Master Naturalist
EAST CENTRAL ILLINOIS

CHAPTER 4

Botany

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Chapter Goals

After completing this chapter, volunteers should be able to:

❒ Describe the basic characteristics of a plant.
❒ Illustrate the correct way to designate scientific names.
❒ Identify and explain functions of major plant parts: roots, stems, leaves, and flowers.
❒ Become familiar with a variety of leaf, flower, and fruit types to assist in identifying plants.
❒ Successfully use a dichotomous key.
❒ Describe plant processes: photosynthesis, transpiration, and respiration.
❒ Understand pollination and become familiar with different pollination mechanisms and methods of seed dispersal.
❒ Describe seed germination.

BOTANY

Botany is the study of plants. What is a plant? The answer is not as simple as you might think.

Most familiar plants:

- Are green, contain chlorophyll, and manufacture their food through the process of photosynthesis.
- Are immobile and rooted to the ground.
- Have neither a nervous system nor an excretory system.
- Have a cell wall composed largely of cellulose.
- Can continue to grow almost indefinitely by cell division.

However, some plants, including dodder, Indian pipes, beech drops, and cancer root, lack chlorophyll and parasitize other plants. Other plants, such as Venus' flytrap and pitcher plants, trap and "digest" insects. These are examples of specialized flowering plants.

Plants and People

Have you thanked a green plant today? Plants are of enormous benefit to humans. As a matter of fact people and all other animals are totally dependent on plants for their existence.

Plants are the only living organisms that are able to convert light energy into chemical energy. In the process of photosynthesis, carbon dioxide and water—in the presence of light—are made into simple sugars, which are the essential building blocks for all life as we know it and for nearly all sources of fuel energy, such as wood and the fossil fuels: coal, oil, and natural gas. In addition, the energy stored in sugars is the only source of energy to sustain living organisms. Without green plants, all animal life would cease to exist. Yet, food from crops is only one of the many plant products useful to people. What plants provide can be summed up with these categories.

- **Food**
- **Fiber/Fabrication**
- **Fuel**
- **Pharmaceuticals**
- **Fermentation**
- **Flowers/Forests/Fancification**
- **Fragrance**

Food — We obviously eat plants but the animals we may also eat rely on plants for their food. Plants also make our food taste better. What would our food taste like without spices such as pepper, garlic, nutmeg, mustard, cinnamon, parsley, sage, rosemary, thyme, vanilla, cocoa, and many others, all of which are plant products? How many of us can do without sugar from sugar cane and sugar beets, coffee or chocolate? For centuries people have appreciated the development of beer, bread, wine and cheese with the help of plants.

Fiber and fabrication — Before the development of synthetic products such as nylon, orlon, and plastics, people were dependent upon plants for fibers and building materials. Wood products were, and still are, a major source of construction materials. Nearly all of the written and printed matter produced through history has depended on the use of paper products derived from plant fibers or wood. Fibers from the cotton, flax, and hemp plants and wool from animals grazing on plants were the major textiles used for cloth. Even synthetics are in most cases plant products since most are made from petroleum or coal, which are remnants of plants from millions of years ago. Before synthetic rubber was developed during World War II, the United States and the world rolled on tires made of latex from the sap of the rubber tree. Latex is still widely used for surgical tubing and many other products that require its unique properties.

Fuel — Wood was once an important fuel, and still is in some parts of the world. All fossil fuels (coal, gas and petroleum) are the product of photosynthesis that took place several hundred million years ago. The problem with using fossil fuels today is that this releases carbon back into the atmosphere that has been stored as organic compounds all this time. Plants are often mentioned in long-range plans to help mitigate the energy crisis because they are a “renewable resource,” unlike the fossil fuels. Biofuels and biodiesels from a variety of plant sources such as soybeans, grains, vegetable oil, sugar cane, and grasses may prove to be important alternatives to petroleum products.

Pharmaceuticals—Some plant products such as alcohol (produced by fermentation of sugar), tobacco, and drugs like heroin from the poppy, cocaine from coca and marijuana from the hemp plant have often been put to less than desirable uses by people. Many other drugs derived from plants are widely used in medicine. A good example is digitalis from the foxglove plant, often prescribed for patients with heart ailments. Plants with medicinal properties have been consumed by people for centuries.

Plants provide beauty, shade from summer sun, wind protection, animal habitat and lovely fragrance. Stop and look around you at all the things that make up your everyday world. How many have been derived from plants or plant products? How desirable would the world be without trees, shrubs, flowers, and grass that color and soften our world and ease the tensions of everyday life? Plants are worth knowing and appreciating for they are indispensable to us in every way. Although people have reached the moon, they have not yet found a substitute for a living plant.

Major Plant Categories and Associated Groups

- Flowering plants (angiosperms)
- Conifers (gymnosperms)
- Ferns, horsetails and club mosses
- Mosses and liverworts
- Algae
- Fungi
- Lichens

In this chapter, the emphasis is on the flowering plants, since these are the most conspicuous and economically important plants. However, brief discussions of other plant categories and their associated groups are included.

Angiosperms

The angiosperms or flowering plants produce flowers and seeds, the latter developing within fruits. Nearly all crop, food, and ornamental plants are angiosperms. There are two major groups of flowering plants, primarily distinguished by the number of seed leaves (cotyledons). Here are their characteristics:

Monocots

(single cotyledon or seed leaf)

- Leaves have parallel venation.
- Flower parts are usually in multiples of three.
- Do not typically produce wood.
- Examples include: grasses, corn, sedges, cat-tails, lilies, orchids, bananas, and palms.

Dicots

(two cotyledons or seed leaves)

- Leaves have net-venation.
- Flower parts are mostly in multiples of four or five.
- Wood is produced by long-lived dicots.
- Examples include: roses, carrots, elms, magnolias, buttercups, apples, and sunflowers.

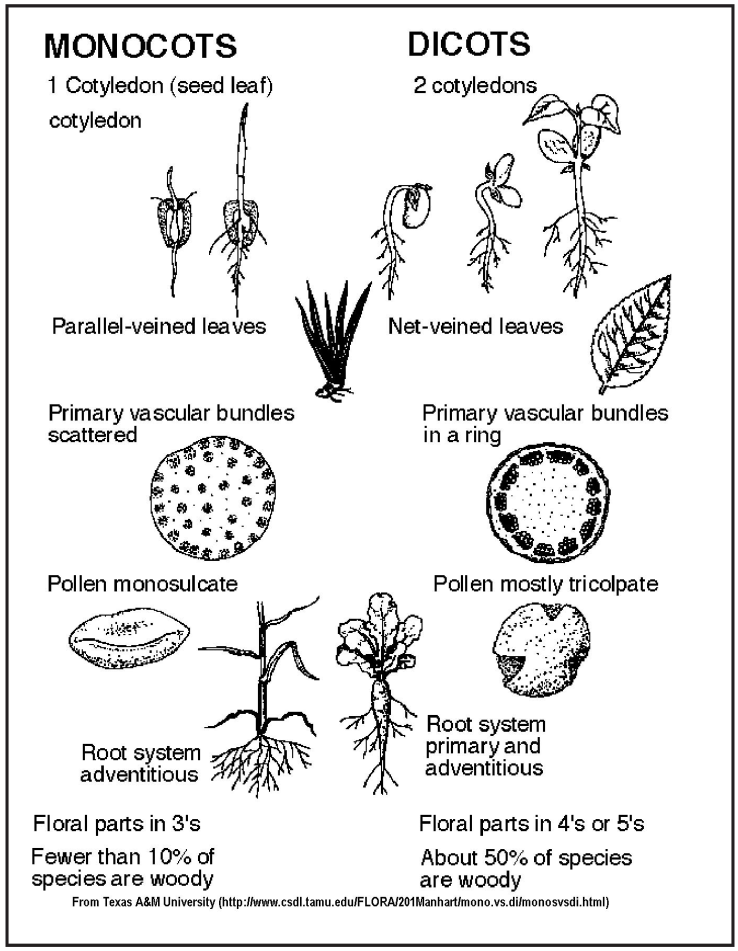

Figure 1

Gymnosperms

The gymnosperms or conifers produce "naked" seeds that are not enclosed by fruits, but develop on the surface of cone scales. They are woody trees and shrubs, and many species produce aromatic oils and resins, which give their leaves and wood pungent odors. The leaves of most conifers are evergreen, remaining on the plant during winter, but those of a few species, such as bald cypress, tamarack and larch, are deciduous, dropping their leaves in the fall. Most gymnosperms have elongated slender leaves called needles, however, ginkgo is a conifer with broad leaves. Conifers thrive particularly in the cooler regions of the temperate zones and make up much of the northern forests of North America and Eurasia. Many conifers are important as ornamentals and for their wood products. Pine, spruce, fir, juniper, arborvitae, red cedar, yew, ginkgo, cypress, hemlock, redwood, and Douglas-fir are gymnosperms.

Ferns, Horsetails, and Club Mosses

Ferns, horsetails, and club mosses, collectively called the **pteridophytes**, have true roots, stems, and leaves; however, they lack flowers and seeds, and modern species do not produce wood. They reproduce by tiny spores, and many multiply vegetatively by creeping underground stems. Typical ferns have large, usually compound leaves, a stem that is an underground rhizome, and roots that grow profusely from the rhizome. Ferns are widely distributed in temperate and tropical regions, and since most cannot withstand drought or bright sunlight, they are usually restricted to moist shaded habitats, such as forest floors and ravines.

The horsetails, once abundant in past geological ages, are represented today by a single genus, *Equisetum*. They have perennial underground rhizomes and mostly annual above-ground stems or canes that are hollow, ribbed, jointed, and impregnated with silica. Pioneers used the stems to scour pots and pans, and some people call these plants "scouring rushes." Horsetails are found in wet, often sandy or gravelly soils of damp woods, along the banks of fast-moving rivers and streams, and in standing waters of rivers, ponds, and lakes.

Club mosses are small, evergreen, perennial herbs with upright or trailing stems and small, simple, spirally arranged leaves. They are found mostly in acidic soil of moist, shaded woods and in bogs, and are especially abundant in the tropics. Some species are sold commercially for use in Christmas decorations.

Mosses and Liverworts

Mosses and liverworts, collectively called the **bryophytes**, are small green plants that lack true roots, leaves, and flowers. They reproduce by spores. Mosses are only a few inches tall and grow in crowded clusters, tufts, or mats. Their plant bodies are stem-like with leafy scales and stalks bearing tiny capsules, which contain the dust-like spores. Mosses are cosmopolitan in distribution, but tend to prefer harsh habitats, such as exposed rocks, bogs, swamps, tree bark, forest floors, decaying logs, areas around waterfalls, dim caves, cracks in city sidewalks, high altitudes, and the arctic tundra.

The most familiar moss product is sphagnum peat moss, which is cut in large blocks from extensive peat deposits that are found at northern latitudes. Peat is used in soil mixtures and, particularly in northern Europe, as a fuel in stoves. Liverworts are of two general kinds. The first grows flat and ribbon-like on wet soil, damp rock, or even on the surface of water, sometimes forming shiny green carpets along streams and ledges. The second kind has distinct stems with leaf-like scales and grows flat or in mats on moist soil, decaying logs, or tree bark.

Algae

The algae include both the smallest and simplest of green plants as well as the giant kelps, which are among the largest of plants. Algae can be green, red, brown, yellowish, or purple, depending on the pigments in their cells. The green algae are grass green in color, may be one-celled, colonial, or filamentous, and are among the most widely distributed of all the algae, with species usually inhabiting fresh water and forming large colonies on the surface. They are important as a source of food for fish and other aquatic animals. Sometimes they become so abundant that they pollute waters, give off vile odors, choke streams, and clog filters in water purifying facilities.

The yellow-green and golden-brown algae are found most often in cold brooks, mountain streams, and springs. The related diatoms are important food for fish, and are so abundant in marine waters that they are called the "grass of the sea." The empty, beautifully ornamented siliceous walls of dead diatoms settle in marine waters and often accumulate, forming diatomaceous earth, which is used as a mild abrasive in polishes, cleansers, and toothpaste, and in insulation.

The blue-green algae have blue and red pigments as well as chlorophyll and are found in a variety of habitats, with most species in fresh water, although a few are marine and some thrive in damp and shaded places, such as on the surfaces of soil, rocks, and flower pots. Some blue-green algae have the ability to "fix" atmospheric nitrogen into organic compounds. The brown algae, which include the giant kelps, have yellow, orange, or brown pigments and are almost entirely marine. They prefer cool water and are especially abundant in the Arctic and Antarctic oceans and along the coasts of the North Atlantic and North Pacific. Brown algae are important food for fish, are used in cattle feed, and are eaten by many people in Asia. Some brown algae are harvested for their abundant gelatinous compounds, which are used in ice cream, laxatives, and cosmetics. The red algae have a unique reddish pigment and are mostly marine, although a few species occur in fresh water.

Fungi

Fungi are a group of organisms that lack chlorophyll, roots, stems, leaves, and flowers. Once considered plants, they are now classified in their own group. Fungi reproduce by means of spores, are usually filamentous, have definite cell walls, and live a saprophytic or parasitic existence. As saprophytes they share with bacteria the role of decaying the remains of dead organisms, and as parasites they cause diseases in plants and animals. The large fleshy fungi, such as mushrooms, toadstools, bracket fungi, and puffballs, are familiar to everyone who has walked the Illinois countryside. Other fungi include the morels, truffles, earthstars, and bird's nest fungi. Most fungi are microscopic and not visible to the naked eye, such as molds, mildews, yeasts, rusts, and smuts. Mushrooms produce a fruiting body that consists of a stalk surmounted by a broad, umbrella-shaped cap. The reproductive spores are produced on the sides of gills located on the underside of the cap. The mushroom is only one part of the body of the fungus: think of a mushroom as the apple on the tree. The remainder consists of an extensive mass of threadlike filaments (hyphae) that grow hidden in the soil or other substrate.

Technically, there is no difference between a mushroom and a toadstool. By tradition, the term "mushroom" refers to edible species, some highly prized for their delicious flavors and aromas. The term "toadstool" is used for poisonous species, which produce toxic compounds that can cause illness or death. Since both edible and poisonous species can occur together and can resemble each other, there is great danger of amateurs confusing safe and toxic species. Only people who are thoroughly familiar with the technical identification of mushrooms should collect and eat wild species. The bracket fungi resemble mushrooms but differ in having pores instead of gills and are often asymmetrical and hang, bracket-like, on dead or living tree trunks. The puffballs produce round or pear-shaped fruiting bodies with a conspicuous outer covering, liberating spores at maturity through a pore or break at the top of the ball.

Some puffballs can reach the size of a basketball. They are found on decomposing wood and bark, decaying leaves, and animal wastes.

Mushrooms can be found throughout most of the year, but the largest number appear with the cool moist weather of autumn. This diversity will last until temperatures fall below freezing. Warm spring temperatures combined with moist weather bring out the second largest number of fleshy fungi, including many gilled and pore fungi, morels, and puffballs. In late spring and summer, the number of fleshy fungi drops to a low point. A cool spell in August, accompanied by showers, will bring out large numbers of puffballs and pore fungi. However, the return of hot weather will quickly reduce the numbers to a few scattered specimens.

Fungi, besides being tasty additions to pizza, are important additions to our medicines and food. Many antibiotics, including penicillin, streptomycin, terramycin, aureomycin, and chloromycetin, were originally produced by fungi. Yeasts carry out the process of fermentation, which makes possible bread, alcoholic beverages, and vinegar. Fungi are also important in the ripening of certain kinds of cheese, such as Roquefort, Camembert, Brie, and Stilton.

Lichens

Lichen is a unique organism composed of a microscopic green or blue-green alga and a colorless fungus. The alga and fungus live together in a mutually beneficial association termed **symbiosis**. The plant body that is formed has no resemblance to either the algal or fungal component. The algal partner provides food energy through photosynthesis and the fungal partner lives on this food, makes up the bulk of the plant body, protects the alga from desiccation, absorbs mineral elements and water, and synthesizes many essential organic compounds. Lichens have a cosmopolitan distribution and are found on a great variety of substrates, such as rock, trees, wood, and soil, from the Arctic (where they are dominant in the tundra) to the Antarctic, from sea level to alpine habitats, in deserts, and in freshwater and marine environments. People are often concerned when they see lichen on the bark of tree trunks. The lichen neither harms nor helps the tree. Some lichen communities last for centuries in the Arctic and Antarctic, but if the environment is disturbed, they are eventually replaced by mosses, liverworts, and plants. Lichens are very sensitive to air pollution, and different species are affected by different concentrations of specific air pollutants. Thus, it is frequently possible to estimate the level of air pollution in an area by determining the kinds and/or numbers of lichens that are present.

Table 1 reveals the diversity of plants in Illinois, past and present. Plants listed as threatened or endangered may be on the list because there are few plants left in the United States or they may be on the edge of their geographic range in Illinois, but more abundant in other states. Endangered species are those in imminent danger of extinction throughout their range. Threatened species are those most likely to become endangered within the foreseeable future. Extirpated refers to plants that are no longer in Illinois, but may be found in other locations. Extinct indicates no examples of the species are in existence in the world.

Table 1. Species of Plants in Illinois

According to Illinois Natural History Survey

Group	Species	Threatened & Endangered	Extirpated	Extinct
Mosses & Liverworts	506		2	
Club mosses	12	3	1	
Horsetails	12	3	1	
Ferns	75	13	2	
Conifers	14	7		
Flowering Plants	1,955	329	53	1
Total	**2,574**	**355**	**59**	**1**

Plant Classification

With at least 500,000 different kinds of plants in the world, it is necessary to organize this diversity into a classification scheme to be able to communicate with others. There are a variety of ways plants can be classified, such as alphabetically (hibiscus, hickory, hollyhock, hydrangea); by growth habit (herb, shrub, tree, or vine); by habitat (aquatic, terrestrial, aerial); or by shared characteristics (white flowers, opposite leaves, edible fruits). However, the classification system that has been most useful to botanists is one that groups related plants together into a series of hierarchical categories, so that very closely allied plants are placed together in the system, plants that are somewhat related are grouped near each other, while plants that have very little in common are placed far from each other.

The classification scheme used for plants has the following categories:

Division
Class
Order
Family
Genus
Species
Subspecies
Variety
Form
[Cultivar]

The basic unit of classification is a **species**. It is impossible to precisely define a species so that the definition would apply to all plants and be agreed upon by all botanists. In general, however, a species is a population or a series of populations whose individuals are distinct and distinguishable from individuals of other such populations, this distinctiveness is self-perpetuating through succeeding generations, and the population(s) is usually reproductively isolated from populations of other species. To the layperson a species is a particular kind of plant or, put another way, all individual plants that look more-or-less alike constitute a species. The word “species” is both singular and plural.

We intuitively recognize some species. All humans constitute a species, and white oak, eastern redbud, flowering dogwood, and white pine are familiar tree species. Variation does exist within species, and these variants are sometimes recognized either as subspecies, varieties, or forms (depending on the magnitude of the variations) if they occur in the wild, or as cultivars or lines if they occur only in cultivation.

Related species are grouped together into **genera** (singular, genus). Again, the layperson perceives this. For instance all oaks belong to one genus, roses to another, and pines to a third. Some species are so distinctive that they are placed in a genus by themselves, as is the case with the ginkgo tree.

Related genera, in turn, are placed in the same family. This category has no equivalent among laypeople, yet it is one of the most useful to botanists. It is relatively easy to learn the identifying characteristics of common plant families in Illinois, and this knowledge is of immense use in quickly identifying unknown plants. Among the common families in the state are: the grass family, the lily family, the mustard family, the rose family, the legume (or bean) family, the carrot family, the mint family, and the aster (or sunflower) family. Approximately half of the world's families of ferns, conifers, and flowering plants occur natively or naturalized in Illinois, and a number of other families are cultivated. A person with a knowledge of the characteristics of plant families in Illinois can go nearly anywhere in the world and recognize the families of the majority of plants.

Plant Names

Since ancient time, people have given names to plants that are of special interest, such as food plants, fiber-producing plants, poisonous plants, and ornamental plants. There are two kinds of names given to plants: common names and scientific names. The two names are complementary and each has a definite purpose.

Common Names

Common names are used by the general population of a given region and are nearly always in the language spoken locally, i.e., English in Illinois, French in Quebec, and Spanish in Mexico. Common names are the only names by which most people know familiar plants, since they are usually composed of everyday words. They also are often easy to remember, can accurately depict outstanding characteristics of a plant, and can be precise and stable within limited geographical areas.

However, the use of common names has several drawbacks. The same common name may be used for more than one kind of plant, both within one area and from place to place. For example, "mayflower" is the name used for a member of the lily family (the scientific name of this plant is *Maianthemum canadense)* and also for a member of the heath family *(Epigaea repens)*. Nearly everyone in the United States uses the name "corn" for the plant known botanically as *Zea mays;* however, in Europe, "corn" is used for any kind of grain. Also the same kind of plant may have more than one common name. In addition to being called "mayflower," *Maianthemum canadense* is also called "wild lily-of-the-valley," and *Zea mays* is called "maize," particularly in Europe. As another example, the name "adder's tongue" can refer either to a quaint fern, *Ophioglossum vulgatum,* or to a lovely member of the lily family, *Erythronium albidum*. The latter is also known as "trout-lily," "fawn-lily," or "dog-tooth-violet." Scientific names mitigate the ambiguity created by the use of common names.

Scientific Names

The science of botany in Europe, particularly the aspect of identifying and naming plants, reached full development in the eighteenth century. At that time, educated people in all fields, from law, medicine, philosophy, and religion to science, used Latin as a universal language, which greatly facilitated communication between people of different nationalities speaking many native languages. Thus, it was only natural that Latin was used for plant names in learned circles. At first, plants were given descriptive phrase names such as *Rosa carolina fragrans, foliis medio tenus serratis*. These names were long, confusing, and difficult to remember, and in 1753, the Swedish botanist Carl Linnaeus applied a system of naming to the entire plant kingdom whereby a plant name consisted of only two words. This binomial system is still used universally by scientists, now following the strict rules of the International Code of Botanical Nomenclature.

The first word of the scientific name is the name of the **genus** to which the plant is assigned, and the second word is the **specific epithet**. Thus, from the examples above, *Maianthemum* is the name of the genus and *canadense* is the specific epithet, and together, *Maianthemum canadense,* they make the scientific name, also referred to as the **species**. These names are always in Latin or, if derived from other languages, treated as if they were Latin. Scientific names are underlined when handwritten and italicized or underlined in print. The first letter of the generic name is always capitalized; that of the specific epithet may always be left uncapitalized, although it can be capitalized if the name commemorates a person or an old generic name.

The generic name refers to a general kind of plant while the specific epithet indicates a particular kind of plant. Thus, the genus *Rosa* is used for all kinds of roses, while *Rosa setigera* is the prairie rose. When the generic name is frequently repeated, it is customary to abbreviate it by the first letter. Accordingly, *Rosa carolina* is the pasture rose, *R. centifolia* is the cabbage rose, and *R. canina* is the dog rose. These examples show that the use of two words for the name of a particular kind of plant is not restricted to scientific names, but that we frequently do this in English with one word modifying the other.

Following the name of the species is the name of the person who gave the plant that name. This is a bibliographic aid to help locate additional information about the name. Many plants in the eastern United States were first named by Linnaeus, for instance, *Rosa carolina* Linnaeus, the pasture rose. Certain people described so many plants that their name is abbreviated, such as *Rosa carolina* L., R. *canina* L., and *R. setigera* Michx. (for Michaux). Some floras give lists of author abbreviations.

Sometimes a species may have two or more recognizable variants. As previously mentioned, if these are discovered in wild plants, they are called **subspecies**, **varieties**, or **forms**—depending on the magnitude of the variations—and are given an additional Latin name. For example, the pasture rose *R. carolina* has two variants, one with the leaves smooth and the other with the leaves quite hairy beneath. The first one is called *R. carolina* var. *carolina* and the second, *R. carolina* var. *villosa*. Author citations are used with these names when the name of the variant is different from that of the species, as in *R. carolina* L. var. *villosa* (Best) Rehder. When variants occur only in cultivated plants, they are given **cultivar** names, which may be in languages other than Latin, and they do not carry an author citation with them. The cultivar name is placed in single quotation marks after the specific name, or, in some cases, after the generic name. Cultivar names are capitalized, but not italicized. For example, the name of the Bradford pear is *Pyrus calleryana* 'Bradford.' It is never correct to use so-called trinomial names, such as *Rosa carolina villosa,* that do not indicate the classification rank of the third name.

The names of plant families are based on the name of a genus with the ending changed to "-aceae." Thus, Rosaceae is the name of the rose family and Liliaceae of the lily family. A few very common families may be called either by their traditional name or by the name that is based on the name of an included genus. Thus, the grass family is Gramineae or Poaceae; the legume or bean family is Leguminosae or Fabaceae; the mustard family is Cruciferae or Brassicaceae; the mint family is Labiatae or Lamiaceae; the carrot family is Umbelliferae or Apiaceae; and the sunflower family is Compositae or Asteraceae.

The International Code of Botanical Nomenclature establishes one set of rules by which plants are named. According to these rules, no two kinds of plants can have the same name, and under a given genus, a species can have only one correct name. This correct name is the combination of the earliest correct generic name with the earliest specific epithet.

Some people wonder why one book will use one scientific name for a plant while another will use a different name for the same plant. There are basically three reasons for this. The first is that there has been a name change made necessary by the rules of the International Code of Botanical Nomenclature. The second reason is that some groups of plants are more difficult to classify than others, and different authors may classify them differently. The third reason is that modern molecular data may indicate that two groups formerly considered related to each other, and thus placed in the same genus or family, may not be related at all; as a result species can be transferred to different genera, and the circumscription of genera and families may be quite different from their traditional delimitation.

Pronunciation of Scientific Names

Many people who would use scientific names are afraid to do so because the words seem difficult to pronounce. A number of generic names have become adopted as common names and are familiar to most people — *Chrysanthemum, Geranium, Rhododendron, Magnolia, Aster, Catalpa, Phlox, Iris, Trillium, Delphinium, Sassafras,* and *Hydrangea*. There are many common names that are very similar to the scientific names: such as lily, *Lilium;* rose, *Rosa;* alder, *Alnus;* spirea, *Spiraea;* violet, *Viola;* gentian, *Gentiana;* elm, Ulmus; pine, *Pinus;* poplar, *Populus*; larch, *Larix;*

and juniper, *Juniperus*. All of these words are easy for most people to pronounce because they are familiar with them. Other scientific names may take a little practice.

Actually, most Latin or Latinized words are easier to pronounce than unknown English words. Finally, there is no need for someone to be afraid of "mispronouncing" scientific names because there are several different systems for pronouncing Latin - "traditional English" pronunciation as used by most botanists and horticulturalists in English-speaking countries, "re-formed academic" attempts to approximate the pronunciation of educated Romans, and Latin as used in the Catholic religion.

In this country most letters of the alphabet are pronounced the same in Latin as in English, including the consonants *b,* c (hard and soft), *d*, *f, g* (hard and soft), *h, k, l, m, n, p, q, r, s* (always as in *so*, not like z), *t,* v, and *z*. The letters *j, u,* and *w* were not in the classical Latin alphabet; when they appear in Latinized words, they are usually pronounced as in English except that *j* sometimes has the sound of *y* in *yellow.* The letter *x* at the beginning of a word has the sound of z; for example, *Xanthium* is zăn´-thē-ŭm and *Xyris* is zī´-rŭs. Elsewhere, x is pronounced as in English, such as *Larix* is lăr-ĭks and *Oxalis* is ŏks-ă´-lĭs. All vowels may be either long or short, as in English.

A Latin word has as many syllables as it has vowels or diphthongs (two vowels pronounced as one sound). The diphthongs commonly used in botanical names, and their pronunciations, are: *ae* (ē as *ea* in *meat), au* (as *aw* in *awful),* and *eu* (as in *neutral* and as *oo* in *tool)*. Some examples are: *Actaea* (ăk-tē´-ă), *laevis* (lē´-vis), *Aureolaria* (ăw-rē-ō-lār´-ĭ-ă), *caudatus* (kăw-dā´-tŭs), *Eleusine* (ĕl-ōō´-sĭ-nē), and *Deutzia* (dōōt´-zē-ă).

Every vowel or diphthong is pronounced, and there are no silent letters at the end of a word. Thus, *Ribes* is rī´-bēs, not rĭbs or rībs; *Androsace* is ăn-drō-sā´-sē; *Leucothoe* is lōō-cō´-thō-ē; *gerardii* is jĕr-ăr´-dē-ī; *illinoense* is ĭl-lĭ-nō-ĭn´-sē; *Rosaceae* is rōs-ā´-sē-ē; *Liatris* is lī-ā´-trĭs; *Illiama* is ĭl-lē-ă´-mă; and *Aloe* is ă-lō´-ē, not ăl-ō.

When a word begins with any of the following combinations of two consonants, the first letter is silent: *cn, gn, mn, ps*, and *pt*. Thus, *Cnicus* is nī´-kŭs; *Gnaphalium* is nă-fā´-lē-ŭm; *Mnium is* nī-ŭm; *Psoralea* is sō-rā´-lē-ă; and *Pteridium* is tĕ-rĭ´-dē-ŭm.

Plant Identification

Plant identification is basic to the study of plants. Once a plant is identified, a wealth of information, such as life cycle and associated plants, may be available about the plant. You can also communicate with others about the plant. Obviously, it is extremely important to identify the plant correctly, for if it is misidentified, then any information you learn or pass on about the plant may be misapplied. As an extreme example, mistaking a foxglove plant for the herb comfrey can be life threatening.

There are several ways to identify a plant. The simplest, and often the best, is to ask some knowledgeable person. Another way is to compare the plant with photographs, drawings, or descriptions in guidebooks or floras, which need not require much technical knowledge, but which can be very time consuming. If one has access to a herbarium collection, unknown plants can be compared to already named specimens. Lastly, plants can be identified with the use of "keys" for identification that are found in nearly all floras or botanical manuals.

Because of the large number of categories of plants, there is no single book to use to identify all plants; rather, different books are used for different kinds of plants. The following are common categories:

- **Food plants and edible wild plants**—Usually well-illustrated and often containing information on how to prepare edible wild plants.
- **Floras and manuals**—Generally include all species of flowering plants, conifers, and ferns for particular geographical areas; nearly all contain keys, some are illustrated.
- **Wildflowers**—Contain the most common species that occur in particular geographical areas; nearly always well illustrated with drawings and/or photographs; rarely with keys.
- **Weeds**—Similar to wildflower books, but for weeds; wildflower and weed books may include some of the same plants.
- **Woody plants**—Contain the means to identify native and/or cultivated trees, shrubs, and woody vines; some with keys, some with illustrations or photographs, some with neither.
- **Cultivated plants**—Like the preceding, but for garden flowers, house plants, and other cultivated plants.
- **Special habitats**—A few books deal with plants in particular

habitats, such as prairies and aquatic situations.

- **Specific plant groups**—Separate guidebooks are available for: grasses, orchids, ferns, mosses, liverworts, lichens, fungi, and algae.

Professional taxonomic botanists usually have a number of books for identifying plants, and botanical libraries contain thousands of such books. However, a student or layperson is usually only interested in a few categories of plants, such as wildflowers or trees, and can identify most plants with a few titles. Most public, school, and university libraries have a number of the different identification books.

Keys

By the use of keys, plants that have particular structural features are separated from all plants that lack such features, and the process of identification is made simpler. A key consists of a series of paired contrasting or contradictory statements: each pair of statements is called a couplet. The first couplet of a key is compared with the plant to be identified. One of the statements will not apply to the plant while the other one will, and leads to another set of couplets. This process of choosing one statement of a couplet and rejecting the other is repeated until only one possibility remains, which gives the name of the plant. This process is called **keying out** a plant.

Most books have a number of separate keys. One key is used to determine the plant family (if it is not known), another to identify the plant to genus, and a third key to identify the species. With experience, common families and genera are readily recognized, which makes the identification to species much more rapid. Often, however, all is not so simple, and the user may not have all the information needed to select the proper statement, or the choices are not clear-cut. Nevertheless, time has proven the usefulness of keys. With experience, keys become relatively easy to use, and you will be able to take pride in your ability to use them.

Hints for the Use of Keys

1. Examine the unknown plant in a general way to see its basic morphological features, such as habit, leaf type and arrangement, flower color and structure, and fruit type. An important skill in plant identification is educating your brain and your eye as to what attributes should be noted. This will save time when using the key; certain other features will have to be checked more thoroughly while using a key.
2. Select a suitable key. This is very important. Use a key that is as specific as possible. For instance, if trying to identify a plant from a pond in Illinois, it would be best to use a book dealing with aquatic plants of Illinois; a flora of Illinois or a manual on aquatic plants in general would be next best; while a flora of the entire eastern United States would be considerably more difficult.
3. Look carefully at the key to determine its arrangement and read any instructions on the use of the key.
4. Always begin at the very first couplet; sometimes it is tempting to jump to the middle of a familiar key.
5. Read carefully both statements of a couplet before selecting one.
6. Use a glossary for any terms you don't understand; remember that the same term may have different connotations for different authors.
7. When measurements are called for, make them carefully and don't guess. Measurements should be made from several samples.
8. Use a hand lens when the key asks about minute structures.
9. Remember that there is variation within a species; most keys apply to the usual situation and may not include extremes.
10. When it is not clear which statement of a couplet to select, choose the one that best suits the unknown plant; it is not always possible to write keys that perfectly fit every plant to which the statement is supposed to apply.
11. When it is seemingly impossible to select one statement over another or not enough information is at hand, arbitrarily select one statement and proceed for several other couplets, then go back and try the other troublesome statement and follow it for a few additional couplets. Usually, it will become obvious which of the two statements is the correct choice.
12. Once a tentative identification is made with a key, check the identification with detailed descriptions, illustrations, photographs, and if possible, with accurately identified herbarium specimens.
13. Check the geographical and habitat descriptions to make sure the plant being identified occurs in the same region and habitat as the species to which it has been tentatively identified.

A Simplified Yoked Key to Separate Certain Genera of Common Trees

1. Leaves alternate.
   2. Leaves simple.
      3. Leaves fan-shaped with a notch at the tip ....*Ginkgo*.
      3. Leaves not fan-shaped, lacking a notch at the tip.
         4. Leaves entire..*Magnolia*.
         4. Leaves lobed or toothed.
            5. Leaves lobed ....Q*uercus*.
            5. Leaves toothed......................................*Ulmus*.
   2. Leaves compound.
      6. Leaflets small ....*Gleditsia*.
      6. Leaflets large..*Cladrastis*.

1. Leaves opposite or whorled.
      7. Leaves whorled...*Catalpa*.
      7. Leaves opposite.
         8. Leaves simple.
            9. Leaves palmately lobed........................... *Acer*.
            9. Leaves entire.......................................*Cornus*.
         8. Leaves compound.
            10. Leaves palmately compound.........*Aesculus*.

   10. Leaves pinnately compound...........................*Fraxinus*.

The Structure of Flowering Plants

Flowering plants are complex organisms and show a wealth of diversity. To describe the distinguishing characteristics of a plant species, a large vocabulary of descriptive terms has been developed. Some of these terms are technical and often have a Latin base. Fortunately, it is not necessary for the novice to learn much of this jargon to identify the more common plants, but a few terms are essential to learn.

Plants may be woody or herbaceous. Those that form **woody** stems may be a subshrub, shrub, tree, or woody vine (called liana with tropical plants). A **subshrub** has lower stems that are woody, but upper stems are herbaceous (prefix "sub" means "almost"). A **shrub** is a woody perennial plant of low stature, generally with many slender trunks arising from near its base. A **tree** is a large woody perennial plant with one to several relatively massive trunks and an elevated crown. A **vine** may be woody or herbaceous with long, slender, more or less flexible stems which cannot support themselves. The leaves of woody plants may be evergreen, persisting for more than 1 year, or deciduous, dropping in autumn.

Herbaceous plants have no above ground persistent woody tissue. They may complete their lifecycle from seed to death in one, two or many years. An **annual** completes its life cycle in one growing season. Annuals grow from seed to maturity and then die in 1 year. Winter annuals such as chickweed may germinate in fall and bloom in early spring. A **biennial** completes its life cycle in two growing seasons. Its first year is vegetative, often as a basal rosette of leaves. The second year a biennial will generally flower, develop fruit and die. A **perennial** lives for more than two growing seasons producing above ground stems and leaves and flowering repeatedly over a number of years. Herbaceous perennials may have swollen underground roots (sweet potato) or stems (tulips) that serve as food storage and in asexual reproduction. Broadleaved herbaceous plants are often referred to as **forbs**. **Succulents** are herbaceous plants possessing thick, usually soft, watery leaves and/or stems.

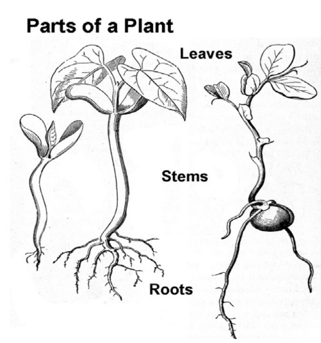

Figure 2

Plant Parts

A complete plant is composed of four basic organs: roots, stems, leaves, and flowers. Each has crucial functions within the plant. Diversity is the key word in the plant world as they have adapted to many different habitats and producing a myriad of different characteristics. This chapter includes some of the more common attributes.

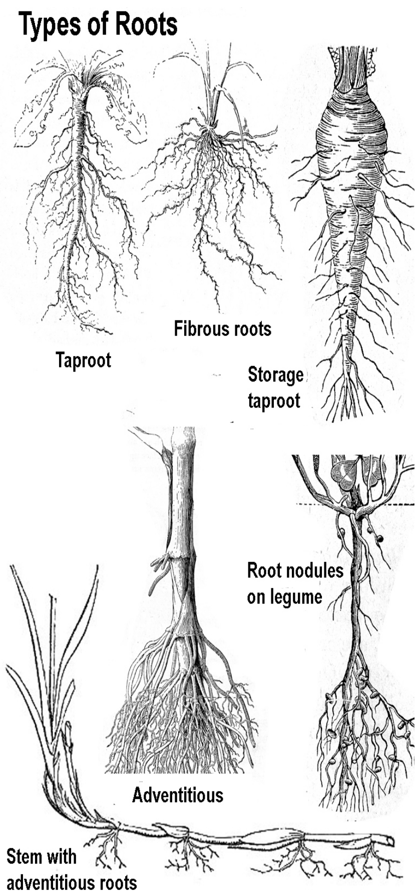

Figure 3

Roots

- Usually the portion of the plant that absorbs water and minerals.
- Mostly underground.
- Principal organ of attachment.
- Lacks nodes and buds.

There are two general types of roots — **primary**, which develop from the primary root of the seedling into either a taproot or a fibrous root system, and **adventitious**, which are roots that originate from any part of the plant other than the root system. A **taproot** is a central main root that descends vertically and is generally larger than any branching root. **Fibrous roots** are thin thread-like roots arising from a taproot or from stem tissue. Sometimes roots are greatly enlarged for food storage for the next growing season or may be a means of asexual reproduction. Examples of enlarged roots are carrots, beets, sweet potatoes, and dahlias. (See Figure 3).

A fungus among us — Mycorrhizae

As many as 90% of plant species have an associated mycorrhizae fungi. Mycorrhizae literally means "fungus-root". Hyphae of specific fungi live within or on plant roots. The fungus helps the plant by increasing the plant's access to nutrients and water. The plant can literally do a better job of mining the soil for water and nutrients. During drought and nutrient stress a plant's mycorrhizal association may mean life or death, or certainly can translate into the difference between either persevering or thriving. The fungus benefits by getting carbohydrates from the plant's roots. Mycorrhizae associations are not the same as nitrogen-fixing bacteria.

Stems

- Main support of a plant containing conductive tissue for transferring water, carbohydrates, and nutrients from one organ to another.
- Leaf- and flower-bearing main axis of a plant.

- Aerial or underground.
- Divided into nodes and internodes.
- Give rise to branches, leaves, and flowers.

Aerial stems are the most common and can be erect or prostrate. Stems that trail along the surface of the soil, sending up new erect stems at nodes or tip, are called **stolons** or **runners**. **Rhizomes** are creeping, usually underground, horizontal persistent stems that produce new upright stems at their tips. Some stems are also modified for the storage of food. Their leaves are often reduced to scales and they usually bear adventitious roots and buds. **Tubers** such as the Irish potato are fleshy, solid, underground and horizontal stems with thick skins. **Corms**, such as those produced by crocus and gladiolus, are underground, very short, erect, swollen stem bases covered by dry leaf bases. True **bulbs**, such as onions and tulips, are usually borne below ground as erect thickened stems surrounded by swollen, fleshy bud-scales, which are modified leaves and which, in turn, are enclosed by a dry, paper-like tunic, also made of modified leaves. Stolons, rhizomes, tubers, corms, and bulbs may serve as food storage areas and/or as a means of asexual reproduction for the plant. (See Figure 4).

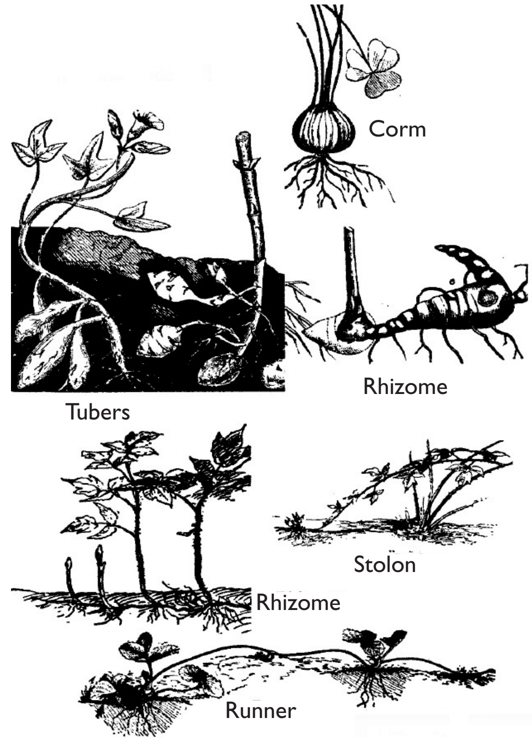

Figure 4

Stem Characteristics

Stems can be very important when identifying plants, particularly when identifying woody plants in winter. Several stem features are worth learning. (See Figure 5).

Node—the position on a stem where a leaf or bud is or was attached.
Internode—the portion of a stem between two nodes.
Lenticel—a pore which allows gas exchange; often raised; variable size.
Axil—the upper angle between a leaf (or any other lateral structure) and the stem to which it is attached.
Bud—the structure giving rise to a leafy stem, a flower, or both; it may be naked or protected by bud scales or stipules; it may be lateral or terminal.
Terminal bud—bud borne at the apex of many stems; often larger than other buds; the first bud to open in spring.
Axillary bud—a bud borne in the axil of a leaf (also called a lateral bud).

Twig Illustration
Horse Chestnut in Spring

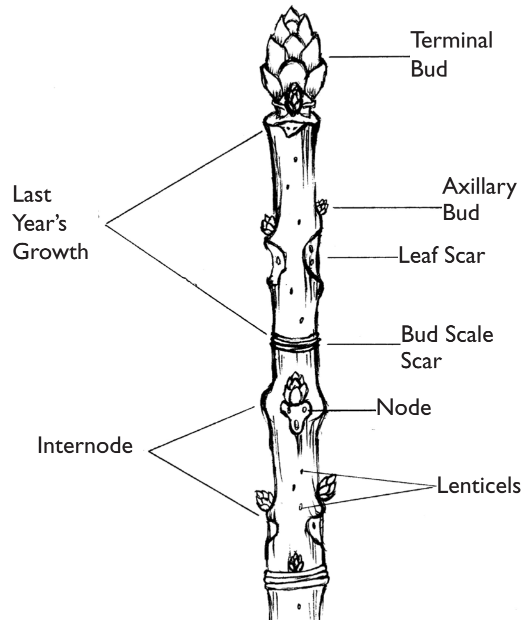

Figure 5

Bud scales—scale-like leaves that protect the buds.
Bud scale scars—scars remaining when the bud scales fall off.
Stipules—usually a pair of appendages located at the base of a leaf but may be fused into a ring around the stem; variable in size, shape and texture; serves for protection or to attract pollinators; not present in all woody plants.
Stipule scars—a pair of scars or a single ring-like scar when stipules fall away.
Leaf scar—the scar left when a leaf falls from a twig; it contains one or more vascular bundle scars.

Leaves

- Lateral appendages on a stem.
- Usually serve as the primary photosynthetic surface of the plant.
- Can be extremely modified in morphology.

Leaf Persistence
Leaves on woody perennials may be deciduous or evergreen. **Deciduous** means leaves are shed during unfavorable conditions (such as at the end of each growing season). Plants that are **evergreen** bear green foliage all year. They do lose older leaves over time, but not all at one time.

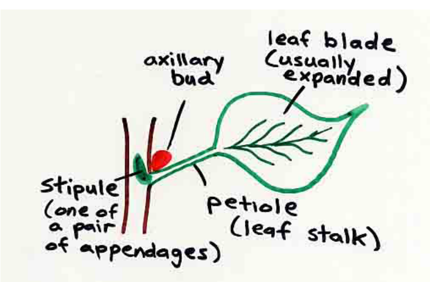

Figure 6

Leaf Complexity
Leaves are either simple or compound. **Simple leaves** are composed of: a **leaf blade** that is the expanded portion of a leaf, and a **petiole** that is the stalk of a leaf which attaches it to the stem. (See Figure 6).

Compound leaves are composed of several to numerous individual leaflets arranged in either a palmate or pinnate fashion. In **palmately compound** leaves the leaflets arise from a common point of attachment similar to the palm of your hand. **Pinnately compound** leaves have more than three leaflets arranged in two rows along a common axis called a **rachis**. The leaflets are attached by a **petiolule** (the stalk of a leaflet) similar to the vanes of a feather. Pinnately compound leaves may have another set of leaflets on the original leaflets making it **bipinnately compound**. Kentucky Coffeetree, *Gymnocladus dioicus* is a good example of this. There are also tripinnately compound leaves. (See Figure 8).

With all this diversity it may seem very confusing; however, an easy way to determine what is the complete leaf is to look for the axillary bud to help identify where the leaf begins. Look for it above the petiole. Everything above the axillary bud is all one leaf.

Leaf Arrangement
Leaves occur on the stems in **alternate** (one leaf per node), **opposite** (two leaves per node), or **whorled** arrangements (three or more leaves per node) as illustrated in Figure 8. Leaf arrangement is often the first characteristic listed in a key.

Leaf Shape
The general outline of a leaf is referred to as the leaf shape, and some of the diverse types are described in the following text and illustrated in Figure 8.

A. **Linear**—long and narrow with the sides parallel (>4:1).
B. **Lanceolate**—spear-shaped; widening above base and then long tapering to apex (3-4:1).
C. **Ovate**—egg-shaped; broad nearest base (<3:1).
D. **Elliptic**—ellipse shaped; widest near middle and tapering at both ends.
E. **Narrowly elliptic**—ellipse shaped but more narrow than above.
F. **Obovate**—ovate, but with narrower end towards point of attachment. (The prefix "ob" means opposite, so "obovate" is the opposite of "ovate.")
G. **Spatulate**—spoon-shaped and attached at the narrow end.
H. **Deltoid**—triangular.
I. **Rhomboid**—parallelogram with oblique angles and only the opposite sides equal.
J. **Reniform**—kidney bean shaped.
K. **Orbicular**—circular.

Leaf Margins (See Figure 9)

A. **Entire**—a margin without any toothing or division (smooth).
B. **Crenate**—scalloped or round-toothed.
C. **Serrate**—a saw-toothed margin with sharp teeth pointing towards the apex.
D. **Dentate**—sharp teeth projecting at right angles from the margin.
E. **Pinnately lobed**—lobed towards the midrib but not reaching

it.

F. **Palmately lobed**— lobes all arising from one point at the base of the leaf.

Leaf Tips (See Figure 8)

Many of the same terms are used to describe tips and bases.

A. Aristate—tapered to a narrow elongated apex with bristle-like structure.
B. Acuminate—sharp, ending in a long-tapering point with concave sides.
C. Acute—sharp, ending in a point with straight sides to the apex (<90 degrees).
D. Mucronate—a small, abrupt point.
E. Obtuse—blunt, rounded (>90 degrees).
F. Retuse—shallow notch in rounded or obtuse apex.
G. Emarginate—with a shallow notch at apex.

Leaf Bases (See Figure 9)

A. **Attenuate**—long slender taper; more gradual than acuminate.
B. **Cuneate**—wedge-shaped; triangular with narrow part at point of attachment.
C. **Obtuse**— blunt, rounded (>90 degrees).
D. **Truncate**—ends abruptly; almost at right angles to main axis as if cut or squared off.
E. **Oblique**—unequal sized lobes at base.
F. **Cordate**—heart-shaped (equal rounded lobes at the base).
G. **Sagittate**—shaped like an arrowhead; triangular-ovate with two straight or slightly concave basal lobes.
H. **Perfoliate**—leaf or petiole completely surrounds stem.
I. **Hastate**—shaped like an arrowhead, but with divergent lobes at the base.
J. **Peltate**—umbrella-like; the petiole is attached to the blade inside of the margin; often orbicular in shape.
K. **Sheathing**—leaf base wraps around the stem.

Leaf Attachment

Leaves may be attached to a stem in several different ways. **Petiolate** describes a leaf attached with a petiole. **Subsessile** refers to a very short petiole. **Sessile** leaves lack a petiole.

Leaf Venation

Leaf venation can be another good clue when identifying plants. **Pinnate** venation consists of a central mid-vein with many secondary veins emerging on both sides to form a feather-like pattern. With **palmate** all primary veins arise at the same point at the base of the leaf, characteristic of maple leaves, *Acer* spp. **Parallel** veins lie more or less parallel to the leaf margins, which is common in dogwoods, *Cornus* spp. (See Figure 7).

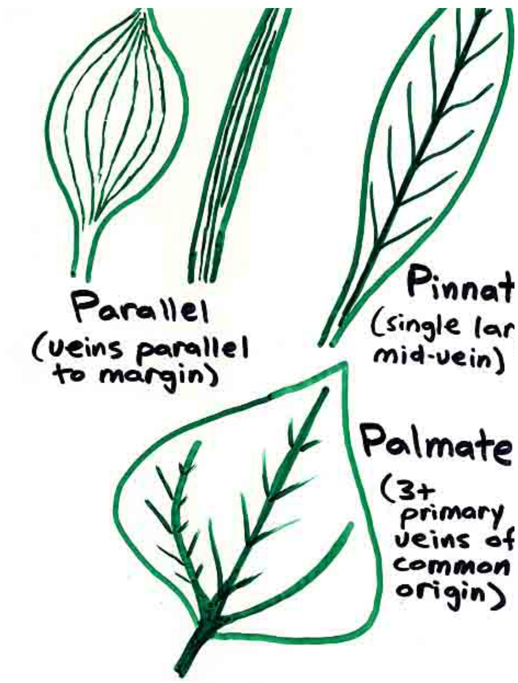

Figure 7

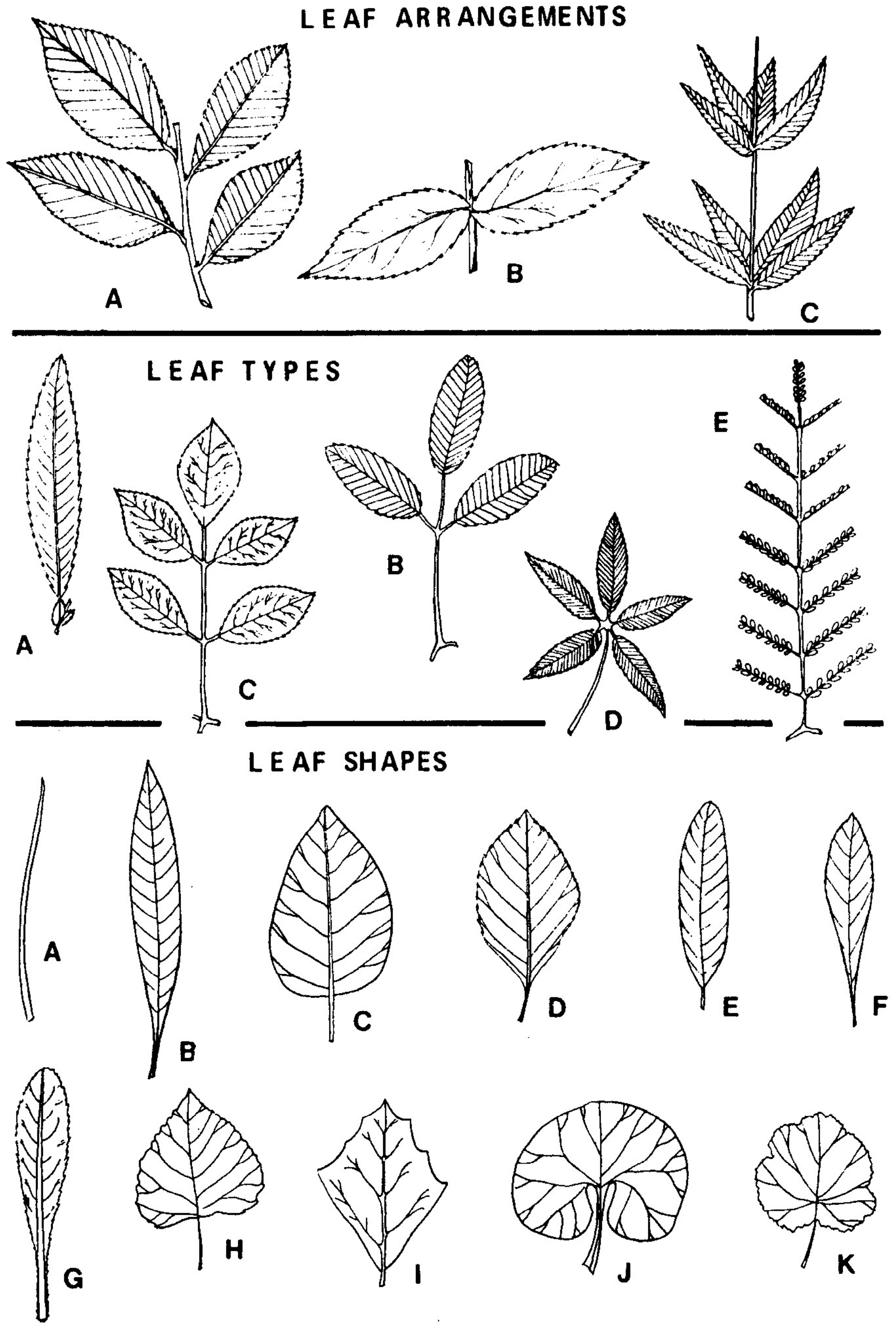

Figure 8. **Leaf arrangements:** A, alternate; B, opposite: and C, whorled. **Leaf types:** A, simple; B, ternately compound; C, pinnately comound; D, palmately compound; and E, twice-pinnately compound. **Leaf shapes:** A, linear; B, lanceolate; C, ovate; D, elliptic; E, narrowly elliptic; F, obovate; G, spatulate; H, deltoid; I, rhomboid; J, reniform; and K, orbicular.

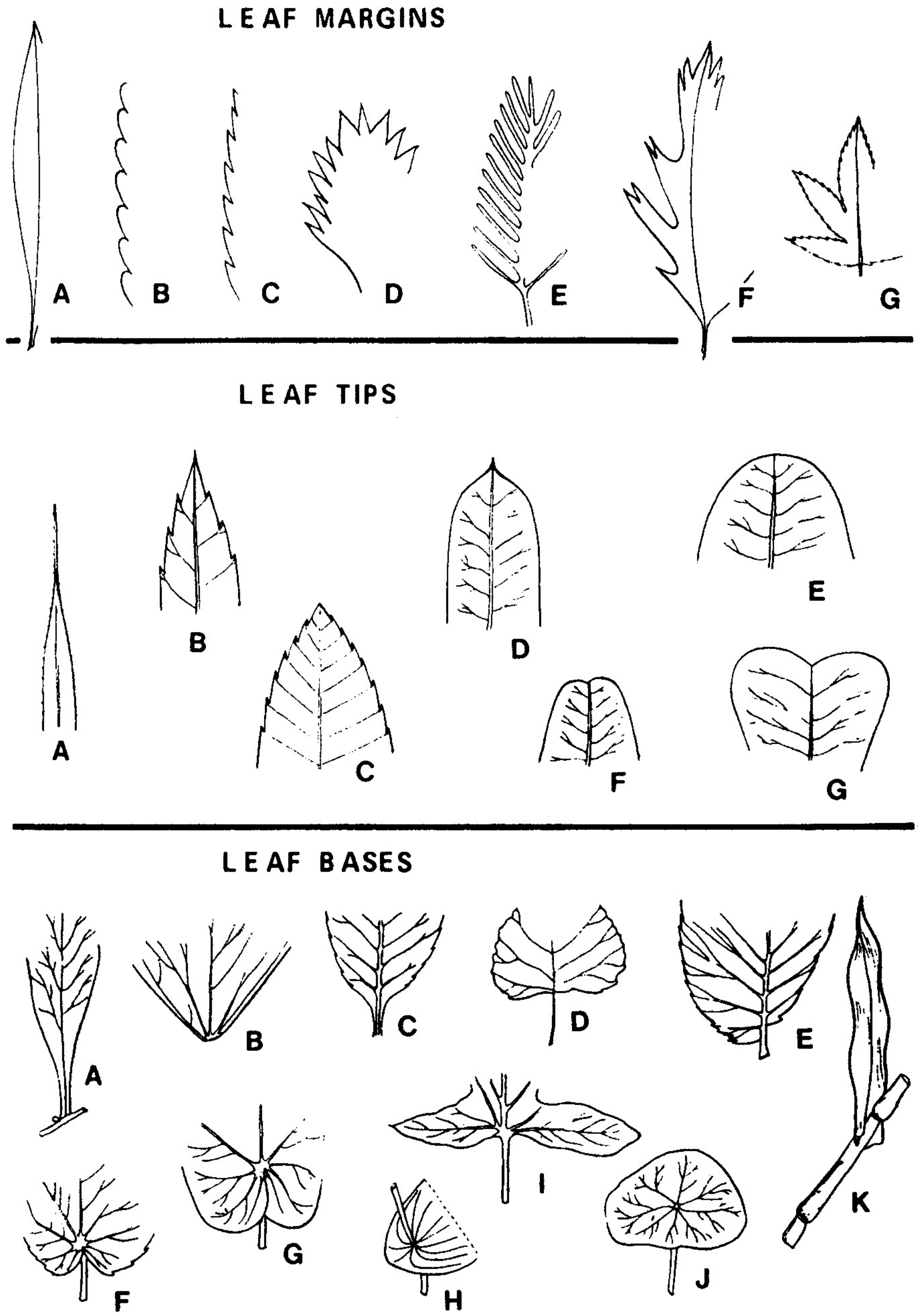

Figure 9. **Leaf margins:** A, entire; B, crenate; C, serrate; D, incised; E, pectinate; F, pinnately lobed; and G, palmately lobed. **Leaf tips:** A, aristate; B, acuminate; C, acute; D, mucronate; E, obtuse; F, retuse; and G, emarginate. **Leaf bases:** A, attenuate; B, cuneate; C, obtuse; D, truncate; E, oblique; F, cordate; G, sagittate; H, perfoliate; I, hastate; J, peltate; and K, sheathing.

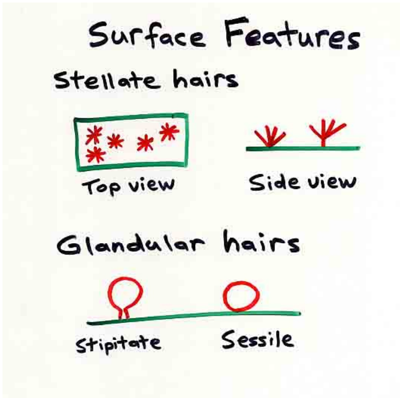

Figure 10

Surface Features
Leaves continue their amazing diversity with special surface features. **Glabrous** leaves have a smooth surface. **Pubescent** leaves are covered with hairs (also called trichomes). **Stellate** describes a leaf surface with hairs that branch at or near their base. The hairs appear star-shaped from above when viewed through magnification. **Glandular** leaves possess hairs that bear glands which release sticky beads of fluid when broken. The hairs may be stalked or sessile. There are many more types of surface features. (See Figure 10).

Special Features
Plants may possess additional modifications. A **tendril** is an elongated, twining segment of a leaf, stem, or flower inflorescence by which a vine clings to its support. A **thorn** is a woody, sharp-pointed, modified stem. A **spine** is a sharp-pointed modified leaf or leaf part. **Stipular spines** are borne in pairs and are lateral to a leaf (or leaf scar). A **prickle** is a sharp pointed outgrowth from the epidermis. Rose thorns are really rose prickles. (See Figure 11).

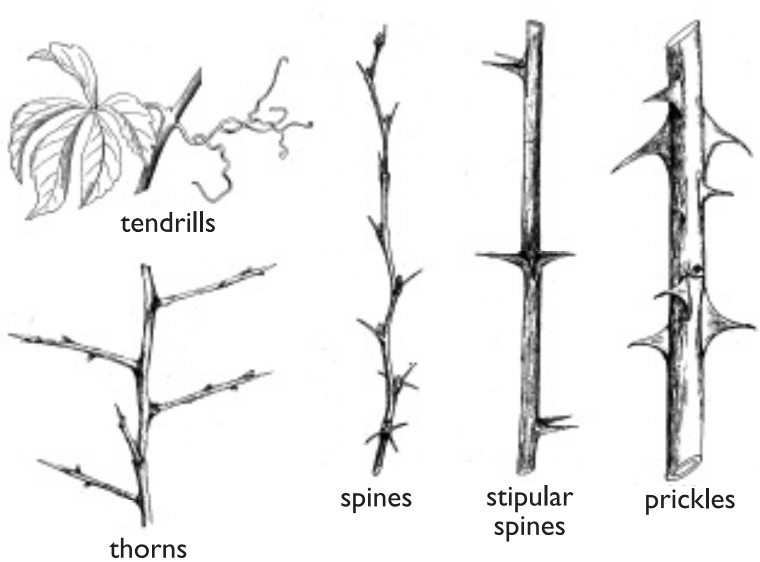

Figure 11

Flowers

- The reproductive part of a plant.
- Mature into fruits that contain seed.

We enjoy flowers for their color, shape and fragrance; however, flowers are designed for one purpose — to perpetuate the species in the most appropriate manner for its habitat. Flowers are composed of several parts, each with a distinct purpose in carrying out the flower's "mission in life."

The **sepals** are the outermost parts of a flower; are commonly green; and rather leaf-like in appearance. Although in some species the sepals are colored and petal-like. Collectively, the sepals are called the **calyx.**

The **petals** are positioned inward from the sepals and are commonly colored and delicate in texture. Collectively, the petals are called the corolla, and the sepals and petals together are called the **perianth.** In some plants, the sepals and petals cannot be determined, and the perianth parts are then called **tepals.**

The **stamens** are inward from the petals and are the "male" reproductive parts of the flower. A stamen usually consists of the **anther,** which contains the **pollen,** and a stalk called the **filament.** Collectively, the stamens are called the **androecium.**

The **carpel** occupies the central position in a flower and is the "female" reproductive part. (The term pistil is no longer used.) It consists of a terminal **stigma,** which is often sticky, the function of which is to receive the pollen; a slender **style;** and, at the base, an **ovary,** which contains one or more **ovules.** The ovules, once fertilized, develop into seeds. Collectively, all the carpels in one flower are called the **gynoecium.** (See Figure 12).

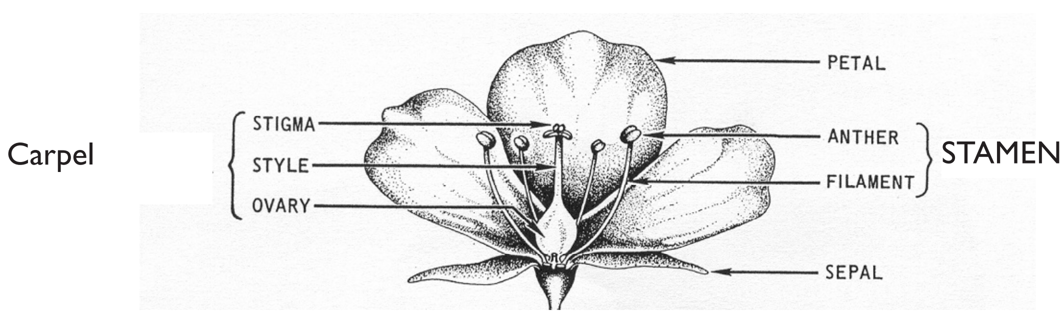

Figure 12. Parts of a Flower

Flower Completeness

Not all flowers have a full complement of parts. Completeness refers to individual flowers. Flowers with all four floral series present (calyx, corolla, stamens, and carpels) are referred to as **complete.** If one or more floral series are absent, the flowers are described as **incomplete.** Flowers with both functional androecium (male) and gynoecium (female) parts are called **perfect.** Either calyx or corolla is missing in perfect flowers. **Imperfect flowers** lack either a functional androecium (male) or a functional gynoecium (female).

Staminate—a male flower; one that has a functional male part, but lacks a functional female part.

Carpellate—a female flower; one that has a functional female part, but lacks a functional male part.

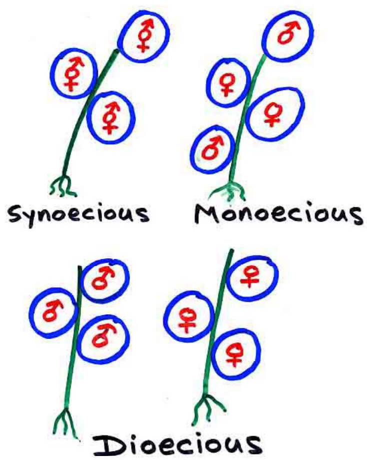

Figure 13

Plant Condition

Additional terminology describes the entire plant in relation to the completeness of its flowers. Synoecious plants have flowers that are all perfect. Monoecious plants possess both staminate (male) and carpellate (female) flowers on the same plant. When staminate and carpellate flowers occur on different plants the plant is called dioecious. (See Figure 13).

Flower Parties

A flower inflorescence is simply the arrangement of flowers on a floral axis; basically a cluster of flowers. A variety of inflorescences are illustrated in Figure 17. You may be familiar with additional inflorescences that are not pictured, such as the spathe and spadix of Jack-in-the- pulpit and catkins of birch trees.

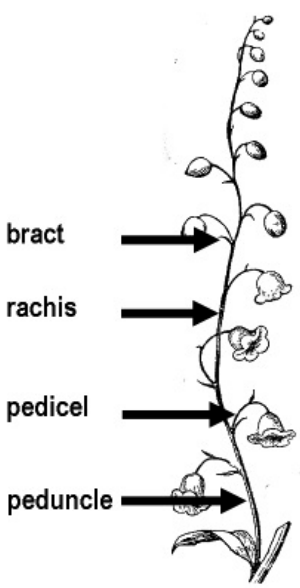

Figure 14

Parts of an Inflorescence

Peduncle—the stalk of an inflorescence or a solitary flower.

Pedicel—the stalk of one flower in an inflorescence.

Rachis—the primary axis of an elongated inflorescence.

Bracts—a modified or much-reduced leaf associated with an inflorescence or flower. These may differ substantially from foliage leaves.

Involucre—a series of bracts immediately subtending a flower or inflorescence.

Positions of Inflorescence

Where the cluster of flowers is held on the plant varies among plants and type of inflorescence.

Axillary—in the axil of a leaf or bract.

Whorled—occurring in whorls at a single node.

Terminal—occurring at the tip.
Intercalary—the inflorescence is disrupted by vegetative growth.
Basal—arises at base of plant on a leafless peduncle (scape).
Cauliflory—flowers that appear to grow directly upon woody branches or trunks. Example: redbud tree.

Sequence of Flowering and Types of Inflorescences
In some inflorescence the terminal or central flower opens first. The primary axis then stops elongating. These are known as determinate inflorescence. (See Figure 16).

A. Simple (or basic) **cyme**—a three-flowered cluster composed of a peduncle bearing a terminal flower and below it two bracts with each bract subtending a lateral flower.
B. **Compound cyme**—a branching cyme.

In some plants the inflorescence primary axis continues to grow as the flowers develop. These are called indeterminate inflorescence. The lowermost or outermost flowers open first; usually no terminal flower is produced.

C. **Panicle**—similar to a raceme but greatly branched.
D. **Raceme**—stalked flowers arranged along an elongate central axis.
E. **Spike**—sessile flowers arranged along an elongate central axis.
F. **Corymb**—short, broad, and flat-topped.
G. **Simple umbel**—several branches radiating from the same point and terminated by single flowers.
H. **Compound umbel**—same as above with additional secondary umbels.
I. **Head** (capitulum)—a compact inflorescence composed of a very short axis and usually sessile flowers; characteristic of sunflower family. (Illustrated in detail in Figure 15).

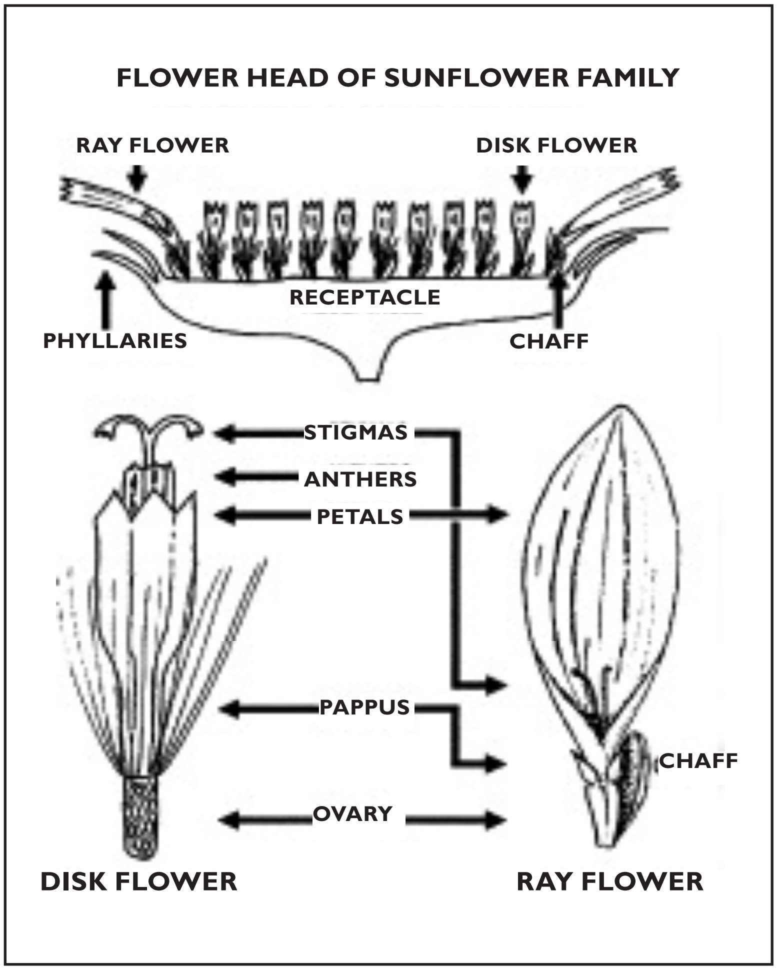

Figure 15

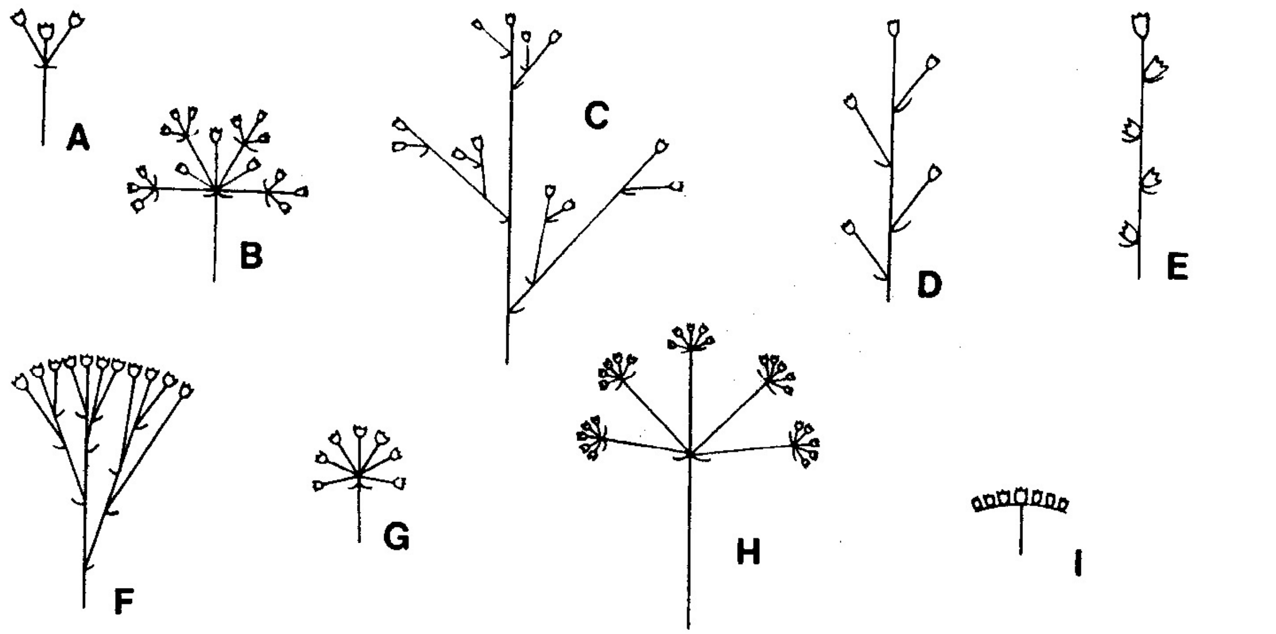

Figure 16. **Inflorescences:** A, simple cyme; B, compound cyme; C, panicle; D, raceme; E, spike; F, corymb; G, simple umbel; H, compound umbel; and I, head.

Fruits

A **fruit** is the ripened ovary of a flower, and a **seed** is the matured ovule. **Simple fruits,** such as grapes, cherries, and tomatoes, develop from a single ovary. Fruits are highly diverse, but can be classified by the number of ovaries involved in their formation, their consistency and structure, and whether they are **dehiscent** (splitting open at maturity) or **indehiscent** (remaining entire at maturity).

Many of these fruit types are shown in Figure 17.

Fruit Types Based On Morphology

Dry Fruit Types

Dehiscent Fruit (shatters open when ripe)

Follicle—a dry fruit derived from a simple carpel and opening by one slit.

Example: milkweed.

Capsule—a dry fruit, but derived from a compound carpel and usually with several areas of dehiscence. Contains few to many seeds.

Septicidal dehiscence—dehisces along the septa (membrane that separates the cavities). Example: dutchman's pipe.

Loculicidal dehiscence—dehisces directly into the locule (cavity). Examples: jimson weed, violets, lilies, and yucca.

Poricidal dehiscence—dehisces by apical pores. Example: poppy.

Denticidal dehiscence—dehisces by apical teeth. Example: shooting star and royal catchfly.

Circumscissile dehiscence (=pyxis)—top comes off like a lid. Example: portulaca and cockscomb.

Indehiscent Fruit (does not shatter open when ripe)

Achene—a dry, one-seeded fruit with the seed attached at one point to the fruit wall. Example: sunflower.

Nut—large, single, dry, one-seeded fruit with a hard shell. Examples: acorn, chestnut and hazelnut.

Are we nuts or what? No, we're not!

Peanuts (a legume)
Coconuts (a drupe)
Almonds (a drupe)
Walnuts (a drupe)
Pecans (a drupe)
Brazil nuts (seeds from a capsule)
Cashews (seeds from drupes)
Pistachio nuts (seeds from drupes)

Nutlet—a small nut; involucre absent.

Schizocarp—derived from a flower with united carpel that splits into two or more one-seeded segments.

Samara—a winged achene. Examples: elm and ash.

Fleshy Fruit Types

Berry—an indehiscent, fleshy fruit with few to many seeds (rarely one seed); carpels variable. Examples: tomatoes, bananas, grapes, blueberries, kiwis, peppers, eggplants, cranberries, and avocados.

Drupe and drupelet—indehiscent; fleshy but with a stone or pit inside. Examples: peaches, cherries, and olives.

Fruit Types Based On Taxonomy

Caryopsis (grain)—(Grass family) Poaceae; a dry, one-seeded fruit with the seed coat fused to the fruit wall. Examples: corn, wheat, rye, and barley.

Hesperidium—(Citrus family) Rutaceae; specific to citrus. Examples: orange, lemon, lime, and grapefruit.

Legume—(Pea Family) Fabaceae; dry pod splitting along two sutures. Examples: beans, peas, locust, and redbud.

Pome—(Apple subfamily/Rose family) Rosaceae; fleshy fruit having united carpels surrounded by a usually edible receptacle. Examples: apple, pear, and quince.

Pepo—(Gourd family) Cucurbitaceae; characterized by hard rind and many seeds. Examples: pumpkin, squash, and cucumber.

Silique and silicle—(Mustard family) Brassicaceae; possessing two valves that fall away from a thin membrane bearing the seeds. Examples: mustard and shepherd's purse.

Special Fruit Types

Aggregate fruits—the product of a number of separate ovaries contained within a single flower. Example: blackberry, raspberry and magnolia (aggregate of follicles).

Multiple fruits—the product of mature ovaries of several flowers that coalesce into one mass. Other floral structures (i.e., accessory tissue) may become fleshy as well. Examples: pineapple, mulberry, and fig.

Accessory fruits—tissue other than, or in addition to, the ovary that enlarges and becomes fleshy. Example: strawberry.
Hip—specific to roses.

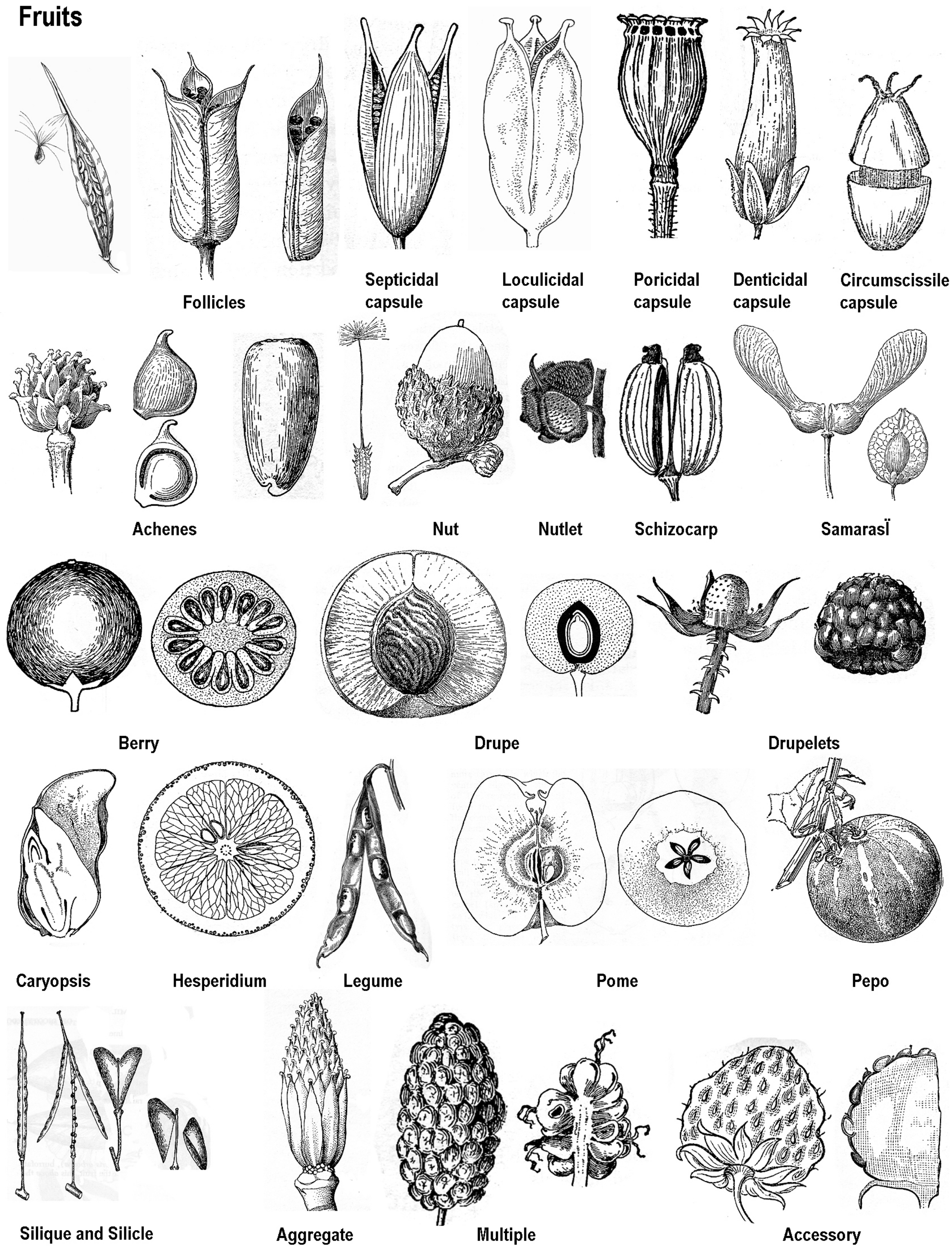
Fruits
Follicles
Septicidal capsule
Loculicidal capsule
Poricidal capsule
Denticidal capsule
Circumscissile capsule
Achenes
Nut
Nutlet
Schizocarp
SamarasÏ
Berry
Drupe
Drupelets
Caryopsis
Hesperidium
Legume
Pome
Pepo
Silique and Silicle
Aggregate
Multiple
Accessory

Figure 17

Life Cycle of a Flowering Plant

Sexual reproduction is just as important for plants as it is for animals when it comes to generating genetic variation, but plants have a singular disadvantage compared to animals when it comes to sex: they can't just get up and find themselves a mate.

May R. Berenbaum, *Bugs in the System (1995)*

Two critical stages in the life cycle of a flowering plant are pollination and dispersal. Pollination is the transfer of pollen from anther to stigma, generally most successful on a different plant of the same species. Most flowering plants have different types of mechanisms to promote the transfer of pollen from an anther in one flower to a stigma in a different flower.

Dispersal is the movement of seeds away from the parent plant. Plants often solicit the aid of animals to accomplish both of these.

Much of the flower diversity that has been discussed thus far is due to adaptations for pollination by different mechanisms. The vast majority of flowering plant species are pollinated by insects; in fact, it seems that flowering plants and many major groups of insects co-evolved. Animals other than insects can also be important pollinators, such as bats, birds (especially hummingbirds), and even a few mammals.

For flowers requiring pollinators, it doesn't pay to hide. To attract biological pollinators, flowers must advertise, offer rewards, provide access and have the correct structure for pollen transfer. Color and/or nectar guides are excellent neon signs to advertise for pollinators. Scent may also be used for advertisement. Not all flower scents smell wonderful to us. Flowers pollinated by flies may stink of rotten meat. Flowers also offer rewards such as pollen, nectar, other food from special structures, breeding sites, and in a few cases, warmth. Flower adaptations for pollinator access include a place to land or to hover. Flowers must also be held in the right position for pollinators to find them. Flowers must possess the correct structure that allows transfer of pollen from plant to pollinator and pollinator to the next flower.

Table 2 describes the main types of pollination mechanisms. However, please keep in mind that there are always exceptions; plants and animals that visit flowers have minds of their own!

Table 2

Mode of Pollination	Visitation & Anthesis (1)	Flower Morphology	Color	Odor
Beetles	Day & Night	Actinomorphic (2); numerous floral parts; large bowl shaped; ovules protected	Dull, white, few visual attractions; no nectar guides	Strong, fruity or aminoid; no nectar; food primarily pollen or food bodies
Carrion & Dung Beetles & Flies	Day & Night	Actinomorphic; deep corolla tube with appendages forming traps	Purple, brown (like meat); no nectar guides or nectar	Strong, like rotting meat; really awful smell
Flies & Bee Flies	Mostly day	Actinomorphic; little depth	Variable, but often dull or light; nectar guides present	Little to (too) much odor; nectar present or absent; accessible; food often pollen
Bees	Day	Often zygomorphic (3); shape variable; little depth to tubular	Yellow, blue, or white, usually not red; often with nectar guides	Sweet odor, nectar usually present, often hidden
Butterflies	Day	Actinomorphic; erect anthers on narrow tubular corolla	Yellow, blue, pink and red; often with nectar guides	Strong or weak; nectar present in corolla tubes or spurs
Hawkmoths	Night or dusk	Actinomorphic; narrow tubular corolla; anthers often versatile; flowers horizontal or hanging down	White or sometimes pale green to yellow; no nectar guides	Heavy, sweet odor at night; abundant nectar
Fly-gnats	Stay open for several days	Urn or kettle-shaped traps; have structures that mimic fungus gills or pores; close to ground level	Dark purple or brown	Musky like a fungus; intense transpiration during flowering period for humidity
Birds	Day	Actinomorphic; stiff, wide tubular with hanging stamens	Often bright red; no nectar guides	No odor; abundant nectar; ovary protected
Bats	Night	Large, sturdy, wide, somewhat zygomorphic; accessible	White, cream, or drab; no nectar guides	Strong at night, often smelling like fermenting yeast; abundant nectar; food bodies, and/or pollen
Mice	Night	Sturdy, often "snout" shaped corolla; many stamens or dense heads of flowers; accessible near the ground	White, cream, dull red, or drab; no nectar guides	Yeasty odor; abundant nectar and/or pollen
Wind	Day	Small, imperfect; produced before leaves unfold or outside crown of plant; inflorescences often hanging	Little color	None

1. **Anthesis** — time when flower comes into full bloom; flower fully expanded.
2. **Actinomorphic** — flowers that are radially symmetric; capable of being bisected into identical halves along more than one axis, forming mirror images.
3. **Zygomorphic** — flowers that are bilaterally symmetrical.

Seed Dispersal

Why is dispersal important?

- Avoid competition with parent and siblings.
- Colonize new habitats.
- Avoid pathogens and predators.
- Minimize inbreeding.

Plants often solicit the aid of animals, as well as abiotic forces such as wind to accomplish dispersal. Insects are much less important for dispersal than for pollination, but ants are often involved in dispersal. Birds, mammals, reptiles, and even fish are much more important for dispersal than for pollination. Wind is important in both pollination and dispersal. Water is of minor importance in pollination and somewhat greater in dispersal. Just like some plants carry out self pollination, some plants have mechanisms for self dispersal.

Units of Dispersal

Different plant parts become modified for dispersal. Fruits, parts of fruit, or other structures such as sepals, bracts or even the whole plant may be involved in dispersal. The term diaspore is used for the unit of dispersal, no matter what it is morphologically.

Wind Dispersal

If you think of all the ways things blow in the wind, there are probably seeds which take advantage of that way. Some seeds, such as in orchids, are dust-like — or tiny, as in Indian paintbrush. Samaras have wings to take them away from their parents, as in maple and trumpet creeper. How many of us have blown the plumed seeds of milkweed and dandelion? Anemones and cattails are wooly to help move their seeds around. The bladdernut is well named, for it balloon diaspores. Some entire plants, such as tumbleweed, break off and blow around.

Water Dispersal

Water dispersal may include splash cups in lousewort, or the use of sea currents, as in coconut. Streams may move some plants from different bodies of water, as in water lily.

Animal Dispersal

Animal involvement in dispersal may be passive, as in the use of awns, hooks, and barbs that attach to animals and to our pant legs. *Bidens*, beggar's tick fruits; *Geum*, white avens fruits; and *Arctium* *minus*, burdock fruits are excellent examples of fruits that hitch a ride. Some plants may use simple adhesion with a sticky, mucilaginous coating around seeds when they are wet.

Animal dispersal may also be active. Birds and squirrels carry seeds such as acorns to other areas to cache for later meals. Ants will cache some seeds to eat the elaiosomes (fruit or seed outgrowths which contain oil). Animals also eat fruit and defecate the seeds into new territory.

Mechanical Dispersal
Some plants with ballistic fruits, such as wood cranesbill and touch-me-not, literally explode their seeds away from the mother plant. Other plants as with shooting star and poppy rely on movement from animals and wind to shake the fruit to expel the seeds. Hygroscopic fruits curl and uncurl with changes of humidity and in the process plant themselves.

Methods of dispersal are often tied to plants of certain habitats. Wind dispersal is typical of prairie/grasslands, mountains, forest trees, and weedy areas. Using external attachment to animals is useful in forest plants that grow relatively low to the ground. Ingestion by animals is another good dispersal mechanism for forest plants. It makes sense that plants that grow in wetlands and along streams would utilize water to disperse their seeds. Plants with ballistic fruits such as some parasitic plants, some forest plants, and some weedy plants may be in various habitats.

Seed Germination

All the adaptations we have discussed lead toward seed deposition into a suitable place for growth. Obviously not all seeds will be successful at producing a new plant. Most plants rely on producing large quantities of seed, so at least some will develop.

A seed is a ripened ovule containing an embryo within a seed coat, often with additional storage tissues. In other words, "a baby in a box with its lunch." The seed has all it needs to develop a new plant given the correct environmental conditions.

Once seeds are dispersed they may germinate immediately, if conditions are correct for that species and provided the seeds are viable. Or they may not germinate even when environmental conditions are appropriate. Many seeds have a dormancy mechanism so the seed will only germinate at an optimal time. In temperate areas a newly germinated seed in autumn might not survive the winter. Its chances of survival are greater if it stays dormant until spring. In other areas of the world seeds may stay dormant during the dry season then germinate when the rainy season returns. Seed dormancy is the failure to grow even under favorable conditions. The dormancy may relate to physiological immaturity. The seed needs an "after-ripening" period even after the fruit has ripened. Seed dormancy often relates to an impermeable seed coat. The seed coat doesn't allow water to be absorbed to begin the germination process. Absorbing water is the first step to germination. (See Figure 18).

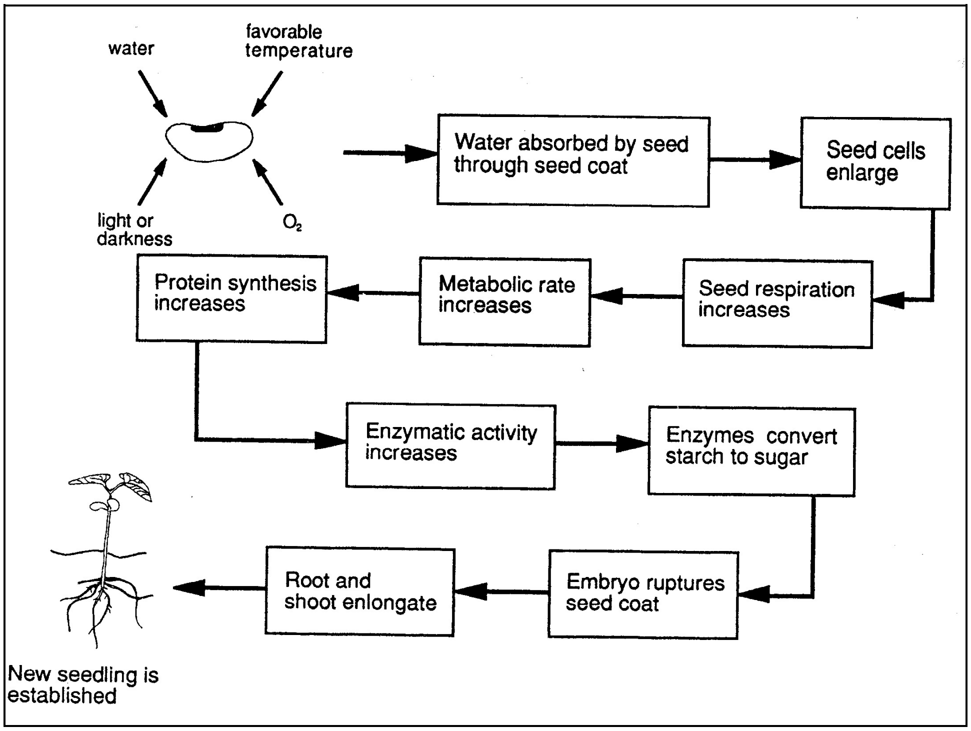

Figure 18

Plant Growth and Development

Photosynthesis

In order to grow, a plant needs light from the sun, carbon dioxide and oxygen from the atmosphere, and chemical elements and water from the soil. In the process of photosynthesis, carbon dioxide and water in the presence of chlorophyll and light energy are converted to sugar with oxygen as a byproduct. A simple representation of this very complex process is often summarized as follows:

$$6\ C0_2 + 6\ H_20 + \text{energy} \rightarrow C_6H_{12}0_6 + 6\ 0_2$$

Carbon dioxide ($C0_2$) and water (H_20) combine in specialized organelles within a cell called **chloroplasts,** containing chlorophyll, in the presence of energy from light to produce sugars ($C_6H_{12}0_6$) and oxygen (0_2). Energy is necessary for cells to stay alive, carry on vital processes, and make new cells. Some chemical reactions within cells require no energy and others release energy when the reaction occurs. Most reactions require energy. Only cells containing chlorophyll in plant leaves and stems can manufacture energy. Chlorophyll absorbs radiant energy from light and uses this energy to split water molecules. The end product, glucose, a type of sugar, may be used in cellular respiration to provide more chemical energy, or it may be converted into other substances such as sucrose, starch, cellulose, amino acids, proteins, fats, and other compounds. Photosynthesis accounts for all the chemical compounds in the cell and provides the energy for all other processes.

Generally, as sunlight increases in intensity, photosynthesis increases, which translates into greater food production within the plant. Some plants, however, are much more efficient at higher light levels than others.

Photosynthesis also requires carbon dioxide, which enters the plant through the stomata of the leaf. Carbon dioxide is split into carbon and oxygen, which are used in the manufacture of carbohydrates. In most instances, carbon dioxide is plentiful in the air. However, in a tightly enclosed greenhouse, plants may use more than can be replenished by outside air movement through the greenhouse covering.

Water is necessary to drive the photosynthetic reaction. Since most plants contain a high percentage of water, limited water for the chemical reaction to take place is unlikely. However, as the plant comes under moisture stress, stomata close down to prevent excess moisture loss through a process known as transpiration. (Explained in more detail in later text.) This has the effect of also shutting down carbon dioxide exchange through the stomata. The plant soon runs out of carbon dioxide for photosynthesis, so the manufacture of food shuts down.

Temperature can also be an important factor. Photosynthesis occurs at its highest rate in most plants at a temperature range of 65 to 85°F. Higher or lower temperatures may hinder this process unless the plant is specially adapted to temperatures outside this range. Of the total sunlight energy that falls on the leaf surface, typically only 3 percent is used for photosynthesis, 15 percent is reflected and 5 percent passes through the leaves. The other 77 percent raises the temperature of the leaf. If it were not for the cooling action of transpiration, leaf temperatures would be excessive. As the temperature rises, photosynthesis increases until the temperature becomes too high. At high temperatures, photosynthesis shuts down. The temperature at which this occurs depends on the type of plant. Some are adapted only to very cool temperatures while others thrive in relatively warm situations.

Respiration

Carbohydrates made during photosynthesis are valuable to the plant when they are converted into energy. This energy is used to build new tissues and to help the plant grow. The chemical process by which sugars and starches produced by photosynthesis are converted to energy is called **oxidation.** Controlled oxidation in a living cell is known as **respiration.**

Respiration is essentially the reverse of photosynthesis. Unlike photosynthesis, respiration occurs at night as well as during the day. Respiration occurs in all life forms, including animals, and in all living cells. The release of accumulated carbon dioxide and the uptake of oxygen occur at the cellular level. In animals, blood carries both carbon dioxide and oxygen to and from the atmosphere by means of lungs or gills. In plants, these gases simply diffuse into intercellular spaces within the leaf and then pass through the stomates.

The differences between photosynthesis and respiration are summarized in Table 3.

Table 3. Photosynthesis and Respiration — Compare and Contrast	
Photosynthesis	Respiration
Occurs only in plants	Occurs in all living cells (plants and animals)
Produces food	Uses food for plant energy
Energy is stored	Energy is released
Occurs in chloroplasts within cell	Occurs in all cells
Oxygen is released	Oxygen is used
Water is used	Water is produced
Carbon dioxide is used	Carbon dioxide is produced
Occurs in sunlight	Occurs in dark as well as light

The higher the temperature, the more rapidly respiration occurs within plants. Unlike photosynthesis, there is no optimum range of temperature for respiration. As temperatures climb, respiration continues to speed up. This is one reason why after a period of hot weather, plants may appear stressed. At high temperatures, photosynthesis will shut down, but respiration continues uninterrupted. During these periods of high temperature, plants are living on stored energy.

Transpiration

Transpiration is the process by which a plant loses water, primarily from leaf stomata. It is a necessary process that uses approximately 90 percent of the water that enters through the plant's roots. The other 10 percent of water is used in chemical reactions such as photosynthesis and in plant tissues (creating turgor pressure). Transpiration is necessary for mineral transport from the soil to plant parts, for cooling leaf and stem tissues through evaporation, for moving sugars and plant chemicals, and for maintaining turgor pressure. The amount of water lost from the plant depends on several environmental factors such as temperature, humidity, and wind or air movement. In general, as temperature or air movement increases, transpiration increases. As humidity decreases, transpiration increases.

Vascular System

Xylem

The **xylem** elements form the plant pipeline for the distribution of water and some solutes from the soil to the shoot. Near root tips, epidermal cells withdraw water from the soil by the process of **osmosis.** During osmosis, water molecules tend to equalize their concentration on both sides of cell membranes. Epidermal root cells, in which salts, sugars, and other substances are concentrated, contain lesser amounts of water than does the soil solution. Thus water diffuses into the root cells. Similarly, equalization applies to the substances dissolved within the cells. They attempt to diffuse out of the cell into the soil solution. However, selectively permeable cell membranes prohibit the dissolved substances from diffusing out. This preferential diffusion of water across the membrane results in an internal (turgor) pressure. The cell walls counteracting the internal pressure discharge water into spaces between internal cells. Finally, osmosis redirects the water into and up the cells of the xylem. Of the several types of cells in the xylem, the **vessels** and **tracheids** form the main channels of water movement. Both of the cell types lack living contents and have hollow interiors that serve as pipes for water conduction. The pressure that develops in the xylem tissues is called **root pressure.**

Although root pressure is adequate to push water to the leaves of low-growing plants, it is insufficient to move water to the top of tall trees. To accomplish this movement, an additional pulling force is generated in the leaves. The leaf mesophyll cells with high concentrations of photosynthesized sugars withdraw water from the xylem. Water evaporates from the mesophyll cells, saturating the intercellular spaces with water vapor. This vapor may ultimately escape the leaf through open stomata by transpiration. Thus there exists a continuous column of liquid water in the xylem from the roots through the stems to the leaves. The evaporative loss of water from the leaves results in a **transpirational pull** and in a continuous flow of water upward through the xylem. Movement of water and solutes in the xylem is in one direction only— upward.

Phloem

While xylem elements form the plant's pipeline for distribution of water and solutes from the soil to the shoot, another tubular system, the **phloem,** acts as the system through which sugar made in the leaves is distributed to all parts of the plant.

The inner bark consists of phloem tissue composed of thin-walled, elongated living cells (**sieve tubes**) joined end to end. The sieve tubes contain not only sugar but lesser amounts of amino acids, hormones, and mineral elements. While xylem content generally flows exclusively from the roots to the leaves, phloem contents move either upward or downward from the source of products of photosynthesis to any point, termed **sink**, at which the substances are utilized.

Sugars are needed to support growth in roots, shoot tips, and young leaves. Transport is also to roots and shoots for storage, or to seeds and fruits to be transformed into materials for growth of the next generation. In some species, special organs of food storage such as tubers, rhizomes, bulbs, corms, or tuberous roots may serve as sinks. When the sugar reaches such organs, it is usually converted to an insoluble storage product such as starch, thus preventing the buildup of high concentrations of osmotically active solutes. At some later time the insoluble storage product may be reconverted to sugars and exported to a new sink. In general, each sink is supplied by its nearest available source. The direction of movement in the phloem is not fixed, as it tends to be in the xylem.

A wide diversity of substances circulates around the plant through a combination of xylem and phloem routes. Mineral ions, for example, are initially absorbed from the soil and transported to the shoot through the xylem. As leaves age, some mobile elements are released and move in the sugar transport stream of the phloem to a new sink. In times of deficiency, these elements can be redistributed to the growing shoot, which will then remain relatively healthy while the older leaves display deficiency symptoms. Nitrogen degraded from amino acid, and magnesium from chlorophyll, show this mobility.

Growth and Development

Plant growth is often described as irreversible increase in size or weight. Growth is therefore subject to quantitative measurements. Two processes taking place at the cellular level contribute to plant growth. In the first process, new cells are formed by the **division of cells** already present in the plant. Each new cell is provided with a nucleus containing a complete complement of genetic material. The second growth process is **cell enlargement** and differentiation into various cellular components.

Meristems

These two phases of growth occur in well-defined areas within the plant called **meristems** (perpetually embryonic tissue). Grasses also have intercalary meristems within their internodes which produce growth both above and below the meristem.

At the tip of each stem and root, an **apical meristem** contributes to the length of these organs. This type of growth, which originates relatively close to apical meristems, is known as **primary growth.** The unlimited or prolonged growth of shoot apical meristems is described as **indeterminate growth.** When growth is restricted by the production of a leaf or flower, growth is said to be **determinate.** Indeterminate tomatoes keep on growing and producing new flowers and fruit until killed by freezing temperatures. Determinate plants, on the other hand, reach a certain size, set fruit, and then stop bearing.

Secondary growth which results in a thickening of stems, branches, and roots originates from two **lateral meristems:** the **vascular cambium** and the **cork cambium.** Most monocots and certain herbaceous dicots exhibit little secondary growth. Growth in plants ceases with the maturation of the primary tissues. Woody plants, however, at the start of each growing season exhibit a resumption of primary growth, and additional tissues are added through reactivation of the lateral meristems.

In woody stems, cork is formed to the outside by a cork cambium which may also form tissue to the inside **(phelloderm).** The cork, cork cambium, and phelloderm make up the **periderm.** At maturity, cells of the phelloderm are living and resemble cortical parenchyma cells. Gaseous exchange to tissues internal to the periderm is accomplished through the lenticels.

Bark

The term bark refers to all tissues outside of the vascular cambium. It includes not only periderm but also secondary phloem. After the first periderm, subsequently formed periderms originate deeper and deeper in the bark. All of the tissues outside of the innermost cork cambium and all of the periderms together with any cortical and phloem tissues included among them make up the outer bark. This outer bark consists entirely of dead tissues. The living part of the bark is from this innermost cork cambium inward to the vascular cambium. This is called the **inner bark** (See Figure 19).

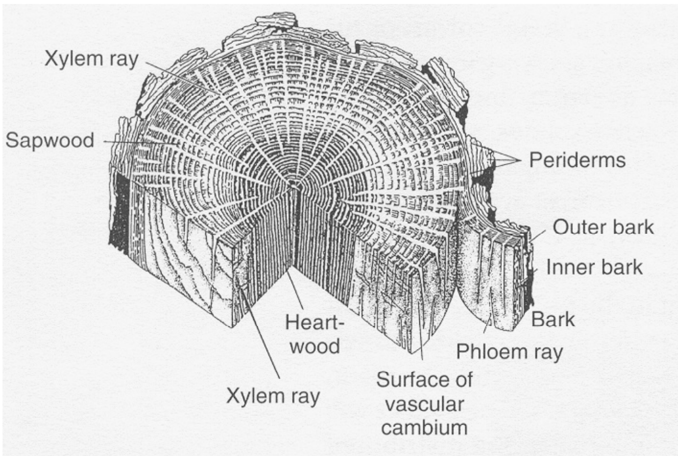

Figure 19

Development involves the differentiation of cells, tissues, and organs and does not necessarily involve increase either in size or weight. During transition to flowering, the vegetative apex undergoes a sequence of physiological and structural changes and is transformed into a reproductive apex. Flowering, therefore, may be considered as a stage in the development of a shoot apex.

Regulation of Growth and Development

Many of the details of the processes which regulate growth and development are not known. However, it is obvious that normal development depends on an interplay of internal and external factors. We have already discussed many of the external factors (water, light, temperature) that affect growth.

The main internal factors that regulate growth and development are chemical. Plant hormones play a major regulatory role. Some are produced in one tissue and transported to another where they produce physiological responses; others are produced and act within the same tissue. Some hormones are stimulatory, whereas others have inhibitory influences.

For example the plant hormone auxin is produced in young leaves and developing seed. Auxin has far-reaching influences including: plant responses to gravity and light, induction of roots, fruit development, and apical dominance of terminal buds. Another naturally occurring hormone, abscisic acid, is produced in mature leaves in response to water stress, yet it influences stomatal closure, transport of food throughout the plant, and dormancy in seeds and buds.

Botany - It's just the beginning

Botany is a study of amazing diversity. This has been but a sample of what plants are and what a crucial position they hold in our world. As we study different habitats during Master Naturalist training, notice the different adaptations of plants found there and how each plant is associated with all the other inhabitants.

