KANSAS MASTER NATURALIST PROGRAM

BOTANY: PLANTS

CHAPTER GOALS

- Describe the major differences between plants and animals.
- Describe how plants are classified and named scientifically.
- Explain the function of the basic plant structures: roots, stems, leaves, buds, flowers, fruit, & seeds.
- Explain the processes of photosynthesis, respiration and transpiration.
- Discuss the environmental factors that affect plant growth; light, water & temperature.

A. Plant Characteristics

Plants have inhabited earth for hundreds of millions of years and are the foundation of the earth's food chain. The study of plants is termed **Botany**.

Plants convert energy from the sun into carbohydrates through the process known as **photosynthesis**. Because animals are not capable of the same process, to survive they must eat plants or other animals that have vegetarian diets. Likewise, plants release oxygen for animals to breathe.

There are three major differences between plants and animals:

- Plants use pigment (chlorophyll) to allow them to make their own food through photosynthesis.
- Plant cells are surrounded by cell walls made out of cellulose ("fiber").
- Plants are generally rooted ("sessile") and do not move from place to place on their own.

B. Plant Classification

In order to study the millions of different organisms living on earth, biologists have classified organisms since the time of Aristotle (384-322 B.C.). Carolus Linneaus (Swedish botanist active in the mid-1700's) developed the system of classification we use today – **taxonomy**. Taxonomy places similar organisms into a common group, or "taxa". Life is organized in groups that become increasingly more specific, like nesting boxes. These are the taxonomic categories:

- Kingdom
  - Phylum or Division (for plants)
    - Class
      - Order
        - Family
          - Genus
            - Species

Linneaus suggested using Latin as the language of taxonomy since most of the educated people already knew it and it was a dead language and wouldn't change over time. The kingdom is the most basic taxonomic category and all plants are included in one kingdom - Kingdom Plantae.

1. The Five Kingdoms of Life:

Monera - bacteria including cyanobacteria, once called blue-green algae
Protista – simple organisms that aren't plants, or animals - including algae, seaweed, amoeba, and paramecia
Fungi - non-mobile and spore-bearing, but not photosynthetic
Plants - mainly terrestrial, possessing cell walls, and capable of photosynthesis
Animals – mobile, heterotrophic organisms whose cells are not surrounded by cell walls

2. The Binomial Name

Every different species has a scientific name composed of two parts – the "binomial name". The scientific binomial consists of the *Genus* and *species*. Some scientific names are familiar, like *Aloe vera*, while others are obscure: *Quercus macrocarpus*.

Scientific names provide one with information – all organisms with the same Genus are closely related. Organisms that look alike but have different Genus names will not be closely related. The latin name also provides a description – "macrocarpus" means literally "large (marcro) fruit (carpus)" .

All scientific names should be written in a specific way – both names are italicized (or underlined if hand-written) and the Genus name always has the first initial capitalized. Some common examples:

Homo sapiens
Canis lupus (Gray wolf)
Canis latrans (Coyote)
Odocoileus virginianus (White-tailed deer)
Odocoileus hemionus (Mule deer)
Ginkgo biloba
Echinacea purpurea (Purple coneflower)

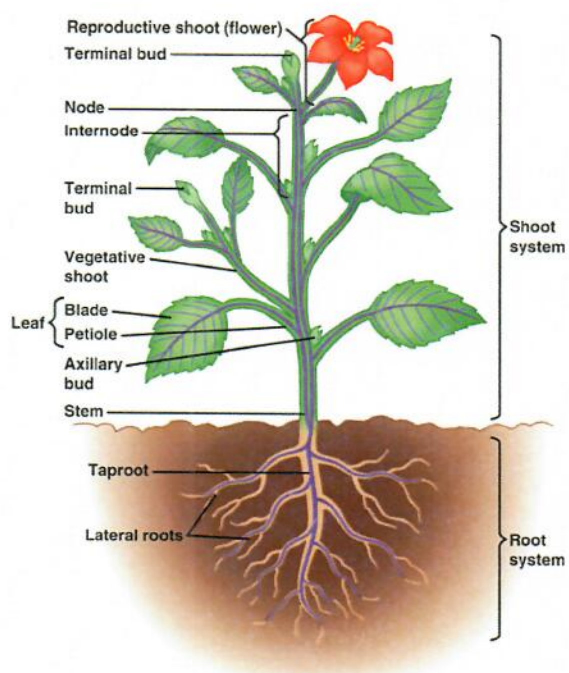
Learning the scientific names of plants can be a lot of fun. After working with these names awhile, you will begin to recognize certain prefixes, suffixes, and word roots and be able to identify plants by physical characteristics that match their names.

C. Basic Botany

In order to gain a working knowledge of horticulture, it is necessary to understand the structure and function of plants and the environmental factors that affect plant growth. In the greatly diversified kingdom of plants, all flowering plants have certain structures and functions in common.

The basic parts of a plant are:

Roots
Stems
Leaves
Flowers
Fruit



1. Roots

Functions of the root system:

- **Absorption** = roots absorb water and nutrients from the soil. Water is essential to deliver materials throughout a plant and providing internal pressure to hold the plant upright.
- **Anchorage** = roots help hold the plant down, they grow down through the soil
- **Storage** = roots store excess starch and water

Note that roots do not typically contain pigment and do not accomplish photosynthesis. They do contain actively-growing cells which need energy. Therefore, root cells need sugar to be delivered from the photosynthesizing cells of the leaves.

(A.) Taproot System

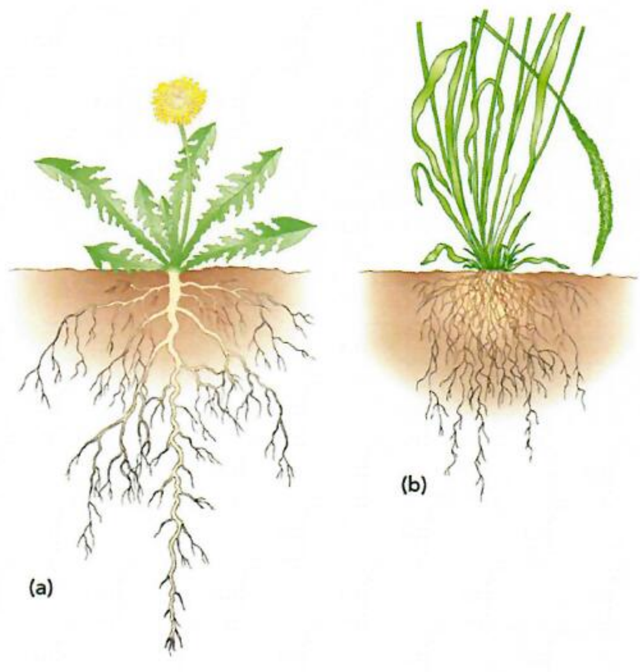
Broadleaf plants (also known as **dicots**) like trees and wildflowers have root systems that typically have a central large root – a taproot (a). These taproots may reach deep into the soil to access groundwater. However, it may take months or years for the taproot to grow deep enough to reach the water and it needs to survive that period. Once underground water is reached, the survival of the plant is much more strongly assured.

A **lateral**, or secondary, root is a side or branch root which arises from another root. Lateral roots provide a greater surface area for absorption and increase the ability of the root to anchor the plant.

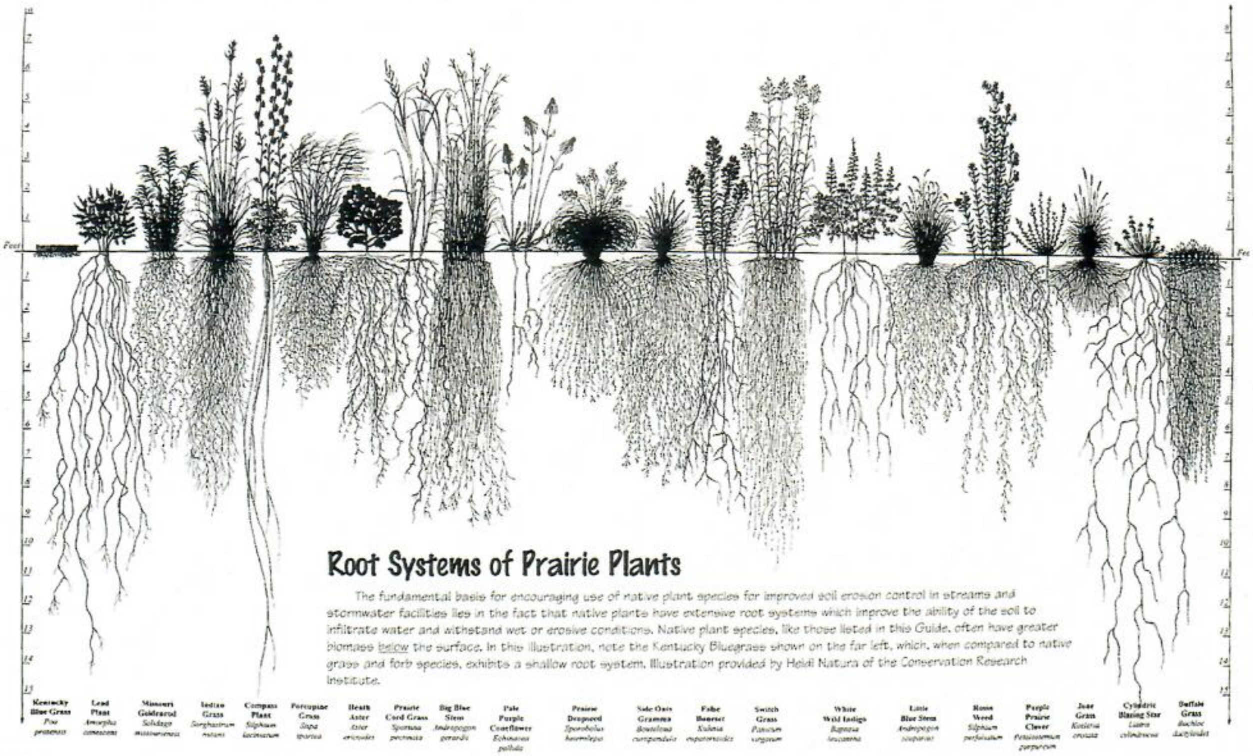
(B.) Fibrous Root System

A **fibrous** root system (b) is made up of many shallow roots of similar size. Fibrous roots are typically found in grassy plants – also known as monocots. The many shallow roots can quickly and easily absorb water from the intermittent rain events typically occurring in a prairie biome.

During long periods of drought, these plants can go dormant, greatly reducing their water consumption but keeping their root systems alive. When water does return to the prairie, the sponge-like fibrous roots very efficiently absorb the available water. In a prairie, fibrous roots vastly out-compete the taproot system of the broadleaf plants. This is why grasses dominate the prairie rather than trees.



Roots of many prairie grasses are fibrous and deep-rooted. This allows them to reach deep groundwater and spread out like a sponge just below the surface. They have amazing abilities to survive in a difficult climate.



2. Stems

Functions of stem:

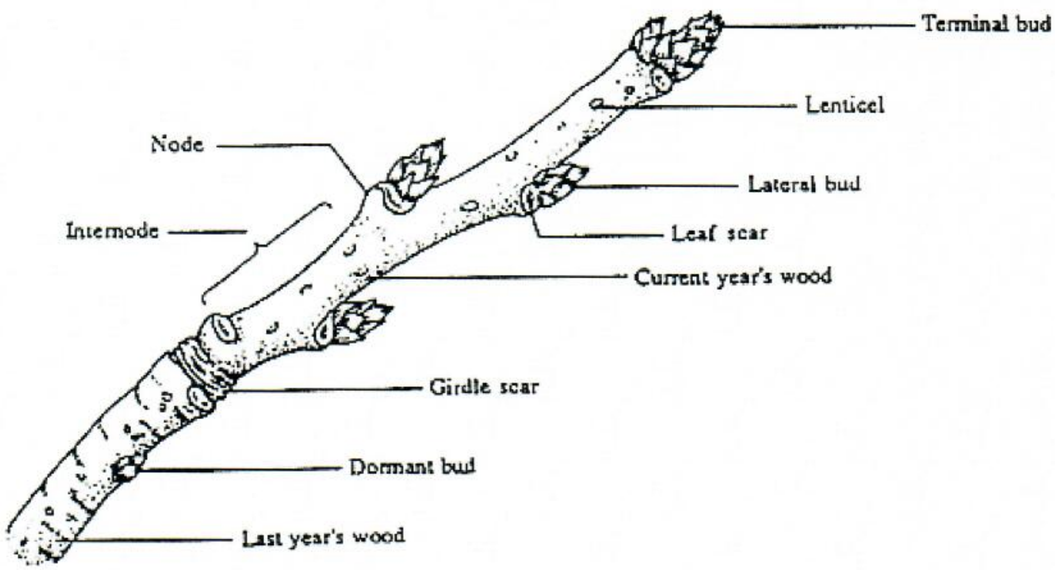
- **Attachment** = not all plants have stems, but those that do use stems to get their leaves up towards the sun. Hopefully, the height of the plant is able to overshadow their competitors.
- **Conduction** = stems use internal tubes to conduct water up from the roots to the leaves (tubes that do this = **xylem**) and to conduct sugar from the leaves to the roots (tubes that do this = **phloem**).
- **Protection** = many stems are thick and hardy and serve to protect plants, especially perennials (plants that live for several to many years). The plant with the hardiest stems are trees with bark.
- **Storage** = some stems are modified to store the two basic things that plants need: water and starch. Examples of storage stems = rhizomes (iris) and tubers (potatoes).

(A.) Stem types

Herbaceous stems = green, new stems that are soft and pliable. Grassy plants (monocots) only have herbaceous stems. Broadleaf plants (dicots) will have herbaceous stems for the first season of growth. If the broadleaf plant is a perennial, the stem will gradually get layers of protective cells that build up along the outside surface, called bark.

Woody stems = older stems of broadleaf plants (dicots) will possess bark and become woody. No monocots (grassy plants) will ever have bark. Broadleaf plants are the source of wood that is essential for many human industries such as construction, furniture, flooring, and paper.

(B.) Stem anatomy



Basic stem regions:

1. **Node** = That region on a stem where buds are located.
    2. **Buds** = Regions of growth on a stem. There are two basic kinds of buds
        a. **Leaf bud** = a small cluster of tissue that will eventually develop into a new leaf. Located at a node on a stem.
        b. **Terminal bud** = a cluster of tissue that grows rapidly, elongating the stem. The terminal bud is where the stem is the ONLY place where the stem is growing in length.
    3. **Internode** = That region of a stem where there are no nodes (and, likewise, no buds).

4. **Scars** = There are two types of scars on stems:
    a. **Leaf scars** = the scar left on the stem from the previous attachment of a leaf. That leaf is now gone.
    b. **Terminal bud scar** = a ring-like scar around a stem that indicates where a terminal bud had stopped growing, usually due to the onset of winter. The distance between terminal bud scars will tell you how much length (and how healthy it is) a stem grew the previous growing seasons.
5. **Lenticels** = Pores through the outside epidermis of a stem – they allow O_2 to pass through the bark to reach the needy cells inside.

(C.) Modified Stems

Although most stems are above-ground, **modified stems** can be found above-ground and below-ground. These modifications are recognized as stems because they possess nodes and internodes.

1. **Stolon** = a horizontal stem that lies along the top of the ground. Strawberry runners are examples of stolons. The leaves on strawberry runners are small, but are located at the nodes, which are easy to see. The nodes on the runner are the points where roots begin to form. The spider plant also has stolons.

2. **Tuber** = a below-ground stem modified for the storage of starch and water. The "eyes" of a tuber, like a potato, are the nodes and contain a cluster of buds. Leave a potato alone long enough and the eyes will sprout leaves.

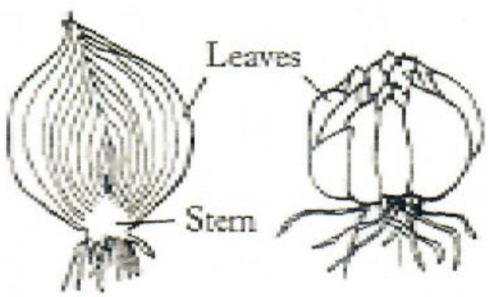
3. **Rhizomes** = are below-ground storage stems but they grow horizontally. An iris is an example of a plant that has a very large rhizome. Since they are storage stems, you can guess that they store starch and water for a plant.

Rhizomes are incredibly important in grasses. The presence of rhizomes helps to form sod – the aggregation of soil and roots that personifies the prairie. Here are some grass species with rhizomes:

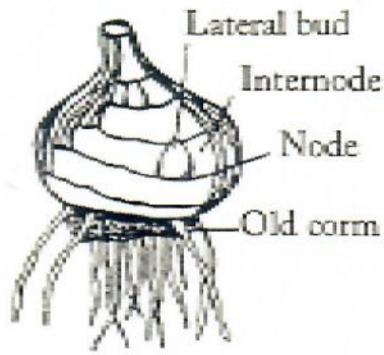
- **Sod-forming grasses with extensive rhizomes:** smooth bromegrass (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), quackgrass (*Agropyron repens*), prairie cordgrass (*Spartina pectinata*), foxtail muhly (*Muhlenbergia andina*), johnson grass (*Sorghum halepense*), and redtop (*Agrostis alba*).
- **Sod-forming grasses with extensive stolons:** bermudagrass (*Cynodon dactylon*), bentgrasses (*Agrostis* spp.), and buffalo grass (*Buchloe dactyloides*).
- **Sod-forming grasses with short rhizomes:** tall fescue (*Festuca arundinaceae*), side-oats grama (*Bouteloua curtipendula*), big bluestem (*Andropogon gerardii*), and indiangrass (*Sorghastrum nutans*).

4. **Bulbs** = underground storage stems that are relatively small and compact. A bulb is actually a modified stem surrounded by many modified leaves – a structure that is evident in an onion. Other plants that produce bulbs include tulips, daffodils, and lilies. Many bulbs require a period of low-temperature exposure before they begin to grow. Both the temperature and length of this treatment are of critical importance to commercial growers who force bulbs for holidays.

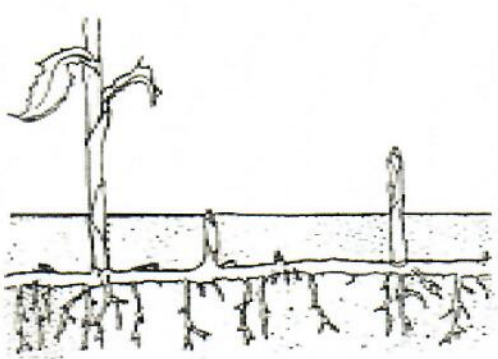
5. **Corms** = are also underground storage stems with a small stem surrounded by leaves. However, in corms the leaves are thin and papery, not fleshy like bulbs. We see corms regularly at Konza Prairie in the Liatris (gayfeather).



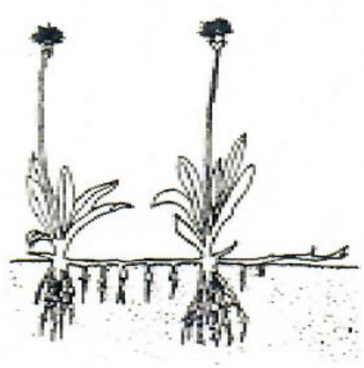
Bulb



Corm



Rhizome



Stolon

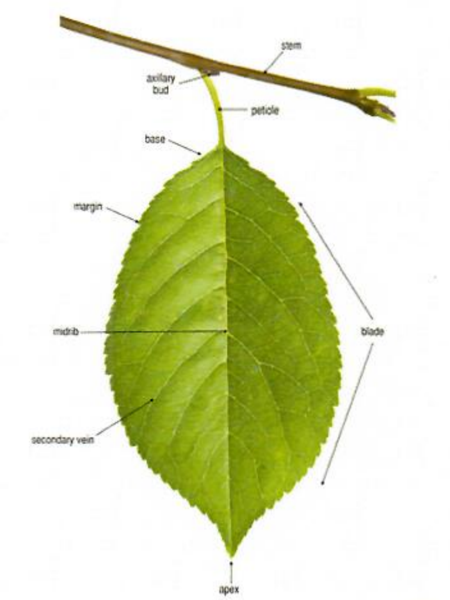
3. LEAVES

Functions of a leaf:

- **Photosynthesis** = leaves contain pigment that is capable of trapping certain wavelengths of light energy and converting this into chemical energy in carbohydrates – specifically, glucose.
- **Storage** = some leaves are modified to store the two basic things that plants need: water and starch. Succulent leaves found in sedums and jade plants are examples of leaves modifies for storage.

(A.) PARTS OF A LEAF

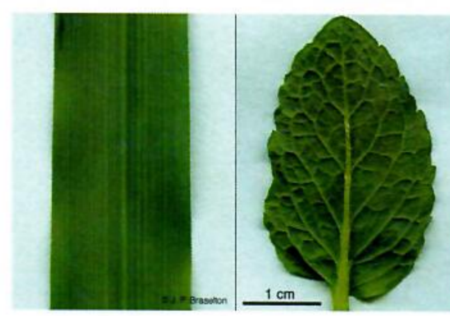
Parts of a Leaf



1. **Blade** = This is the main part of a leaf. Some leaves have just one blade, others have many blades.
2. **Petiole** = This is the stalk of the leaf. It attaches the blade to the stem at the node. Leaves that do not have a petiole are termed "sessile".
3. **Veins** = These are the tubes that conduct water (xylem) and sugar (phloem) throughout the plant. A central vein going down the middle of the blade is the **midrib**.
4. **Margin** = The margin is the outside edge of the blade. It may be smooth and entire or it may have teeth (dentate) or it may have deep lobes.

(B.) VENATION OF LEAVES

The pattern of veins on a blade ("venation") can be used to describe and identify different species of plants. Two principal types of venation are parallel veined and net-veined.



1. Parallel venation = veins which run essentially parallel to each other. This type of venation is seen in grasses (monocots).

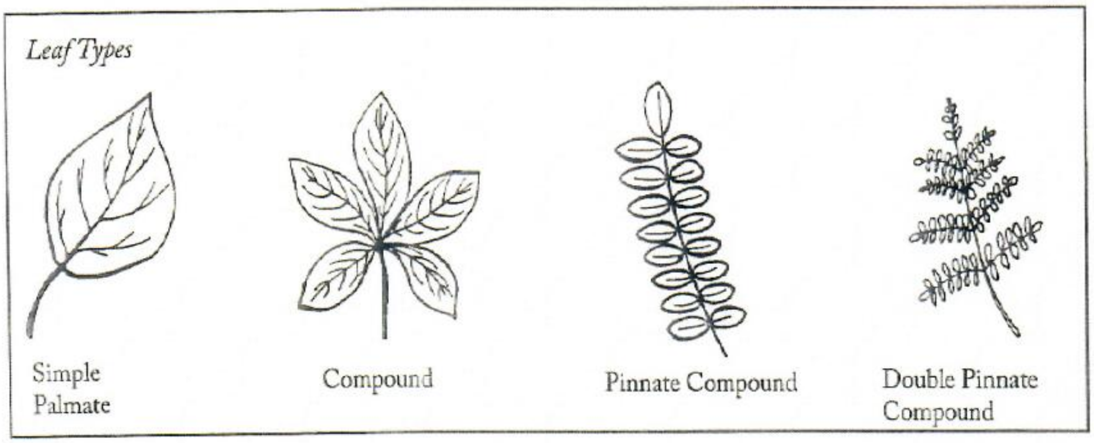
2. Net venation = the veins form a net pattern, usually with a midrib present. Net venation is characteristic of the broadleaf (dicot) plants.

There are two types of net venation: a. Pinnate net venation

b. Palmate net venation

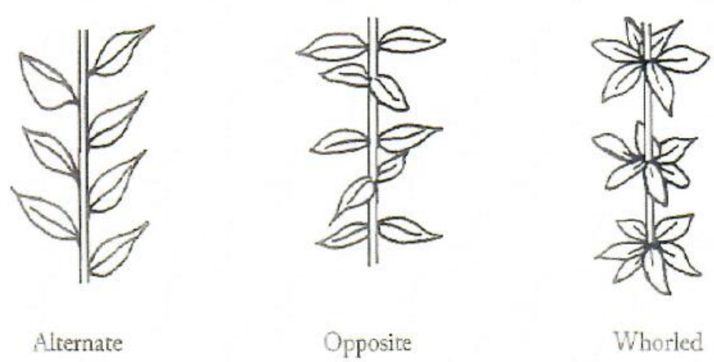
(C.) Leaf Complexity

Leaves are useful in identifying species and varieties of horticultural plants. The shape of the leaf blade and the type of margin are of major importance as identifying characteristics. **Simple leaves** have one blade arising from one petiole. A **compound leaf** is composed of several separate blades arising from the same petiole.



(D.) Leaf arrangement along a stem

The various ways leaves are arranged along a stem also are used to help identify plants. **Opposite leaf attachment** has leaves are positioned across the stem from each other, two leaves at each node. **Alternate leaf attachment** has leaves attached in alternate steps along the stem with only one leaf at each node. **Whorled leaves** are arranged in circles along the stem with 3 or more leaves per node.



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4. Flowers

The sole function of the flower, which is generally the showiest part of the plant, is sexual reproduction. Fragrance and color are devices to attract pollinators – insects that play an important role in the reproductive process.

(A.) Parts of the Flower

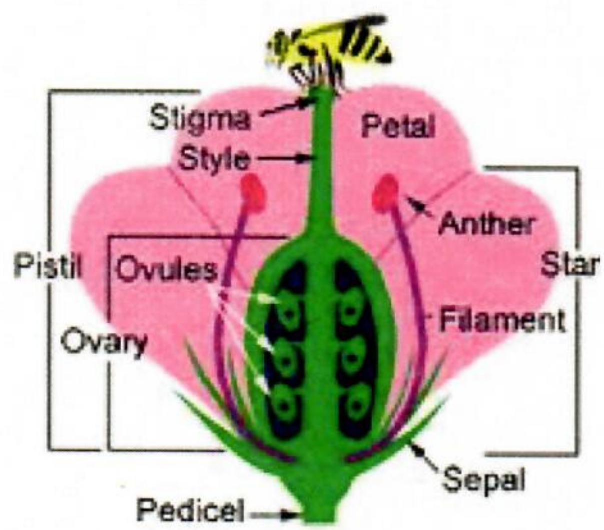
The flower is the site of reproductive organs of a plant. There are four basic floral structures:

1. Pistil = female structure
2. Stamen = male structure
3. Petals = brightly colored modified leaves
4. Sepals = usually green-colored modified leaves that surround a flower bud

Pistil - is the female part of the plant. It is generally shaped like a bowling pin and located in the center of the flower. It consists of the stigma, style, and ovary. The stigma is located at the top, and is connected to the ovary by the style. The ovary contains the eggs, which reside in the ovules. After the egg is fertilized, the ovule develops into a seed.

Stamen - is the male reproductive organ. It consists of an anther and a long, supporting filament. The anther is the site of pollen grain formation. The long filament holds the anther upright so the pollen may be disbursed by wind or carried by insects or birds.

Petals – modified leaves that may be brightly colored to attract animal pollinators. <u>NOTE: not all flowers are brightly colored</u>. Only flowers that are pollinated by animals (e.g. bees, ants, butterflies, hummingbirds, bats) will have large, showy flowers. Flowers that are wind pollinated will have small, dull flowers that produce lots of pollen. All of the petals of one flower are collectively referred to as the **corolla**.

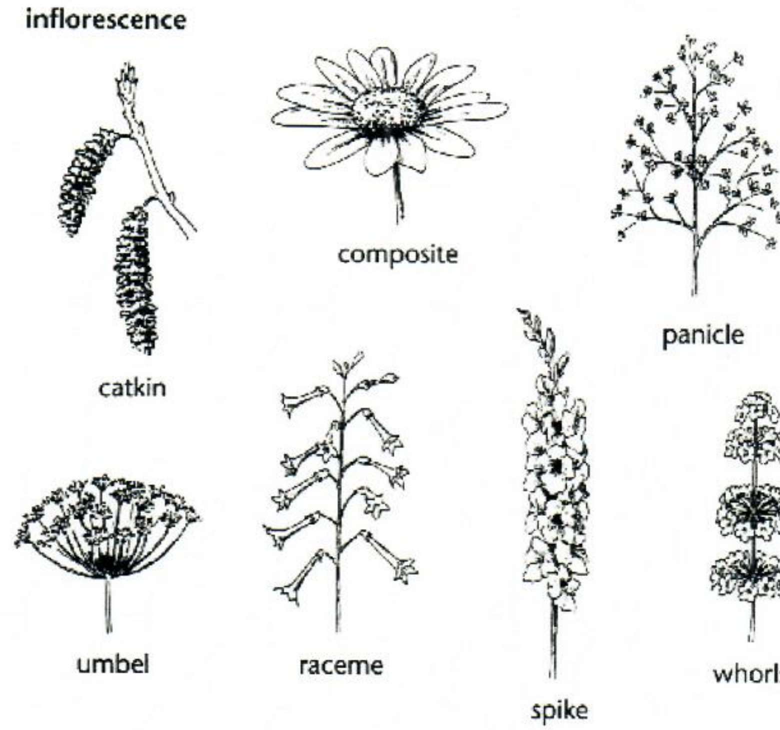


Sepals – modified leaves (they are usually small and green) that encase a developing flower bud. Not all flowers will have sepals. All of the sepals collectively for one flower are termed the **calyx**.

(B.) INFLORESCENCES

A flower that has just one set of floral parts (pistil, stamens, petals, and sepals) is termed a **solitary flower**. E.g. Rose, petunia, violet, lily.

A bloom that has many simple flowers that make up the who structure is technically referred to as an **inflorescence**. E.g. Penstemon, sunflower, sage, indigo.



5. FRUIT

Fruit consists of the fertilized seeds and the ovary wall, which may be fleshy, as in the apple; or dry and hard, as in an acorn.

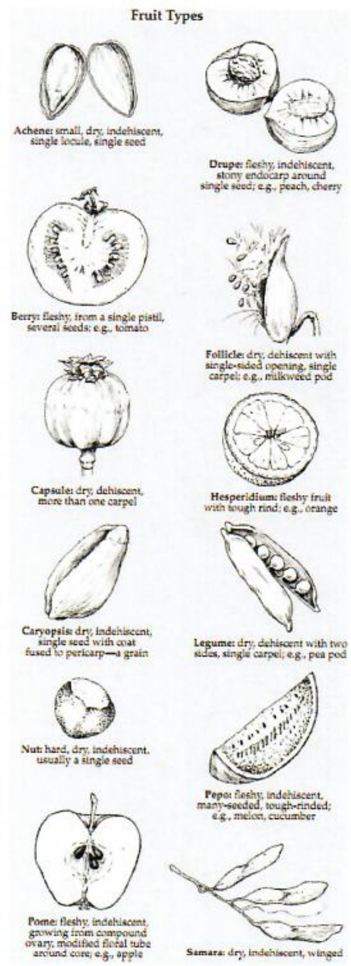
All fruits contain seeds and the fruit structure itself is modified for the dispersal of the seed. Some fruits are **fleshy** and encourage animals to eat them – such as tomatoes and berries. Other fruits are **dry** and use wind for seed dispersal – such as dandelions.

The definitions for a botanical fruit and a dietary fruit may be different. In botany, any structure that has seeds is a fruit. With that definition, the following are fruits:

- Green peppers
- Tomatoes
- Corn on the cob

Botanically speaking, vegetables are roots, stems, and leaves:

- Onion
- Lettuce
- Garlic



D. Physiology: Plant Growth and Development

The three major plant functions that are the basics for plant growth and development are **photosynthesis, respiration**, and **transpiration**.

1. Photosynthesis

Plants are capable of making their own food by the process of photosynthesis. An organism that is capable of making their own food is termed "**autotrophic**". To accomplish photosynthesis, a plant requires energy from sunlight, carbon dioxide from the air, and water from the soil. If any of these ingredients is lacking, photosynthesis, or food production, will stop. If any factor is removed for a long period of time, the plant will die.

Carbon dioxide + Water $\longrightarrow$ Sugar + Oxygen

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

Glucose is the basic food for a living cell. Plants make the glucose in the leaves and transport it throughout the plant structure to feed all of the cells. Any excess glucose that is not used by the cells is hooked together to form starch. Starch is the storage molecule of fuel for plants (animals use fat instead of starch).

Photosynthesis is dependent on the availability of light. Generally speaking, as sunlight increases in intensity, photosynthesis increases. This results in greater food production.

Photosynthesis

1. Produces food
2. Stores energy
3. Occurs in cells containing chloroplasts
4. Releases oxygen
5. Uses water
6. Uses carbon dioxide
7. Occurs in sunlight

Respiration

1. Uses glucose for cellular energy
2. Occurs in all cells
3. Uses oxygen
4. Produces water
5. Produces carbon dioxide
6. Occurs in darkness as well as light

Water is a necessary ingredient for photosynthesis. When a water molecule is broken apart during the chemical reaction, oxygen is released and leaves the plant as a waste product. Thus, water is the original source of oxygen in our atmosphere and photosynthesis is the only process that releases oxygen.

Carbon dioxide (CO_2) is the source of carbon for the production of glucose during photosynthesis. Plants take in CO_2 through small pores in the leaf – stomata. Carbon dioxide in the air is plentiful enough so that it is not a limiting factor in plant growth.

Although not a direct component in photosynthesis, temperature is an important factor. Photosynthesis occurs at its highest rate in the temperature range 65 to 85-F (18 to 27°C) and decreases when temperatures are above or below this range.

2. Respiration

Carbohydrates (glucose) made during photosynthesis are of value to the plant when they are converted into energy. This energy is used in the process of building new tissues (plant growth). The chemical process by which sugars and starches produced by photosynthesis are converted into energy is called **respiration**. This process in cells is shown most simply as:

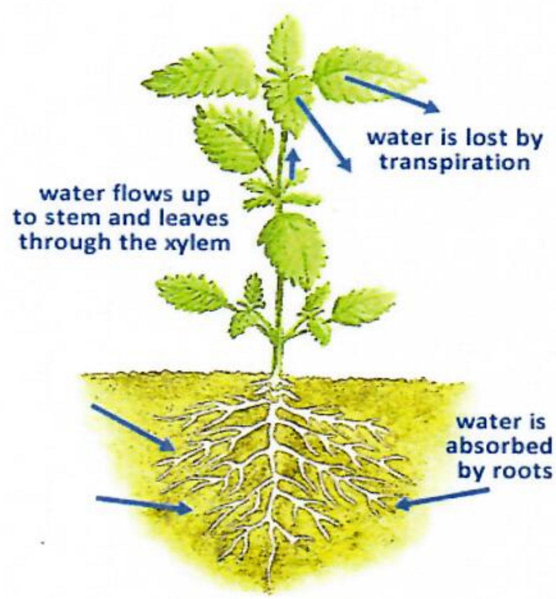
$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \text{Energy}$$

This equation is precisely the opposite of that used to illustrate photosynthesis. However, it is appropriate to relate photosynthesis to a building process, while respiration is a breaking-down process.

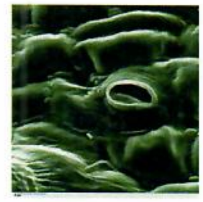
Unlike photosynthesis, respiration occurs at night as well as during the day. Respiration occurs in all life forms and in all cells. The breakdown of glucose results in the formation of CO_2 and water. These waste products are then released from the cell. In animals, blood carries both CO_2 and oxygen to and from the atmosphere by means of the lungs or gills. In plants, there is simple diffusion into the open spaces within the leaf, and exchange occurs through the stomata.

3. Transpiration

Transpiration is the process by which a plant loses water, primarily from leaf stomata. Water enters the plant through the roots and moves upwards, against gravity, to the leaves. Since water molecules stick to one another, the long line of cohesive water molecules moves up a plant. Water exits a plant through the pores of the leaf, or the stomata. This evaporation of water molecules from the leaf surface results in the entire water column being pulled upwards.



The hotter and drier the air conditions around a plant, the more water that is evaporated from the leaf surface. A plant can protect itself from water loss by closing the stomata, but these stomata are the same place where CO2 enters to allow photosynthesis. If the stomata are closed, the plant risks starving to death from the shutdown of photosynthesis. If the stomata are open, the plant risks dehydration and death from the loss of too much water. Therefore, the stomata are open some times and closed some times – to best regulate photosynthesis and water movement throughout a plant.



Stomata