

# Plant Function

Chs 38, 39 (parts), 40



KEB no office hour on  
Monday 23 March

10 March 2009  
ECOL 182R UofA  
K. E. Bonine

Videos:  
39.3, 34.3, 39.1, 34.1  
Web Browser Open

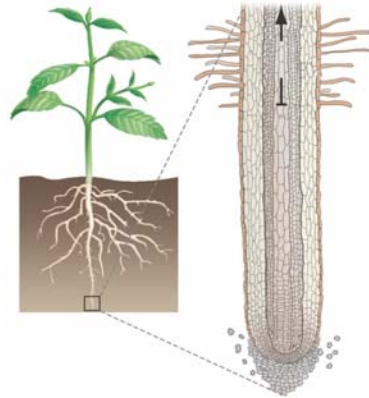
1

Video 39.3 Pollination of a  
night-blooming cactus by a  
bat



2

# Plant Nutrition



182 Bonine  
Spring 2009  
10 March  
(Freeman Ch38)

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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=ymlpQNYI6g&feature=related>



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- 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.

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## 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]

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**Experiment**

**Question:** Where does the mass of a growing plant come from?

**Hypothesis:** The mass of a growing plant comes from soil.

**Alternate hypothesis:** The mass of a growing plant comes from water.

**Experimental setup:**



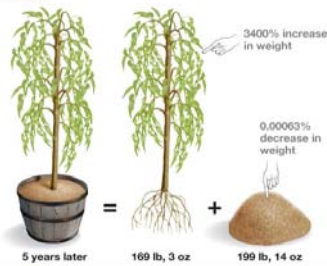
5-lb willow sapling + 200 lb soil = Day 1

1. Measure the weight of a willow sapling and a large amount of soil. 2. Plant the sapling and allow it to grow for 5 years.

**Prediction:** After 5 years, the soil mass will decrease by the same amount that the plant mass increased.

**Prediction of alternate hypothesis:** The soil mass will not decrease.

**Results:**



5 years later = 169 lb, 3 oz + 199 lb, 14 oz

3400% increase in weight

0.00003% decrease in weight

**Conclusion:** The mass of a growing plant comes from water. [Note: This conclusion was later found to be incorrect.]

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## Which Nutrients Are Essential?

- An essential **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.

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## Which Nutrients Are Essential?

- Classified based on whether from **water &/or carbon dioxide** versus from         .
- Essential nutrients available from  $H_2O$  or  $CO_2$  are  
They make up **96%** of the plant.
- Soil elements can be divided into **macronutrients** and **micronutrients**.

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- **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).

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## Which Nutrients Are Essential?

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

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## Which Nutrients Are Essential?

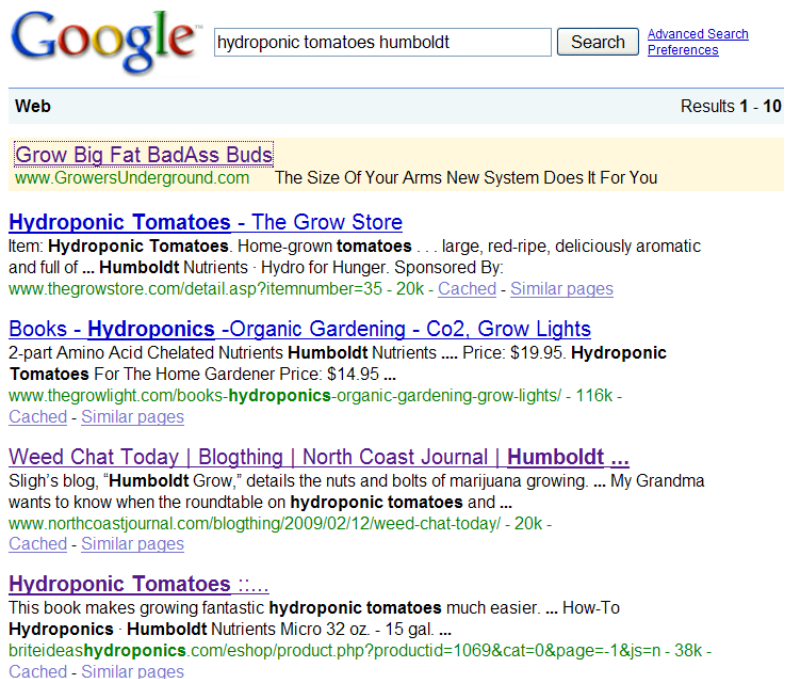
- **Micronutrients** are required in very **small quantities**. Rather than acting as components of macromolecules, they usually function as **cofactors** for specific enzymes. Examples include:
  - **iron, zinc, boron, copper, and nickel.**

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## nutritional deficiencies

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

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Web Results 1 - 10

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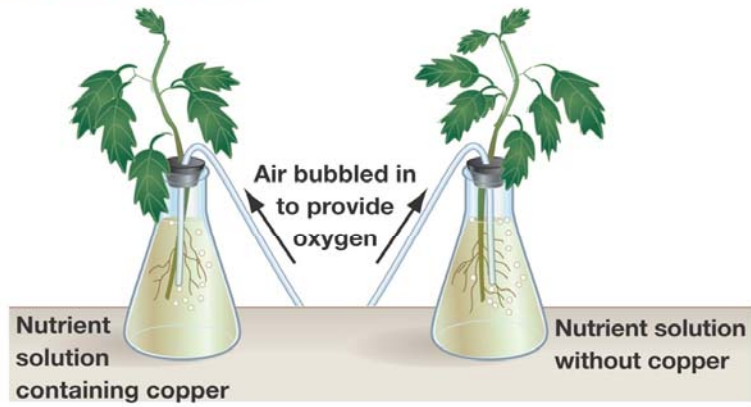
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Sligh's blog, "**Humboldt** Grow," details the nuts and bolts of marijuana growing. ... My Grandma wants to know when the roundtable on **hydroponic tomatoes** and ...  
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## Experiment

### Experimental setup:



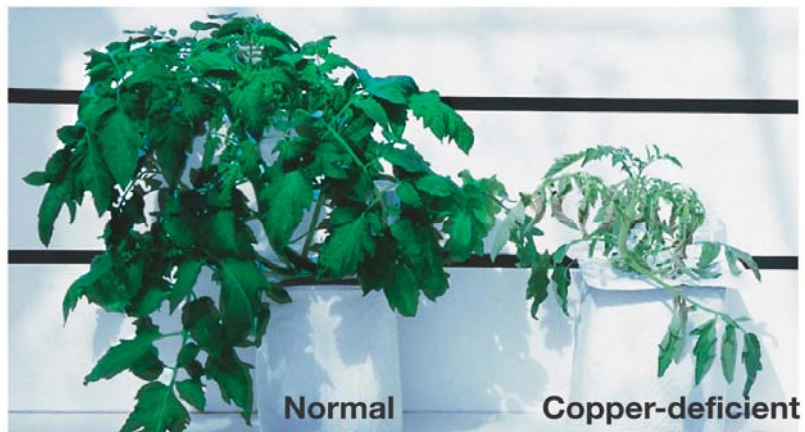
**Prediction:** The copper-deficient plant will grow less than the normal plant.

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

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## Experiment

### Results:

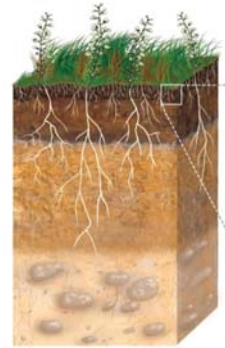


**Conclusion:** Copper deficiency leads to poor growth. All tissues appear to be affected adversely.



# Soil

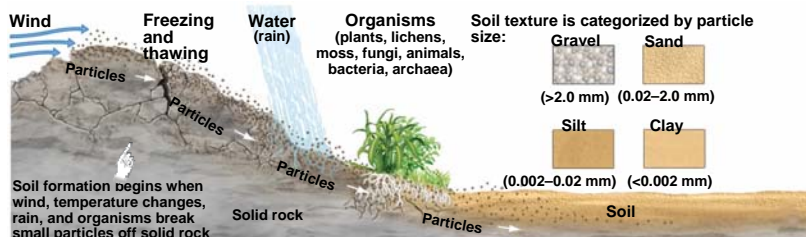
- **Weathering**—the forces applied by rain, running water, and wind—begins the process of building soil from solid rock.
- Particles derived from rocks are the first ingredient in soil. As organisms occupy the substrate, they add dead cells and tissues. This organic matter is called \_\_\_\_\_.



- Organic + Inorganic = Mature Soil

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## Soil Formation Begins with Erosion of Rock



Succession...

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## 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**.

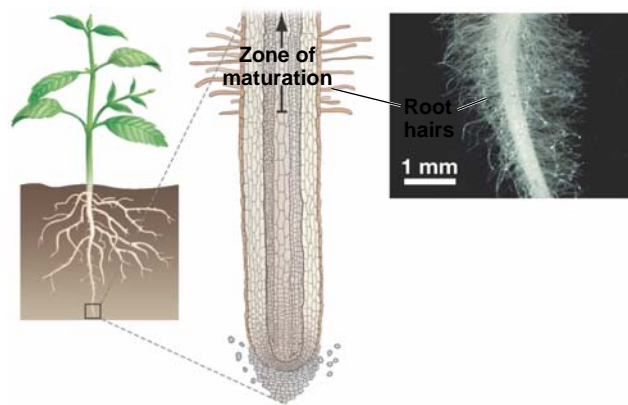
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## What Factors Affect Nutrient Availability?

- Soil pH can also influence the availability of essential elements. Soils can be **acidic** (low pH) or **alkaline** (high pH).

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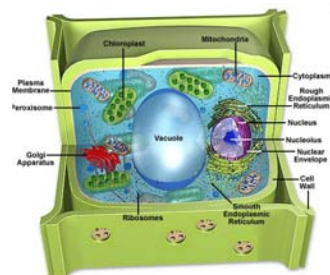
## Root Hairs Increase the Surface Area Available for Nutrient Absorption



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## 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.



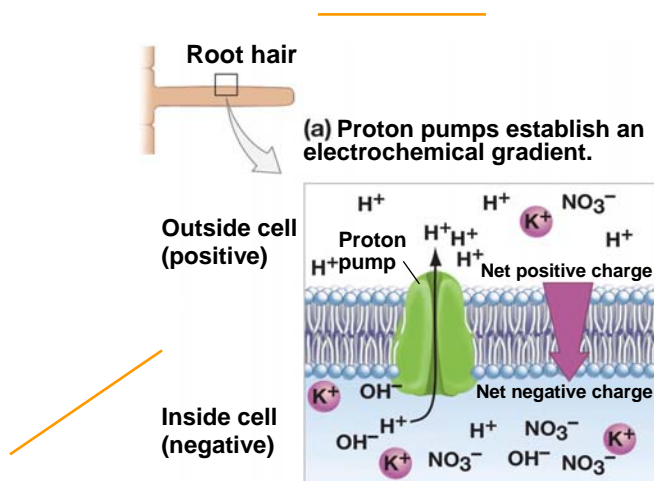
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# Establishing and Using a Proton Gradient

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

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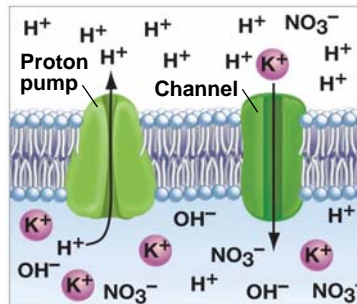
## Ions Enter Roots along Electrochemical Gradients Created by



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## Cations Enter Roots via \_\_\_\_\_

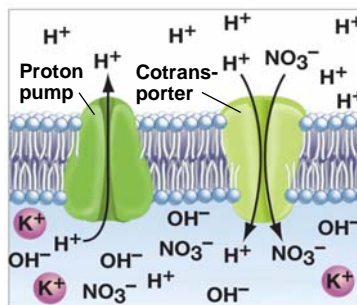
(b) Cations enter root hairs via channels.



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## Anions Enter Roots via \_\_\_\_\_

(c) Anions enter root hairs via cotransporters.

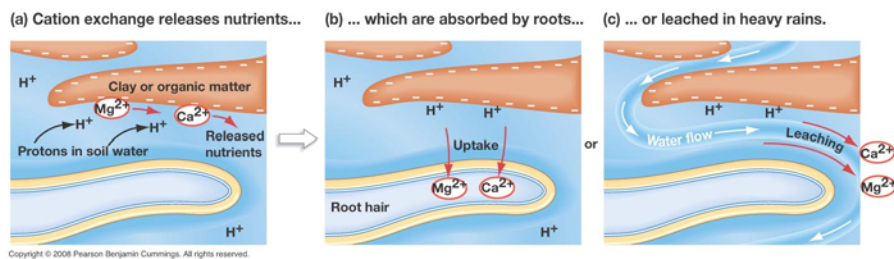


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## Cation vs Anion Nutrients

- **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.

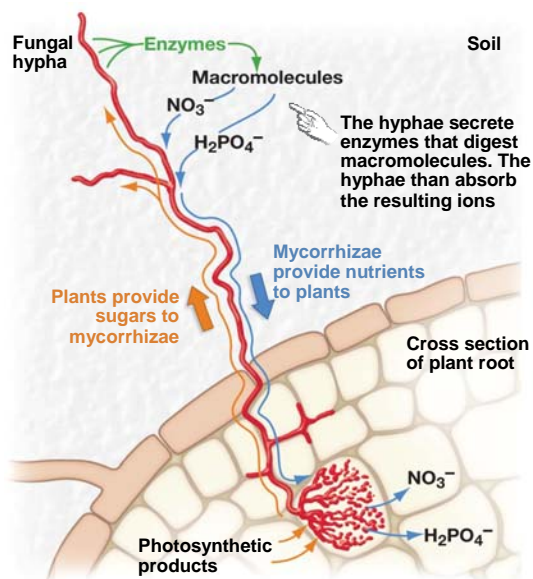
Plants facilitate by pumping  
 $H^+$  out of root hairs

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## 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 \_\_\_\_\_

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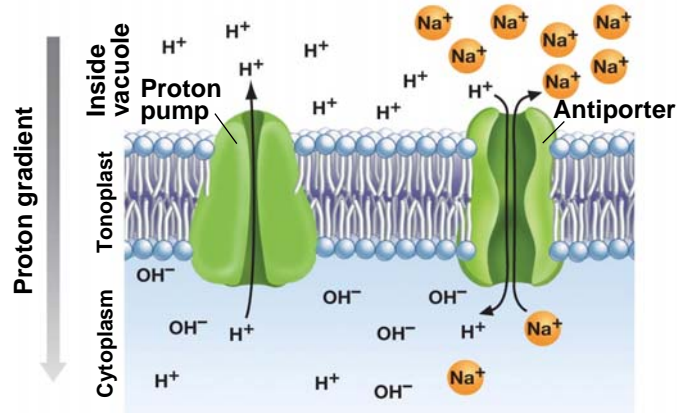
mycorrhizae provide \_\_\_\_\_ and/or \_\_\_\_\_ to the plants in exchange for sugar.

\_\_\_\_\_ mutualism

30

Not all soil ions are "good" for the plant  
 In Salt-Tolerant Plants, an \_\_\_\_\_  
 Concentrates Sodium in Vacuoles

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



31

cranberries

carnivores

peat

'mummies'

Why are these all found in the same habitat?

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

**BOGS**

32



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

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## 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** \_\_\_\_\_.

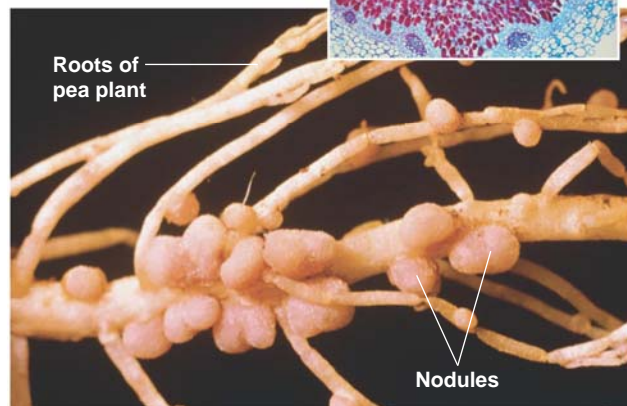
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# Nitrogen Fixation

- 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 \_\_\_\_\_ on the roots of legumes and provide the plant with
- **ammonia in return for sugar and protection**

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



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# 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) \_\_\_\_\_.

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## 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.

(b) Water-holding "tanks" formed by leaves of an epiphytic bromeliad



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# Epiphytes Are Adapted to Grow in the Absence of Soil

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



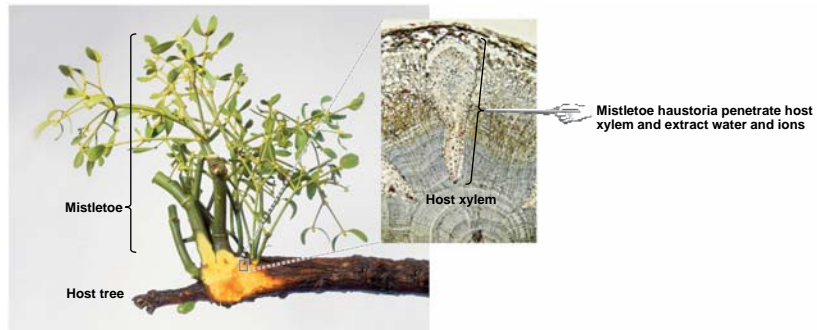
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## Parasitic Plants

- **Most** parasitic plants make their own sugars through            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

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# Some Plant Parasites Tap into the Xylem Tissue of Their Hosts



## Mistletoe

41



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## 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**            available in the environment, which is often lacking.

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Sundews Have Modified Leaves with  
a Sticky Surface That Catches  
Insects



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