



# Plant Biology and Forest Ecology

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How Plants and  
Forests Function



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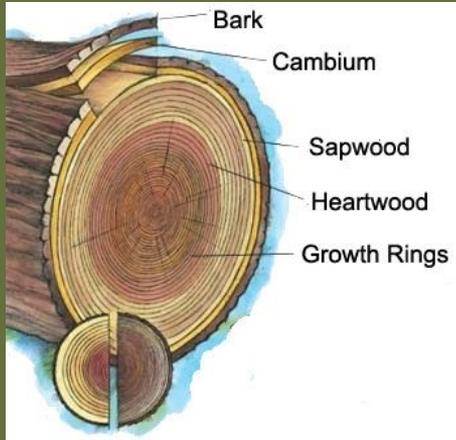
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Forests and Stands  
Forest Structure  
Succession  
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# Tree and Plant Anatomy



# General Tree Anatomy



## Leaves

Carry out photosynthesis and gas exchange

## Twigs

Support structure for leaves, flowers, fruit, and seeds that also transports nutrients and material between trunk and leaves

## Trunk/ Bole

**Bark:** protective layer

**Sapwood:** outer, living layer within trunk that transports water and nutrients

**Heartwood:** inner, dead core of the tree that provides structural support

## Roots

**Taproot:** large, dominant root growing directly downward that anchors the tree and takes up water and nutrient from deeper in the soil

**Structural roots:** provide mechanical support and anchor tree to the ground

**Feeder roots:** fine roots that absorb water and nutrients from the soil

Tree Anatomy Review:

<https://www.youtube.com/watch?v=QSZJyNBLBCI>

# Plant Tissues

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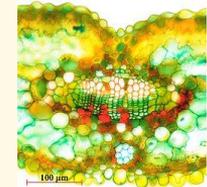
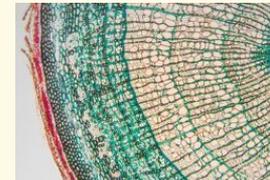
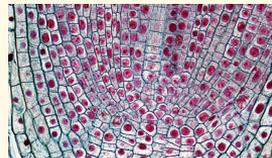
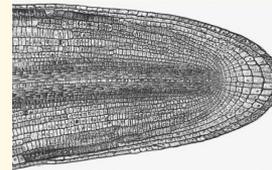
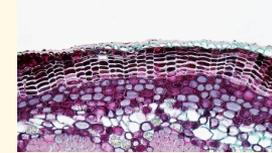
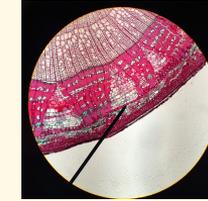
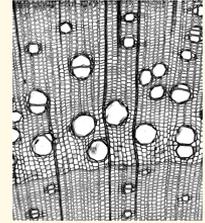
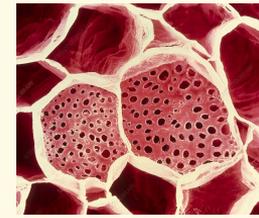
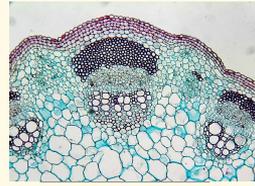
Similar to animals, plant cells that work together form tissues which work together form an organ system that performs a unique function.

Two organ systems in plants:

- Shoot System: mainly above ground parts of the plant. Involved in energy creation
- Root System: underground parts of the plant that absorb water and minerals, provide support, and store the products of photosynthesis

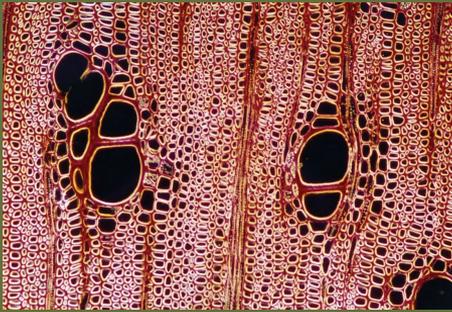
Plant Tissue Review:

<https://www.youtube.com/watch?v=gms6BrFl6mc>



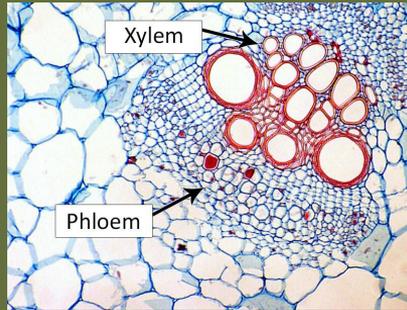
# Plant Transport Tissues

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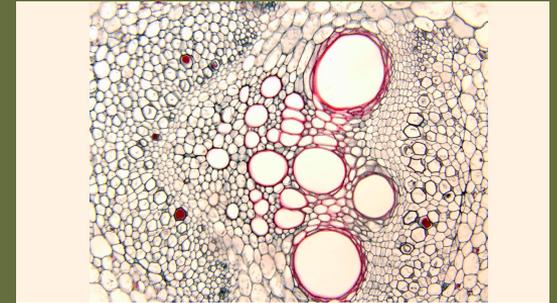
## Xylem

- Located in leaves, stem, and roots
- Moves water up from roots to other parts of the plant like stems and leaves
- Replaces lost water during transpiration and photosynthesis



## Phloem

- Located in leaves, stem, and roots
- Transports soluble organic compounds made during photosynthesis (particularly sugars) to the rest of the plant

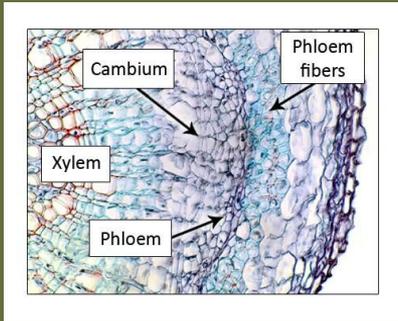


## Vascular Bundle

- Located in leaves, stem, and roots
- Bundle of tissues includes the xylem, phloem, and cambium
- Xylem is oriented towards the center of the stem or root and phloem is closer to the exterior

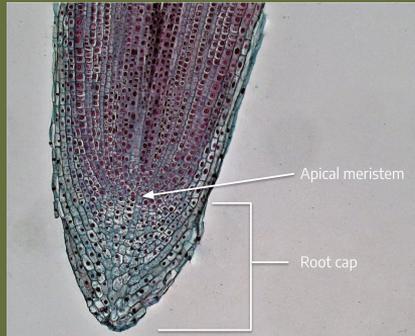
# Plant Growth Tissues

**Meristems:** structures composed of stem cells (known as meristematic cells) which are undifferentiated cells that are capable of continuous cellular division and play a key role in plant growth and regeneration



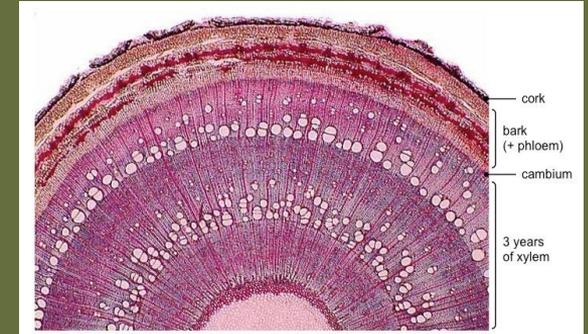
## Cambium

- Located in stems and roots
- Layer of actively dividing cells located between the xylem and the phloem
- Cells in the cambium divide to become secondary xylem cells toward the center of the stem and secondary phloem cells toward the outside of the stem



## Apical Meristem

- Located at tips of roots and shoots
- Give rise to primary growth or elongation of shoots and roots



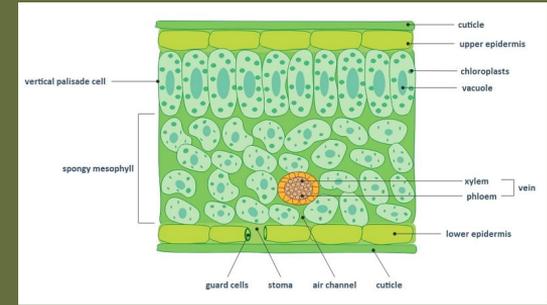
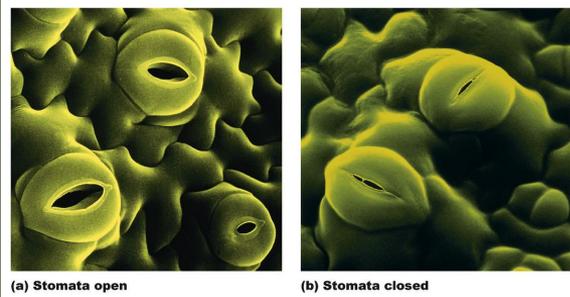
## Lateral Meristem

- Located on the lateral sides of stems and roots
- Responsible for increasing a plants girth or diameter
- Includes cambium

# Plant Leaf Tissues

## Cuticle

- Protecting, waxy film covering the outermost skin layer of leaves, young shoots, and other aerial plant organs (parts not embedded in soil or substrate) that are not covered with bark
- Functions:
  - Barrier preventing evaporation of water from epidermal surface
  - Prevents external water and solutes from entering tissues
  - Prevents contamination



## Stomata

- Microscopic openings or pores on the surface of leaves and young stems
- Allow gas exchange for photosynthesis and respiration
- Bordered by a pair of specialized guard cells (parenchyma cells) that regulate the size of the stomatal opening
- Most plants have open stomata during the daytime when air spaces in the leaf are saturated with water vapour (from transpiration)

# Plant Life Cycles



# Types of Plant Life Cycles



## Annuals

- Plants with a life cycle that lasts only one year.
  - Typically seeds are planted in the spring, the plant blooms in the summer, and then it dies off in the fall.
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## Biennials

- Plants with life cycles that take two years to complete.
  - They typically grow from seed in the spring and grow roots, stem, and leaves in the first year, go through a dormant period in the winter, flowers in the second summer, and produce seeds before dying off in the fall of the second year.
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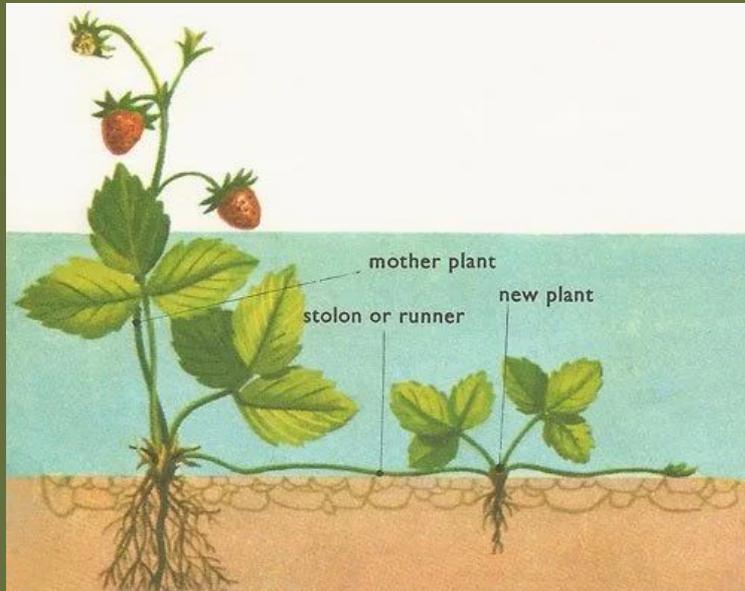
## Perennials

- Plants with life cycles that last more than two years.

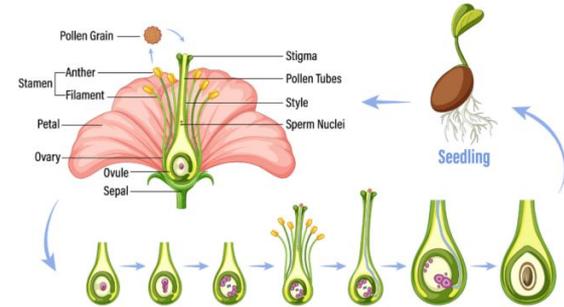
# Plant Life Cycles - Early Stages

Seed	Germination	Seedling	Growth
<p>Embryonic stage of the plant life cycle.</p> <p>Seed Parts:</p> <ul style="list-style-type: none"><li>• Embryo: tissues that will develop into stems, leaves, and roots of the plant</li><li>• Endosperm: storage organ for the embryo, contains starches and some fats and minerals for growth</li><li>• Seed Coat: hard tissue surrounding seed for protection</li></ul>	<p>Process by which a plant grows from a seed into a seedling.</p> <p>Seeds are dormant until conditions are favorable for germination. Once in proper conditions, water and oxygen are taken in through the seed coat and the embryo begins to grow.</p>	<p>Young plant that develops out of a seed.</p> <p>Seedling Parts:</p> <ul style="list-style-type: none"><li>• Radicle: embryonic root</li><li>• Hypocotyl: embryonic root</li><li>• Cotyledons: seed leaves</li></ul>	<p>Process driven by cell division and elongation in meristem tissues,</p> <p>Plants need sunlight, water and nutrients to grow,</p>

# Plant Life Cycles- Reproduction



## Sexual Reproduction in Plants



### Sexual

- two parents produce offspring by fusion of gametes which results in offspring that are genetically different from parents
- Involves pollination, fertilization, and seed and fruit formation

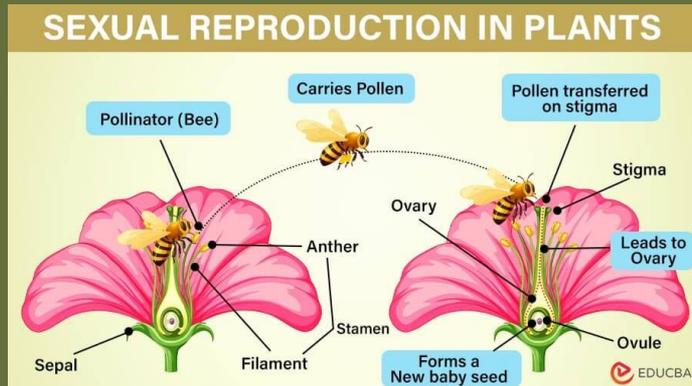
### Asexual

- Involves only one parent and producing clones
- Occurs through budding, fragmentation, spore formation, regeneration, and vegetative propagation

# Plant Reproduction - Angiosperms

Flowering plants that produce seed enclosed within an ovary that matures into a fruit

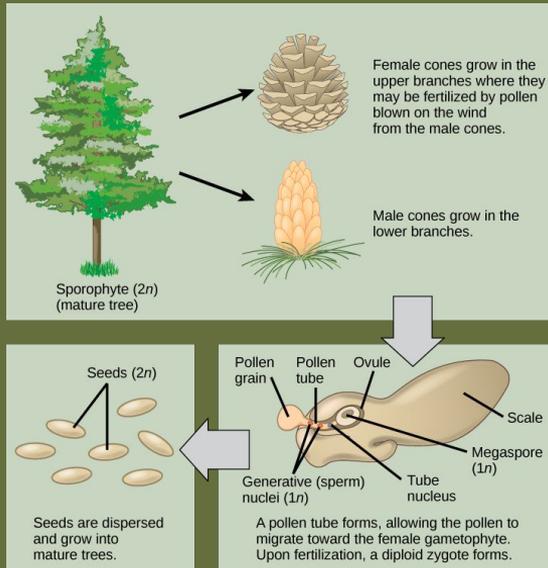
Includes: most herbaceous plants, shrubs, grasses, and most trees



# Plant Reproduction - Gymnosperms

Plants that produce seeds that are unprotected by an ovary or fruit.

Includes: Conifers (trees with cones), cycads, ginkgo

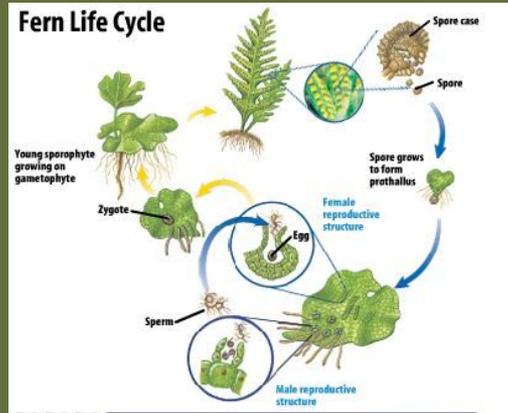


# Plant Reproduction - Pteridophytes and Bryophytes

Two plant groups that reproduce via spores (special reproductive cells).

**Pteridophytes** are vascular plants (have water and nutrient transport tissues) like ferns, horstales, and club mosses.

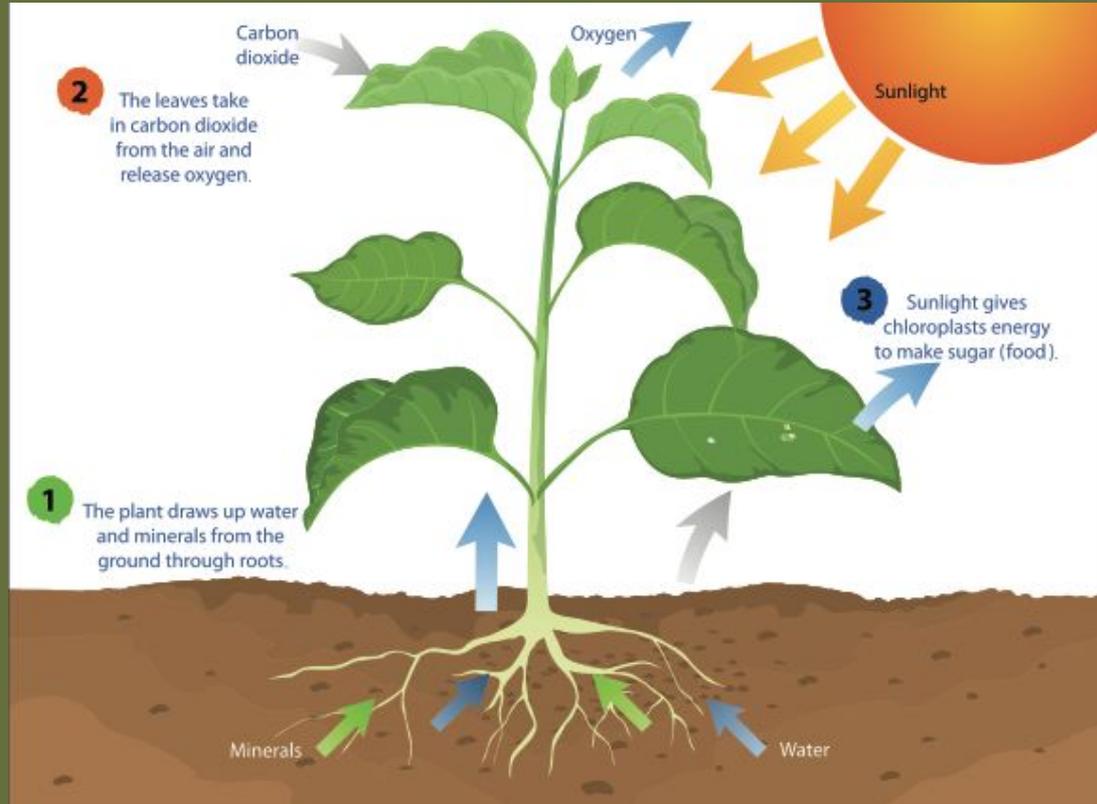
**Bryophytes** are small, non-vascular plants that absorb water and nutrients directly from their environment. They include mosses, liverworts, and hornworts.





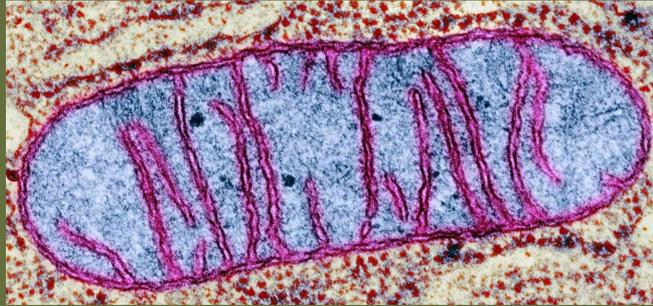
# Energy Creation - Photosynthesis

- Plants take in carbon dioxide, water, and light to produce glucose.
- Glucose (sugar) molecules contain covalent bonds that store energy.
- The process takes place in the leaves of a plant inside an organelle called a chloroplast.



Photosynthesis Chemical Equation:





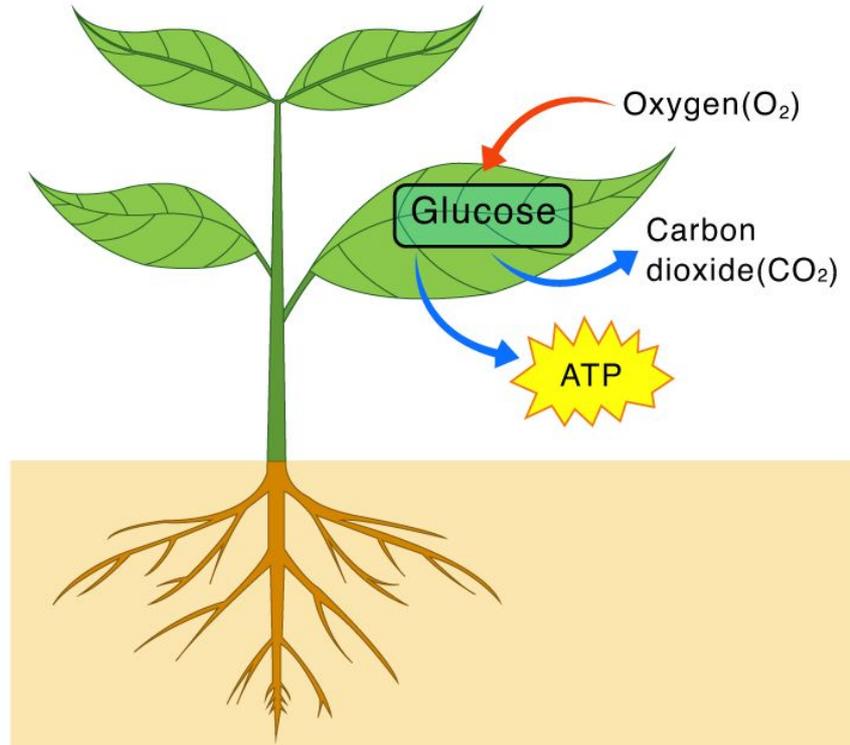
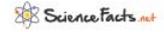
# Energy Use - Respiration

- The direct opposite of photosynthesis.
- Occurs so plant cells can use the glucose created during photosynthesis along with oxygen to create ATP.
- ATP provides necessary energy for various plant functions like growth and nutrient transport.
- This process occurs in the mitochondria.

Respiration Chemical Equation:



## Respiration in plants

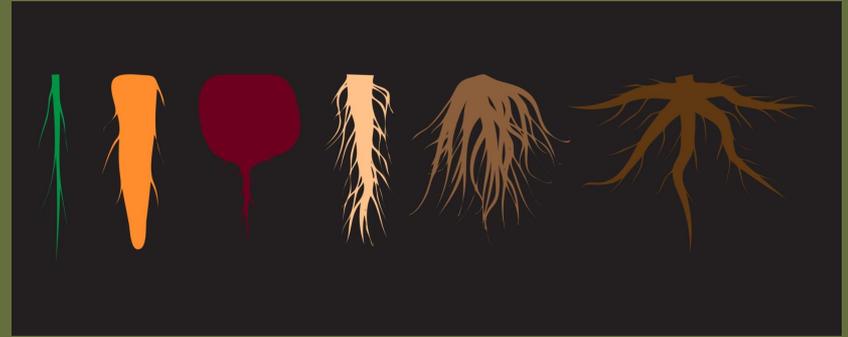


# Plant Growth - Plant Nutrients

- Must be broken down into their most basic forms in order to be used by plants.
- Enable plants to complete their life cycle through vital functions like photosynthesis, growth, and reproduction.
- Microorganisms and fungi aid plants in the process of breaking down nutrients and in taking in nutrients through the plants roots.
- All nutrients are taken up through its roots except for carbon which is absorbed through leaf stomata.

Plant Nutrition Video:

[https://www.youtube.com/watch?v=w\\_x-WDdQdxI](https://www.youtube.com/watch?v=w_x-WDdQdxI)



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**Primary Nutrients** - Usually required in large amounts

- Carbon, Hydrogen, Nitrogen, Oxygen, Phosphorus, Potassium

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**Secondary Nutrients** - needed in moderate amounts

- Calcium, Magnesium, Sulfur

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**Micro Nutrients**

- Boron, Chlorine, Copper, Iron, Manganese, Molybdenum, Zinc
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# Tree Groups and Terminology

## Deciduous

Trees that lose their leaves and become dormant in winter months

Example Trees: Maple, Oak, Aspen, Hickory, Cherry, Birch, Larch



## Evergreen

Trees that keep their leaves throughout the year

Example Trees: Pine, Spruce, Fir, Cedar, Hemlock



## Coniferous

Cone bearing trees

Example Trees: Pine, Spruce, Fir, Cedar, Larch



## Broad Leaf

Flowering trees with broad, flat leaves

Example Trees: Maple, Oak, Aspen, Hickory, Birch, Cherry



## Hardwood

Flowering trees that grow slowly with dense, durable, strong wood

Example Trees: Maple, Ash, Beech, Oak, Hickory, Cherry



## Softwood

Cone producing trees that grow relatively quickly and have less dense wood

Example Trees: Pine, Spruce, Fir, Cedar, Larch



# Forest Ecosystems



# Forest Terminology



## Forest

Large areas covered in trees and undergrowth, a collection of stands

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## Stand

contiguous group of trees with similar characteristics, such as age, species composition, or structure, that can be distinguished from the surrounding forest

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## Stand Species Composition

Species within a stand:

**Pure Stand:** at least 80% of the trees are of one species

**Mixed Stand:** less than 80% of the trees are of one species

# Forest Terminology



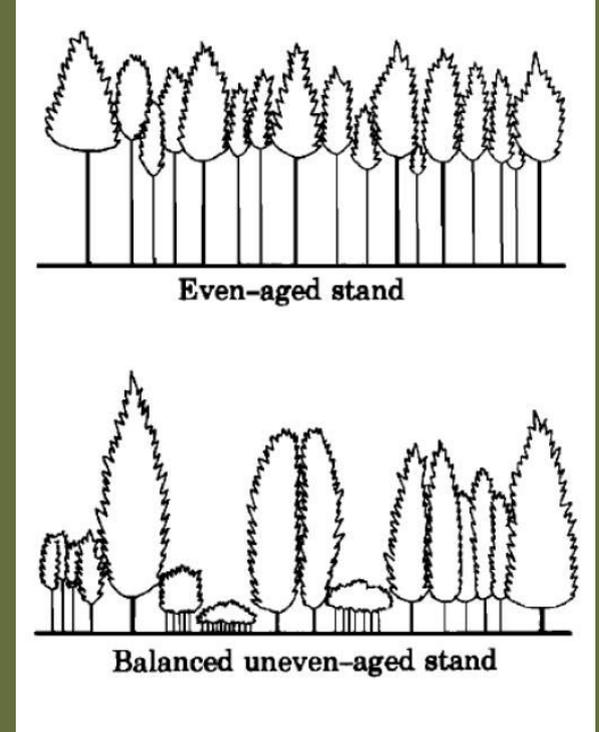
## Even-aged Stands

relatively small age difference between trees in stand



## Uneven-aged Stands

relatively large age differences between trees, and at least three ages are present



# Forest Structure

Trees are often classed based on crown position in the canopy. There are four categories:

## Dominant (D)

- Larger trees with crowns that extend above surrounding trees
- Receive full light from above and partially from the side

## Codominant (C)

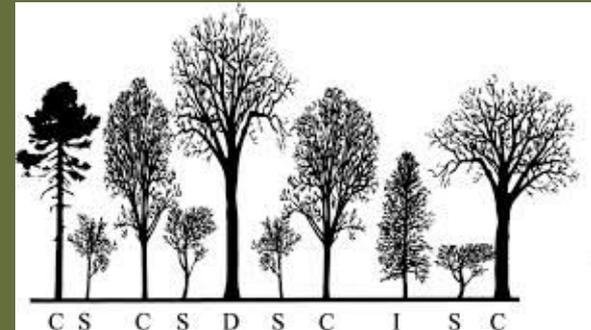
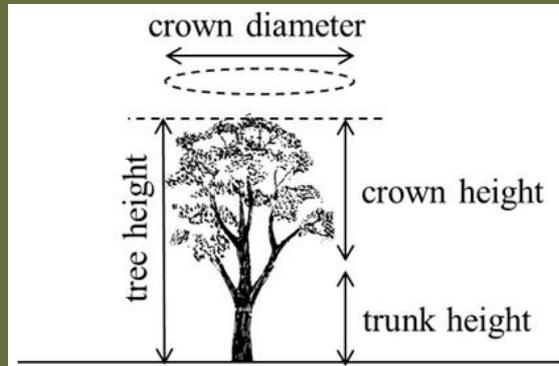
- Trees with crowns that mainly form the forest canopy
- Receive full light from above but little from the sides

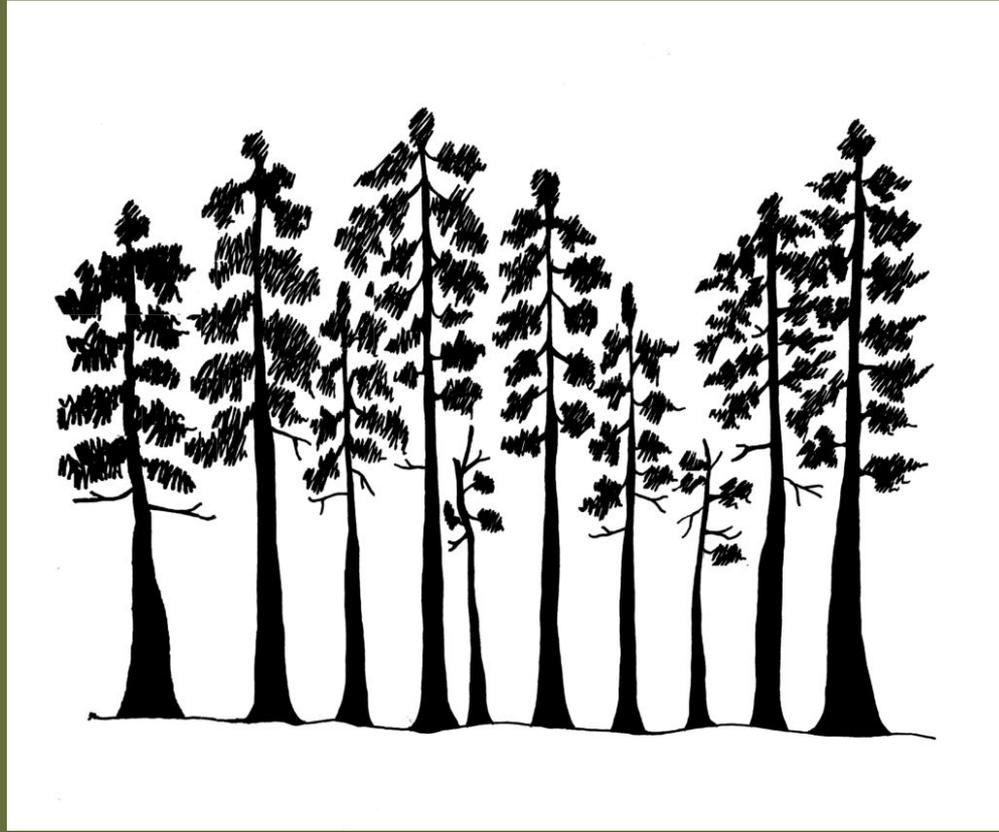
## Intermediate (I)

- Shorter trees whose crowns only reach slightly into or just below the canopy layer
- Receive only some light from above and none from the side

## Suppressed (S)

- Trees with crowns entirely below other trees crown cover
- Receive no direct light from above or the sides





# Crown Classes - Knowledge Test

# Forest Succession

The consecutive, predictable changes that occur in a forest ecosystem over time

## 1 Disturbance

- Beginning stage in the successional cycle
- Event in which a stand is mostly destroyed like a wildfire or logging event



## 2 Pioneer Stage

- Initial stage after disturbance
- Dominated by rapidly growing, sunlight loving plant species (pioneer species) like grasses, wildflowers, and shrubs



## 3 Early Succession

- Pioneer plants are replaced by fast growing, sun-loving trees like aspen, paper birch, and pine



## 4 Mid-Succession

- As the canopy of Early Successional trees begin to shade the forest floor, slower-growing, shade tolerant species like maple, beech, and hemlock begin to establish and outcompete other trees



## 5 Late (climax) Succession

- Shade dominant trees become the dominant trees and the forest reaches a relatively stable state



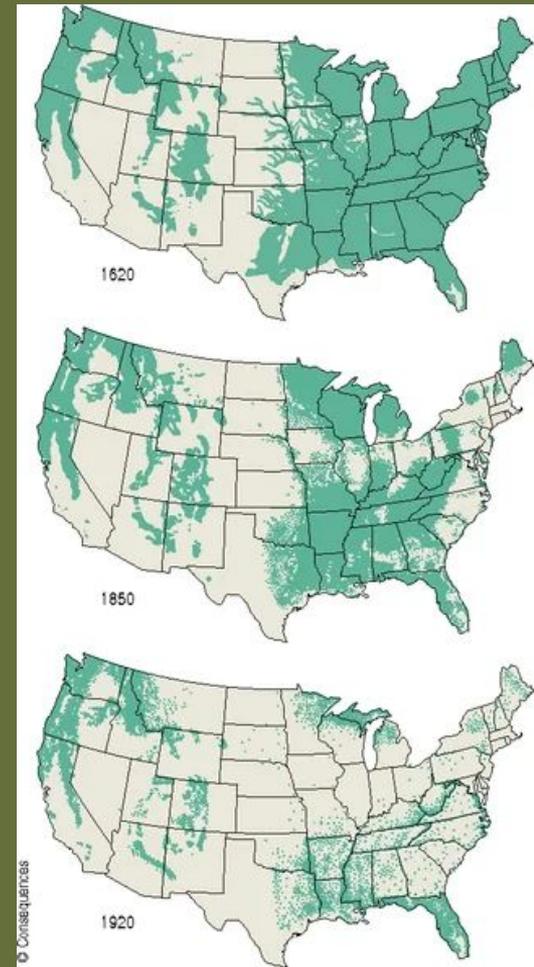
# Old Growth Forests

Forests that have developed over a long period of time without disturbance

Often characterized by large, old trees, multi-layered canopies, and abundance of dead wood

Significance:

- Biodiversity: Old growth forests tend to be areas of great biodiversity
- Ecosystem: Store more carbon than other forests
- These forests are rare, only 1% of Vermont's forests are considered old growth



Maps of undisturbed forests from 1620 to 1920

# Vermont Forests

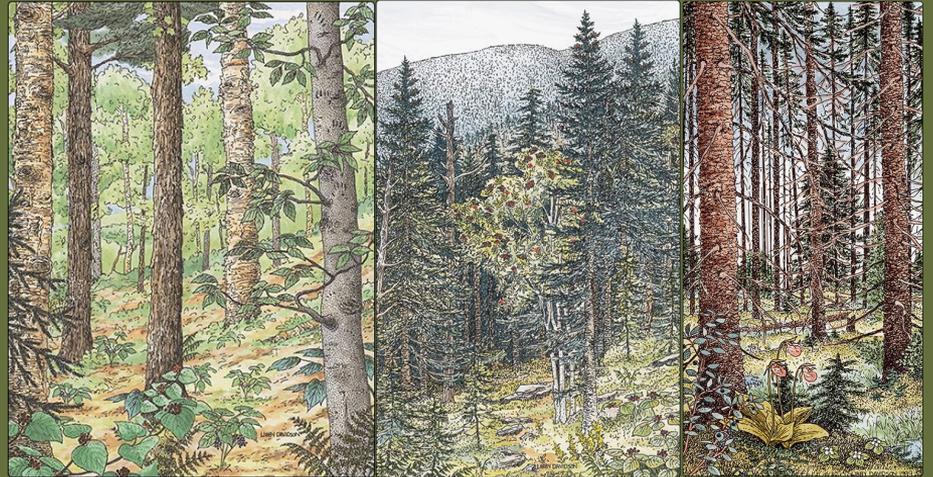
Vermont's Agency of Natural Resources classifies Vermont's forests into 97 wetland and upland natural community types.

Natural community types are based on the tree and plant communities present, soils, and wildlife habitat.

Broadly, these community types can be grouped within upland forests and forested wetlands.

Explore Vermont's Natural Communities:

<https://www.vtfishandwildlife.com/conservation-planning/natural-community-inventory/natural-community-fact-sheets>



# Vermont - Upland Forests

Water is present to support plant growth, but soils are not saturated. Trees are common to abundant.



## Spruce-Fir-Northern Hardwood Forests

Found in Vermont's coldest regions at higher elevations and in low, cold, moist areas. **Red spruce** and **balsam fir** often dominate the canopy. Warmer sites have a good number of hardwoods (**yellow birch**, **sugar maple**, and **beech**).

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## Northern Hardwood Forests

Found throughout the state, typically at Vermont's middle elevations. **Beech**, **sugar maple**, and **yellow birch** are prominent, and **hemlock**, **red oak**, **red maple**, and **white pine** are also common. **Red spruce** is only occasionally present.

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## Oak-Pine-Northern Hardwood Forest

Found mainly in the warmer regions of Vermont, often occurring as patches within Northern Hardwood Forests. **Sugar maple**, **beech**, and **yellow birch** are common, but warmer climate species like **red oak**, **shagbark hickory**, and **white oak** are also present in large numbers. **White pine** is also often present.

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# Vermont - Forested Wetlands

Trees cover more than 20% of the forest area. These are the most abundant wetland types in Vermont.



## Floodplain Forests

Found in river and lake floodplains. Typical dominant trees include **silver maple**, **cottonwood**, **black cherry**, and **sycamore**. **Balsam fir** and **white spruce** are also characteristic in floodplains in the northern areas of Vermont.

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## Hardwood Swamps

Dominated by broad-leaved deciduous trees but may still have some conifers. Common trees include **red maple**, **black ash**, **green ash**, **yellow birch**, **silver maple**, or **black gum**.

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## Softwood Swamps

Dominated by conifers, including **northern white cedar**, **red spruce**, **black spruce**, **balsam fir**, **tamarack**, and **hemlock**. Broad leaved deciduous trees may be present but are less abundant.

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# Forests and Water

Forests are critical to watersheds because they filter and store water and regulate the flow of runoff.

- **Flood Mitigation:** The forest floor absorbs and then slowly releases water, reducing runoff and flood risk
- **Groundwater Recharge:** Water that infiltrates into forest soils can help replenish underground aquifers
- **Erosion Control:** Tree and plant root systems hold soil in place, reducing erosion from stormwater runoff
- **Temperature Regulation:** Shade from forest trees and plants regulates water temperature, allowing for better habitat for aquatic organisms





[www.VACD.org/Envirothon](http://www.VACD.org/Envirothon)