Plant Classification, Structure, Growth and Hormones

- **Multicellular autotrophs** (organisms that use the energy of inorganic materials to produce organic materials)
- Utilize the energy of the sun, water and carbon dioxide (all inorganic) to manufacture carbohydrates (organic) through photosynthesis

**Plant Classification - let’s break it down…**

**Tracheophytes vs. Nontracheophytes**
- Nontracheophytes lack vascular tissue
- Examples of nontracheophytes are mosses
- Tracheophytes are plants that have vascular tissue for fluid transport.
- Examples of tracheophytes are pines, ferns and flowering plants (almost all plants except mosses)
- Tracheophytes may be further broken down into…

**Seed plants vs. Seedless plants**
- Seedless plants include ferns
- Seedless plants use spores to reproduce
- Seed plants may be further broken down into…

**Gymnosperms vs. Angiosperms**

**Gymnosperms**
- Non-flowering plants
- Examples are pines, firs and redwoods
- Were the first plants to evolve the use of the seed in reproduction

**Reproduction in Gymnosperms**
- Have cones that are involved in reproduction, one cone that produces male spores (released as pollen) and one that produces female spores (enclosed in eggs)
- Pollen reaches the female cones and the eggs are fertilized, producing seeds
- The seeds are not enclosed in a fruit and may fall to the ground when released by the female cone

**Angiosperms**
- Flowering plants
- Presently, angiosperms are the dominant land plants (once ferns were, proceeded by gymnosperms, and now angiosperms)
- Angiosperms may be divided into monocots and dicots

<table>
<thead>
<tr>
<th>Monocot</th>
<th>Dicot</th>
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</thead>
<tbody>
<tr>
<td>One cotyledon (seed leaf)</td>
<td>Two cotyledons</td>
</tr>
<tr>
<td>Parallel veins</td>
<td>Netted veins</td>
</tr>
<tr>
<td>Tapering blade</td>
<td>Expanded blade</td>
</tr>
<tr>
<td>Sheath encircles stem</td>
<td>Petiole</td>
</tr>
<tr>
<td>Floral parts in 3’s</td>
<td>Floral parts in 4’sa and 5’s</td>
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<td>-------------------</td>
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<tr>
<td>Scattered vascular bundles</td>
<td>Vascular bundles in a circle</td>
</tr>
<tr>
<td>Fibrous root system</td>
<td>Taproot system</td>
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</tbody>
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**Plant Structure**

1. **Stem**
   - The stem allows for the transport of water and nutrients through vascular tissue and provides support against gravity.
   - The transport of water and nutrients in plants is known as **translocation**.
   - **Fibrovascular bundles** run up and down the stem and contain the **xylem**, the **phloem** and the **cambium**.
   - The phloem is found on the outside of the vascular bundle, and the xylem is found in the center. The cambium is located between the phloem and the xylem.

**The Xylem**

- The xylem is found at the center of the fibrovascular bundles in the stem.
- The xylem consists of long, thick-walled, dead cells. **Tracheids** and **vessel cells** are the xylem cells responsible specifically for water transport.
- The thick walls of these cells give the plant rigid support.
- The xylem carries **WATER** and **MINERALS UP** from roots to rest of plant.
- You may ask yourself, how does water travel up the plant stem against gravity? This is accomplished by:
  1. **Transpiration Pull and Cohesion** – the water in the xylem forms a long, continuous column because the molecules are held together by cohesion. As water evaporates from the leaves by transpiration, a vacuum is created and the water column is pulled upward as more water enters from the roots.
  2. **Root Pressure** – pressure exerted by water entering the root hairs.
  3. **Capillary Action** – the rise of any liquid in a thin tube because of surface tension.

**Phloem**

- The phloem is found on the outside of the fibrovascular bundles.
- It consists of live, thin-walled, tube-shaped **sieve cells** (which are responsible for carrying out transport but lack nuclei) and **companion cells** (which have nuclei and assist in directing the sieve cells’ activities).
- The phloem is responsible for transporting **NUTRIENTS** manufactured by photosynthesis **DOWN** from the leaves to the rest of the plant.

**Meristem**

- Meristem cells are undifferentiated cells that undergo active cell reproduction and eventually elongate and differentiate into cell types.
- There are two main types of meristem tissue: **Lateral Meristem** or **Cambium** and **Apical Meristem**.
**Cambium or Lateral Meristem**
- Cambium is undifferentiated tissue that is located within the fibrovascular bundles between the xylem and phloem (note that it is not an active tissue in monocots or herbaceous dicots)
- It consists of actively dividing cells which differentiate into xylem cells, phloem cells and more cambium cells
- The cambium is responsible for **lateral growth**, or growth in the width of the stem or trunk

**Apical Meristem**
- Apical Meristem consists of undifferentiated cells found at growing tips of stems and roots
- It is responsible for growth in length which occurs only at root and stem tips

**Pith**
- Pith cells are found either in the center of the stem or are scattered throughout the stem as rays (columns) of cells
- Pith cells are large, thin-walled cells and they serve to store food for the plant

**Epidermis of the Stem**
- The epidermis is the outside layer of cells in a plant
- The epidermis of the stem consists of thick-walled cells and prevents water loss and protects the underlying plant tissues from injury
- In woody stems (such as tree trunks) the epidermis is known as **bark**
- Stems have openings called **lenticels** which allow for the exchange of gases through the stem

**Green Cells**
- Green cells are found in the stems of young plants
- They contain chloroplasts and are thus responsible for carrying out photosynthesis

2. **Root**
- The roots of a plant absorb minerals and water from the soil and anchor the plant to the soil
- The root contains xylem cells (so that minerals and water may be transported from the roots up to the rest of the plant) and phloem cells (so that nutrients produced in the leaves may be transported to the roots for usage or storage)
- Root tissue may also play a role in food storage

**Apical Meristem**
- As mentioned before, apical meristem cells are found in the **root tip** which is constantly growing and pushing through the soil
- Just behind the root tip is a region that elongates considerably and is the most rapidly growing part of the root
- The **root cap** covers the growing root tip and protects it as it pushes through the soil
**Epidermis**
- The epidermis of the root is soft and thin to permit the absorption of water and minerals from the soil.
- Cells of the epidermis produce projections called **root hairs** which are thin-walled, single cells with large vacuoles.
- The root hairs serve to:
  1. **Increase the surface area in the root for absorption** - as a matter of fact most of the water and minerals absorbed by the roots is taken in through the root hairs.
  2. **Anchor the roots to the soil** – root hairs adhere to nearby soil particles, helping to anchor the plant in the soil.
- Root hairs are essential for the absorption of **soil water** (water in the ground containing minerals).
- Soil water enters the root hairs by active transport and diffusion. Diffusion of soil water into the root hairs occurs because there is a higher concentration of water and minerals in the soil than in the root hairs (remember – substances diffuse along their concentration gradient, from high concentration to low concentration).
- Once it has entered the root hairs, the soil water continues to diffuse along its concentration gradient from one cell to the next, eventually diffusing into xylem cells which transport it around the plant.

**Leaf**
- Leaves are the primary site of photosynthesis in plants.

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**Epidermis**
- A leaf has both an **upper epidermis** (top, outermost layer of the leaf) and a **lower epidermis** (bottom, outermost layer of the leaf).
- The epidermis is made up of a layer cells whose thickened walls contain a waxy substance that is called **cutin**. Cutin forms the **waxy cuticle** on the leaf’s surface that conserves water.
- Tiny openings called **stomates** are found only on the leaf’s lower epidermis (**NOTE**: the upper epidermis does not have any openings. This is adaptation which allows the plant to conserve water).
- The stomates allow for the exchange of oxygen and carbon dioxide between the plant and the atmosphere and also permit the evaporation of water vapor out of the leaves in a process known as **transpiration**.
- In transpiration, water, which reaches the leaves through the xylem in the veins, diffuses out of the veins into spongy layer cells. The water then evaporates into air spaces in the **spongy layer** of the leaf and diffuses out of the stomates.
- Two **guard cells** surrounding each stomate and regulate the size of the stomate opening.
- When water is lost by transpiration more quickly than it is absorbed by the roots, the leaf will wilt. As a result the guard cells close, reducing the amount of water lost through transpiration.
**Palisade Layer**
- The palisade layer is located just below the upper epidermis
- It is made up of column-like, long cells that contain many chloroplasts
- The main function of the palisade layer is to carry out photosynthesis (notice how palisade cells are rich in chloroplasts and are located near to the top of the leaf where they will receive a lot of sunlight)
- Between palisade cells there are small air spaces that are connected to the larger air spaces of the *spongy layer* which are in turn connected to the stomates. These air spaces allow carbon dioxide to diffuse in and oxygen to diffuse out of the palisade layer.

**Spongy Layer**
- The spongy layer is located below the palisade layer
- It is made up of loosely packed cells surrounded by large air spaces which are connected to the stomates
- Air passes through the stomates, into the air spaces between the spongy layer cells and into the air spaces in the palisade layer where carbon dioxide is absorbed for photosynthesis. Oxygen diffuses from the palisade layer cells into the surrounding air spaces, into the spongy layer air spaces and finally out of the stomates.
- Transpiration keeps the spongy layer cells moist, facilitating their role in gas exchange (remember that all surfaces involved in gas exchange must be moist)
- The spongy layer cells are not as active in photosynthesis as are the palisade layer cells (notice how they are located further from the top of leaf and therefore receive less sunlight and do not contain nearly as many chloroplasts)

**Veins**
- Veins run through the spongy layer of the leaf
- The veins contain the fibrovascular bundles which include xylem and phloem cells. The xylem cells provide the leaf with water for photosynthesis and the phloem cells absorb the nutrients produced in photosynthesis in the leaf and transport them throughout the plant.
- Veins also provide support for the leaf

**Plant Growth**
- **Apical Growth** – growth in length of the plant (occurs at the stem tips and roots for example)
- **Lateral Growth** – growth in width of the plant (occurs in the stem or trunk of the plant)
- **Tropisms** - growth of an organism towards or away from an external stimulus
  - **Positive Tropism** – growth toward a stimulus
  - **Negative Tropism** – growth away from a stimulus
  - **Phototropism** – growth toward light
  - **Negative Geotropism** – growth away from gravity (against gravity)
  - **Positive Geotropism** – growth toward gravity
**Hydrotropism** – growth toward water

**Thigmotropism** – growth in response to contact. A grape vine shows thigmotropism as it responds to contact with its supporting stick by growing up around the stick

**Plant Hormones**

- The regulation of plant growth is largely accomplished by hormones
- These hormones are produced in abundance by actively growing parts of the plant such as the apical meristem in roots and stems, young leaves and developing seeds

1. *Auxins*
   - *Auxins* are growth hormones produced in the plant’s growing tips that cause cells to elongate
   - Auxins stimulate the production of new xylem cells from the cambium
   - Auxins are the hormones associated with tropisms
   - **Auxins and Phototropism** – when light strikes the tip of a plant from one side, the auxin supply on that side is reduced. Therefore the cells of the shaded side of the plant will elongate more rapidly than the cells on the side of the plant exposed to light, causing the plant to grow towards the light source.
   - **Auxins and Negative Geotropism** – if a plant is turned on its side (so that it is horizontal to the ground) it will eventually turn upward. This occurs because gravity causes auxins to accumulate on the lower side of the stem, while auxins on the upper side decrease. This stimulates the cells on the lower side to elongate faster, causing the shoot to turn upward.
   - **Auxins and Positive Geotropisms** – roots exhibit positive geotropism. Auxin accumulates in the elongation region of the root tip where root growth is most active. In the case of a plant turned on its side (so that it is horizontal to the ground) the auxins that accumulate on the lower side of the plant inhibit growth, thus the upper side elongates more rapidly and the roots turn downward.

2. *Gibberellins*
   - Stimulate rapid stem elongation
   - Stimulate the production of new phloem cells from the cambium
   - Terminate the dormancy of seeds and buds

3. *Ethylene*
   - Stimulates the ripening of fruit and induces aging

4. *Cytokinins*
   - Promote cell division
   - Stimulate growth in roots, stems, leaves and buds
   - Break seed dormancy
   - Stimulate leaves to expand
5. Inhibitors

- Some inhibitors are very important in the maintenance of dormancy during autumn and winter. However, they break down gradually over time so that the buds and seeds can become active during the growing season.
- Many inhibitors are reversed by auxins, gibberellins or cytokinins
- Antiauxin – regulates the activity of auxin