Plant Function
Chs 38, 39 (parts), 40

KEB no office hour on
Monday 23 March

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ECOL 182R UofA
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Video 39.3 Pollination of a
night-blooming cactus by a
bat

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How do plants get nutrients they need?

Usually from soil through roots. A few interesting exceptions...

http://www.youtube.com/watch?v=ynmILpQNyI6g&feature=related
In addition to carbon dioxide and water, plants require essential nutrients.

Most nutrients are available as ions dissolved in soil water and are taken up by roots.

Nutrient absorption occurs via specialized proteins in plasma membranes of root cells. Most plants also obtain ______ or ______ from ________ associated with their roots.

Nutritional Requirements

• early 1600s, classic experiment by van Helmont

• mass of a growing plant comes from soil?
• mass of a growing plant comes from water?

• [Most of the mass of the tree actually comes from ________ in the atmosphere] _______
Which Nutrients Are Essential?

- An **nutrient**: required for both normal growth and reproduction and for a specific structure or metabolic function.

- There are **17 essential** nutrients for most vascular plants.
Which Nutrients Are Essential?

- Classified based on whether from water &/or carbon dioxide versus from ___.

- Essential nutrients available from H$_2$O or CO$_2$ are
  They make up 96% of the plant.

- Soil elements can be divided into macro nutrients and micronutrients.

- Macronutrients are the building blocks of nucleic acids, proteins, carbohydrates, phospholipids, and other key molecules required in relatively large quantities. They are
  - nitrogen (N)
  - potassium (K)
  - calcium (Ca)
  - magnesium (Mg)
  - phosphorus (P)
  - sulfur (S).
Which Nutrients Are Essential?

- **Limiting nutrients** are macronutrients that commonly act as limits on plant growth. __N__, __P__, and __K__ are often limiting nutrients.

Which Nutrients Are Essential?

- **Micronutrients** are required in very small quantities. Rather than acting as components of macromolecules, they usually function as cofactors for specific enzymes. Examples include:
  - iron, zinc, boron, copper, and nickel.
nutritional deficiencies

- **Hydroponic growth** takes place in liquid cultures, without soil, so the availability of nutrients can be precisely **controlled**.
**Experiment**

**Experimental setup:**

- Air bubbled in to provide oxygen
- Nutrient solution containing copper
- Nutrient solution without copper

**Prediction:** The copper-deficient plant will grow less than the normal plant.

**Prediction of null hypothesis:** Both plants will grow the same.

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**Experiment**

**Results:**

- Normal plant
- Copper-deficient plant

**Conclusion:** Copper deficiency leads to poor growth. All tissues appear to be affected adversely.
Soil

- **Weathering**—the forces applied by rain, running water, and wind—begins the process of building soil from solid rock.

- Particles derived from rocks are the first ingredient in soil. As organisms occupy the substrate, they add dead cells and tissues. This organic matter is called **humus**.

- **Organic + Inorganic = Mature Soil**

Soil Formation Begins with Erosion of Rock

Succession...
What Factors Affect Nutrient Availability?

• Cations tend to bind to soil particles, while anions stay in solution.

• The loss of nutrients via washing is called **leaching**.

What Factors Affect Nutrient Availability?

• Soil pH can also influence the availability of essential elements. Soils can be **acidic** (low pH) or **alkaline** (high pH).
Root Hairs Increase the Surface Area Available for Nutrient Absorption

Mechanisms of Nutrient Uptake

- Plant cell walls are permeable to ions, small molecules, and even large molecules.
- The plasma membrane, however, is highly selective. Membrane proteins allow only specific ions to cross the plasma membrane.
Establishing and Using a Proton Gradient

• Root-hair cells have **proton pumps** (H\(^+\)-ATPases) in their plasma membranes that move nutrients into the cell against a strong concentration gradient.

Ions Enter Roots along Electrochemical Gradients Created by

![Diagram showing proton pumps establishing an electrochemical gradient](image)
Cations Enter Roots via Channels

Anions Enter Roots via Cotransporters
Cation vs Anion Nutrients

- **Anions** easier to get than cations
  - But anions can leach out of sandy soils
  - Anions better retained in clay soils

- **Cations** often bound to organic or inorganic soil particles

  - $H^+$ (proton) for $Mg^+$ or $K^+$ or $Ca^+$ etc.
  - Plants facilitate by pumping $H^+$ out of root hairs

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**H+ (proton) for Mg+ or K+ or Ca+ etc.**

**Plants facilitate by pumping**

**H+ out of root hairs**
Nutrient Transfer via Mycorrhizal Fungi

• Vast majority of plants take up nutrients through their root hairs

• But, most need more nitrogen and phosphorus

• Help from fungi that live in close association with their roots.

• These fungi are called **mycorrhizae**

mycorrhizae provide _______ and/or _______ to the plants in exchange for sugar.

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mutualism
In Salt-Tolerant Plants, an Antiporter Concentrates Sodium in Vacuoles

(a) In the tonoplast, antiporters send $H^+$ out and $Na^+$ in.

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Not all soil ions are “good” for the plant

In Salt-Tolerant Plants, an Antiporter Concentrates Sodium in Vacuoles

Why are these all found in the same habitat?

- Stagnant water
- Low oxygen levels
- Acidic
- Nutrient poor

BOGS
Some species of plant have specialized methods of obtaining nutrients, including associations with nitrogen-fixing bacteria, parasitism, and carnivory.

Nitrogen Fixation

• Plants and other eukaryotes cannot use $N_2$ from the atmosphere.

• However, some _______ are able to absorb $N_2$ from the atmosphere and convert it to ammonia, nitrates, and nitrites in a process called nitrogen _______. 
Nitrogen Fixation

• Such bacteria often take up residence inside plant root cells.

• For example, members of the bacterial genus *Rhizobium* associate with plants in the pea family (*legumes*).

• Rhizobia (*Rhizobium* species and close relatives) are found in nodules on the roots of legumes and provide the plant with
  • ammonia in return for sugar and protection

In Some Plants, Roots Form Nodules where Nitrogen-Fixing Bacteria Live
Nutritional Adaptations of Plants

- **Most** plants use proton pumps as a mechanism for importing nutrients from the soil and/or acquire nutrients from symbiotes.
- In addition, **99%** of plants make their own sugars.
- Some plants don’t follow these rules, some appear to live on:
  - 1) _, some 2) _ others, some catch 3) _.

Epiphytic Plants

- **Epiphytes** are plants that are adapted to grow in the ___________ They often grow on leaves or branches of trees.
  
  - They absorb most of the water and nutrients they need from **rainwater, dust, and particles** that collect in their tissues or in the crevices of bark.
Epiphytes Are Adapted to Grow in the Absence of Soil

(a) Epiphytes grow on trees (e.g., Bromeliads).

Parasitic Plants

• Most parasitic plants make their own sugars through photosynthesis and tap into the vascular tissue of their hosts for water and essential nutrients.

• Some plant parasites are nonphotosynthetic and obtain all their nutrition from the host.

• There are at least 3000 species of parasitic plants
Some Plant Parasites Tap into the Xylem Tissue of Their Hosts

Mistletoe

Mistletoe haustoria penetrate host xylem and extract water and ions.
Carnivorous Plants

- Carnivorous plants use modified leaves to trap insects and other animals, kill them, and absorb the prey's nutrients.

- Carnivorous species make their own carbohydrates via photosynthesis but use carnivory to supplement the nutrient available in the environment, which is often lacking.

Sundews Have Modified Leaves with a Sticky Surface That Catches Insects