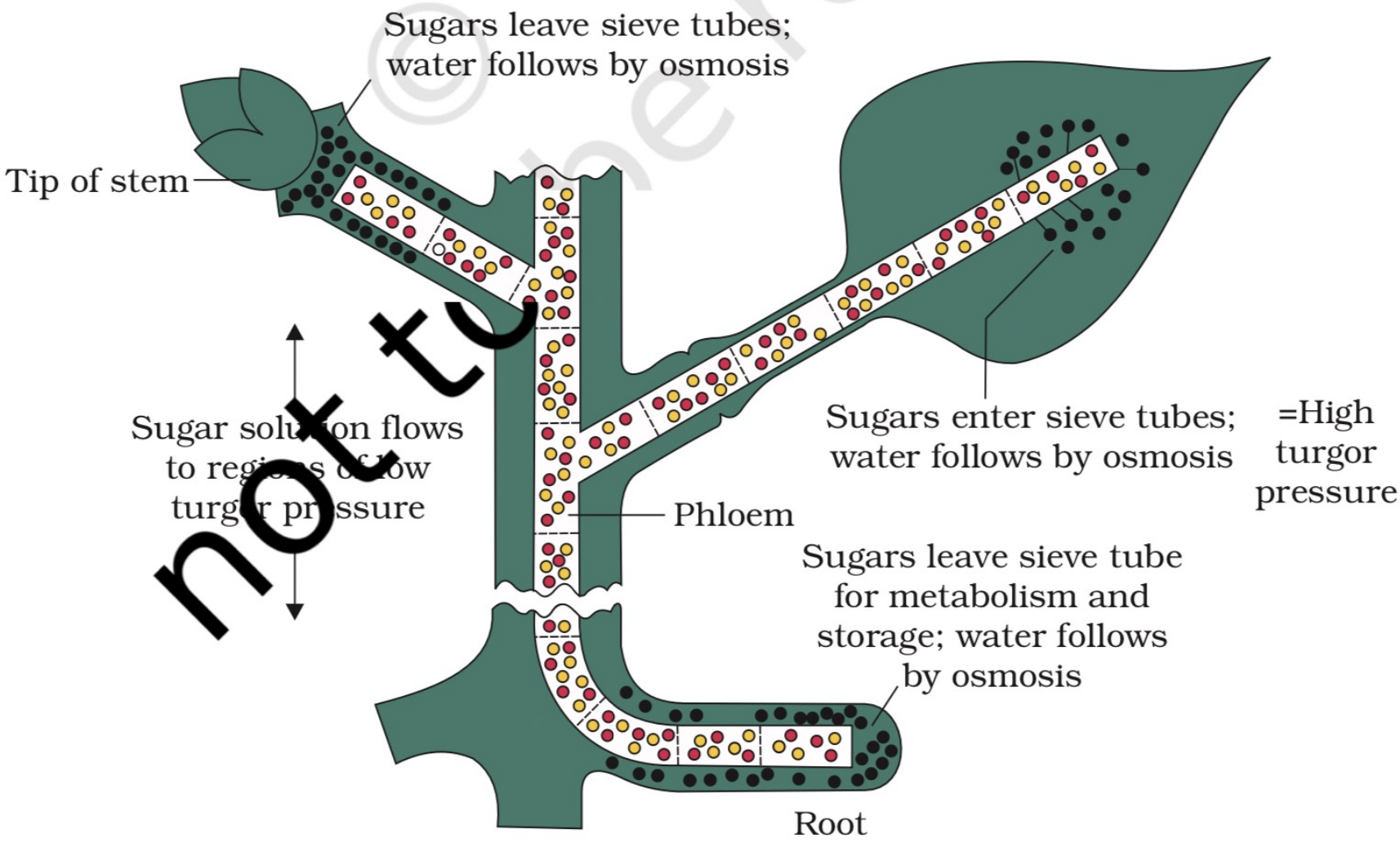


Figure11.10 Diagrammatic presentation of mechanism of translocation