Plant Transport Mechanisms – Acquiring and distributing water (and food)

A. Introduction to distribution needs in multicellular organisms

Multicellular organisms cannot use simple diffusion or other direct mechanisms of cell/organism interaction with the environment. They need distribution systems.

B. Transport interactions at the cell and molecular level

Diffusion is a process that occurs at the molecular level and is dependent on permeable membranes.

Active transport mechanisms (remember Chapter 8), involve expenditure of metabolic energy by the cell and usually involve –

- solute concentration gradients
- voltage (charge difference) gradients

FIG. 36.2 summarizes chemiosmotic mechanisms -- Review

C. Water potential and water transport in plant cells

Osmosis through passive transport will occur over permeable membranes.

In plants, the cell wall contributes a secondary factor – pressure – to water movement.

Water potential is a measure of the osmotic state of a plant cell

\[ \Psi = \text{solute concentration} + \text{pressure} \]

Review FIGs. 36.3 and 36.4 to get an idea of these concepts
D. Bulk flows of water and solutes over long distances

**Lateral transport** can involve --

- movement through cell cytoplasm (plasmodesma)
- through cell walls and cytoplasm
- through cell walls

**REVIEW FIG. 36.6**

E. Root transport mechanisms – water and minerals

**Surface area is critical.** Highly branched, numerous, tiny root hairs and rootlets provide a large surface area.

**Symbiotic fungi** form large hyphal masses with plant roots (the entire symbiotic mass is called **mycorhizae**) that add to water/mineral absorption.

**Endodermal cell layer** (next to the vascular bundle) is the final filtering checkpoint for movement of water/minerals into the plant.

F. Transport of Xylem sap – the way up

The **ascent of xylem sap** is driven by **transpiration** and the **properties of water**.

Consider **root pressure** – the push of sap into the root stele. What does this do and what are its limits as a transport driver?

The **Transpiration – cohesion – tension mechanism** of pulling xylem sap up depends upon –

- the physics of flow through pipes
- solar powered evaporation of water in leaves (note stomata)
- leaf anatomy
- cohesive and adhesive properties of water
G. **Controlling Transpiration**

There is a balance – a *photosynthesis-transpiration compromise* – that controls the rate of transpiration.

- CO₂ needs to enter leaves (through stomata) for photosynthesis
- but, this increases water loss (through stomata)

**Stomata** are structures regulating active transport at a tissue/organ level.

H. **Translocation of phloem sap – the way down**

- There is movement of carbohydrates (sugar) produced by photosynthesis from the leaves to the rest of the plant – *generally down*.

**Phloem vessels** do this, but the mechanism involves movements from sugar **sources** to sugar **sinks**.

- Review FIGs. **36.13** and **36.14** for examples of pressure flow.
Plant Nutrition

A. Introduction to plant nutrition

Remember that nutritional mode or metabolic mode of an organism is how they obtain their energy and carbon. How do plants do this?

In Chapter 37 (Plant nutrition), how plants obtain other materials necessary for life is considered.

Review FIG. 37.1 and consider the nutrients needed by plants.

B. Macronutrients and Micronutrients

Table 37.1 reviews the macronutrients and micronutrients that are essential for plant maintenance, growth, and reproduction.

C. Why Soil is so important

The Soil environment is the key interface for obtaining nutrients.

Consider the origin of soil, and its physical features –

Ultimate and proximate origins
Topsoil – sand, silt, and clay particles
Loams
Humus
Availability of water and minerals (to plants)

Adding fertilizers and water (irrigation) to soils (artificially or naturally) are keys to “enriching” the quality of soils for plant growth and productivity.
D. Nitrogen cycling – a very special essential element for plants

Review FIG. 37.8 to appreciate the important relationships between nitrogen cycling in atmosphere, soils, via activities of nitrogen-fixing organisms, and plants.

E. Symbiotic relationships involving nitrogen

Symbiotic relationships between roots and nitrogen-fixing bacteria are critical to many plant species.

Root nodules are enlargements of lateral roots that are infected by bacteria. (Note especially common in legumes).

See FIG. 37.10

Symbiotic relationships between roots and fungi are critical to many plant species.

Mycorrhizae are symbiotic associations of modified roots and fungal hyphae (the same concept as lichens for algae and fungi).

Two major forms of mycorrhizal associations are recognized — ectomycorrhize and endomycorrhizae — that differ in how extensively the hyphae invade root tissues.

Symbiotic relationships between host plants and parasitic plants are found involving many species pairs.

Parasitic plant species can obtain nutrients by extracting them from host plants (a parasitic relationship). Epiphytic plants live literally “on plants” with their roots contacting and even penetrating the tissues of hosts.
Photosynthesis – an organismal perspective

A. Reflecting on photosynthesis as an organismal function

We dealt with photosynthesis as an energy transforming process at the cell and molecular level last semester.

REVIEW FIG. 10.2

What is the overall equation for photosynthesis?

\[
6 \text{ CO}_2 + 12 \text{ H}_2\text{O} + \text{ Light energy} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{ O}_2 + 6 \text{ H}_2\text{O}
\]

Energy conversions to glucose and O\textsubscript{2} is a two step process. Light and Dark reactions are summarized in FIG. 10.4

Reflect back on the photosynthesis– transpiration compromise and add to this, cellular respiration.
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<thead>
<tr>
<th>ELEMENT</th>
<th>AVAILABLE TO PLANTS</th>
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