BOTANY

Botany is the study of plant life of the Kingdom Plantae (all land plants). Plants are categorized by being multi-cellular organisms composed of eukaryotic cells (have a nucleus). Their cells are organized into tissues and have cell walls made of cellulose. Plants are a fundamental part of life and are vital component of nearly all food chains; they transfer light energy from the sun and nutrients from the soil and atmosphere, converting them into chemical energy stored in food and oxygen that can be consumed and utilized by animals, including humans.

Through photosynthesis, plants absorb carbon dioxide, a greenhouse gas that in large amounts can affect our global climate. Plants stabilize the soil preventing soil erosion, filter impurities out of ground water, are influential in the water cycle and provide homes for billions of arthropods and larger animals. Plants are also an important aspect in medicines, clothing and home building materials.

Plants have many strategies that help them survive in all different environments. Most plants grow in the ground others survive in the rainforest canopy. Plants can be very small or as tall as redwoods. They can be annuals and complete their entire life cycle within one year without any secondary growth or they can be perennial and live over multiple years and have secondary growth. Plants can grow very rapidly or they can live for hundreds of years. They are an integral component of every ecosystem.

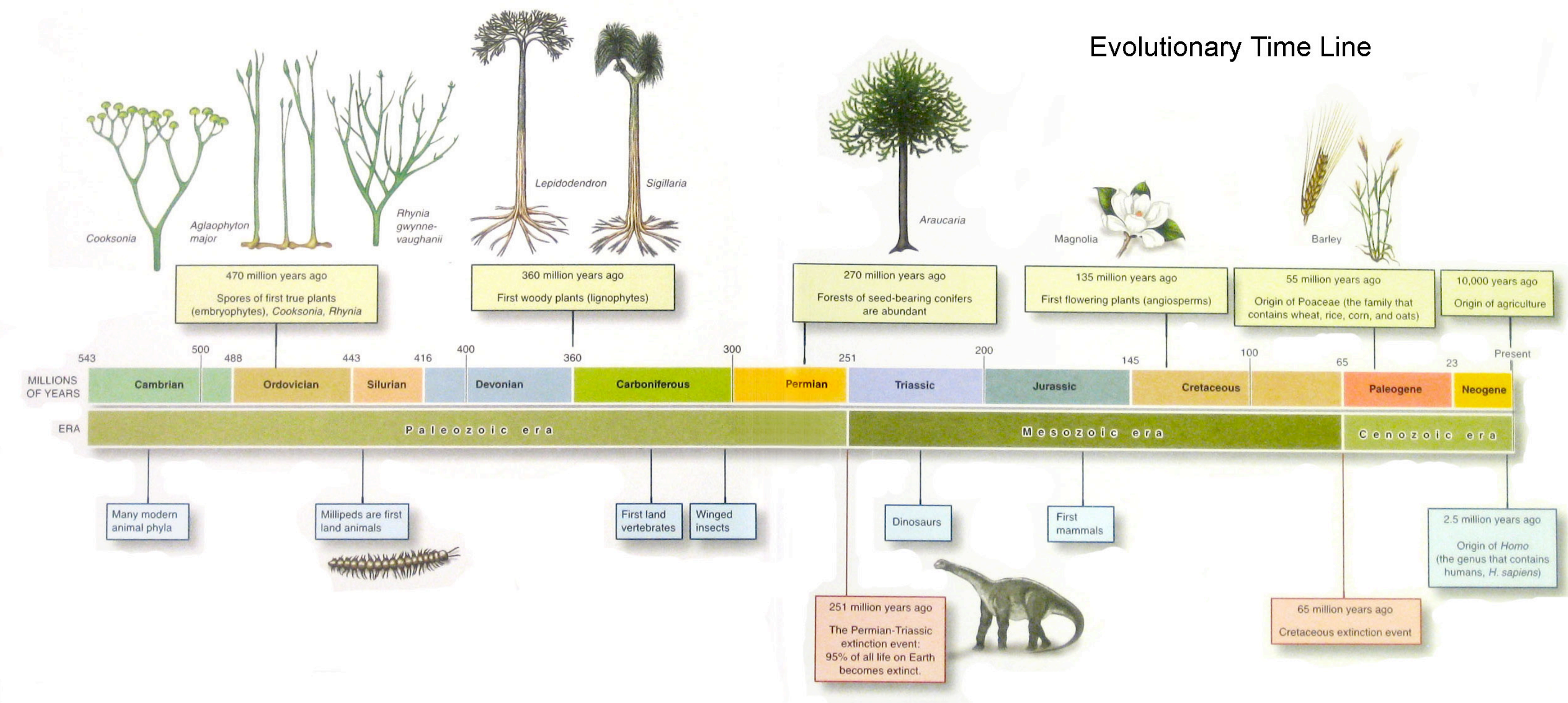
I. Classification of Plants

- A. Bryophytes: non vascular plants (i.e. mosses, liverworts and hornworts)
- B. Tracheophytes: vascular plants
  - i. Seedless plants: reproduce by spores (i.e. ferns)
  - ii. Seed plants
    - Gymnosperms (“naked seeds”): Nonflowering plants, includes conifers (i.e. pines, firs, redwoods, cypress and sequoias), ginkgos and cyads.
    - Angiosperms: (seeds enclosed in ovary) Flowering plants (i.e. roses, daisies, and apples)

II. Evolution of Plants

Plants began life in the seas and moved to land as competition for resources increased. They evolved from aquatic green algae about 500 million years ago and colonized the land during the Paleozoic era. Land posed several problems for plants including: supporting the plant body, absorbing and conserving water, and reproducing outside of a watery environment. Bryophytes were the first dominant form of plant life on earth but their lack of vascular tissue for transport of water and nutrients limited their size. These first land plants reproduced by spores and later evolved into cone bearing and flowering plants that dominate landscapes today.

Evolutionary Time Line



Spores are dependant on moisture so when plants began to spread from the edges of streams, they needed a way to protect their reproductive cells that fell onto dry land. The evolution of the seed protected the embryo from parasites, drying out, excessive heat and cold, mechanical damage, and the chemical action of the digestive juices of animals. The evolution of these hard covered seeds, along with vascular plant's more efficient transport system, allowed the tracheophytes to explore and establish themselves in new habitats and create new biomes.

Gymnosperms (typically a cone) were the dominant land plants in the Jurassic period (208 - 145 million years ago). But with the co-evolution of the flowering plants (angiosperms) and their associated insect pollinators, which arose during the Cretaceous (145 - 65 million years ago), gymnosperms were quickly outnumbered and landscapes began to resemble what we see today.

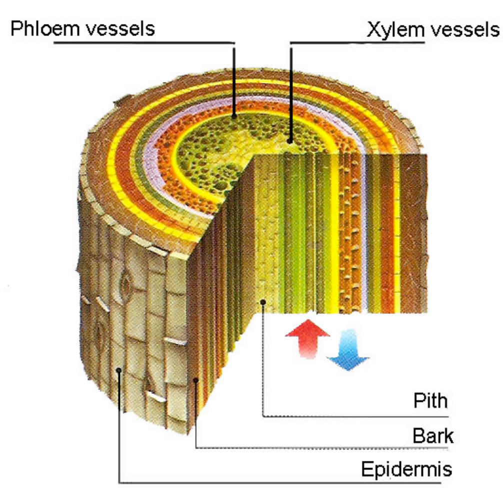
I. Structure and Growth

The primary body of a plant consists of roots, stems and leaves. Plants depend on vigorous roots to supply water and nutrients, provide support, and anchor the plants in the soil. The roots of the plant also helped stabilize landscapes that provide habitats for other organisms, especially insects and small animals.

The first root that develops from a seed is the taproot or primary root. The taproot will grow straight down and may grow for several inches before above growth above ground is seen. In some cases, the taproot remains dominate for the life of the plant (i.e. carrots, dandelions, and spinach). The majority of plants have roots that radiate out in many directions splitting and branching many times.

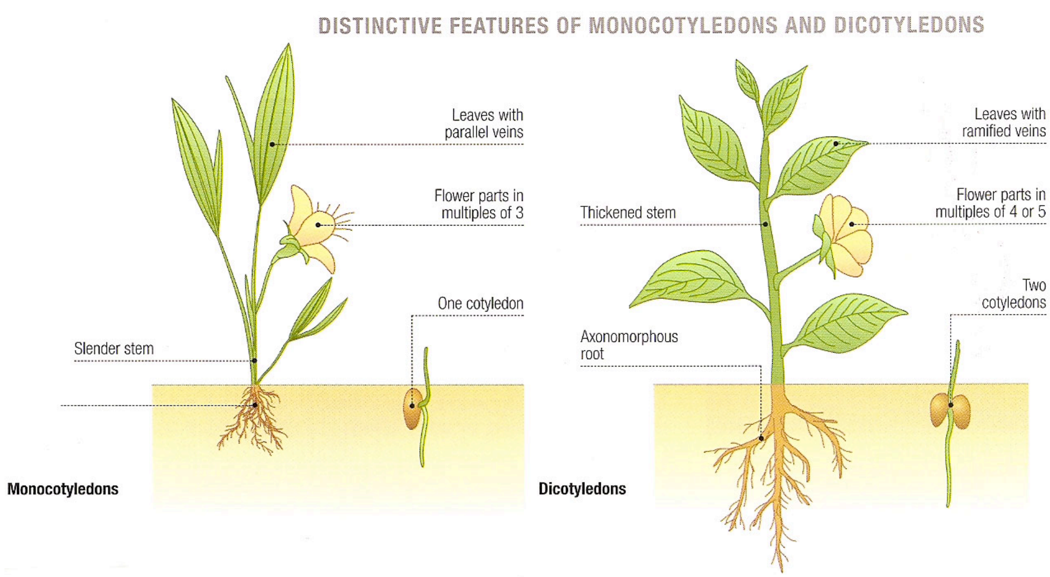
The youngest of the root system is the root tips and root hairs. Water and nutrients are collected from the soil through these young roots. As roots grow, these tips and hairs are continually exploring new soil looking for nutrients. Water and nutrients are transported up through the plant from the roots to the leaves via the xylem. The phloem transports sugars from the leaves to all parts of the plant body including the roots.

A Stem in Cross Section

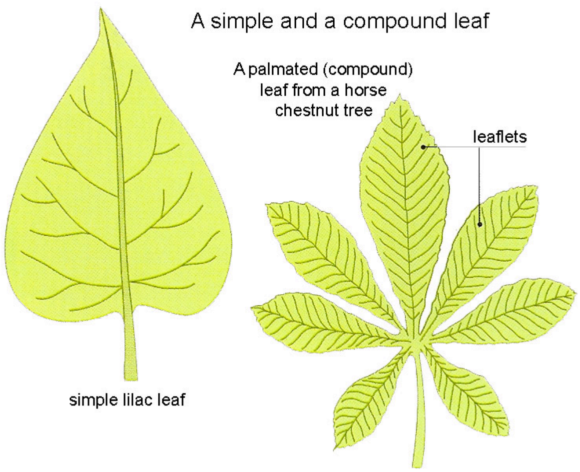


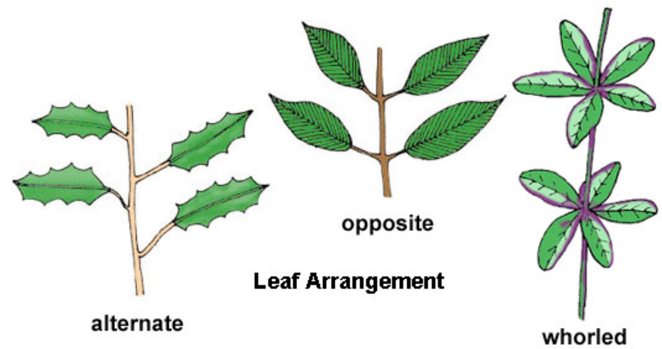
Stems are the support structures of a plant and are either herbaceous, woody or liana. An herbaceous plant dies down to soil level at the end of the growing season. They have no persistent woody stem above ground but the roots continue to live. Trees and shrubs are said to have woody stems. A tree is a relatively large woody plant ordinarily with a single upright stem, the trunk. A shrub, by contrast, usually has several main stems and branches more profusely than a tree. The liana is a vine that is rooted in the soil but use trees, as well as other means of vertical support.

Leaves come in an array of sizes, shapes, textures, and colors, but all serve a common function of absorbing light energy for the purpose of photosynthesis while at the same time protecting the plant's water supply. To absorb as much light as possible, most leaves are flat and face broadside to the sun and are positioned to avoid shading other leaves on the same plant. When light strikes a leaf, the chlorophyll in the leaf tissue absorbs some of sun's energy.

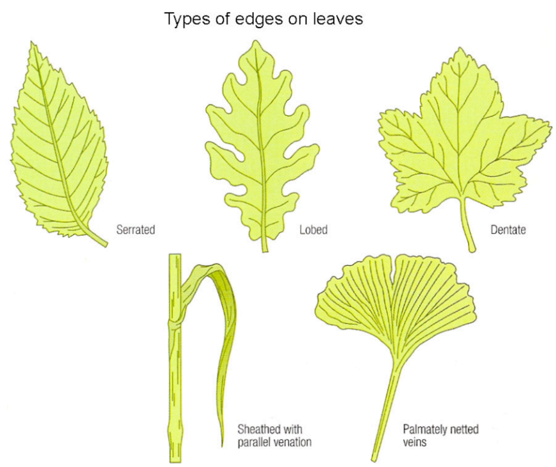


Almost all flowering plants have either a grass-like leaf (monocot) like the iris or have broadleaf (dicot) such as the geranium. The monocot has one embryonic leaf or cotyledon, whereas the dicot has two (see diagram above). A leaf may be a simple leaf, which has an undivided blade; or a compound leaf, in which the blade is divided into leaflets in various ways. In a compound leaf, small leaves with small stems branch from a central point or vein. Sometimes each one of these small leaves is similar to a leaf and is called a leaflet. Compound leaves can further be divided into pinnate and palmate patterns. The pinnate leaf has its leaflets arranged on the sides of the main leaf stalk and with the palmate leaf, the leaflets are attached directly to the end of the petiole and extend outward like fingers on your palm.





Leaves may also be distinguished from their attachment to the stem. When there is one leaf at each node it is alternate pattern. Two leaves at each node and on opposite sides of the stem have an opposite arrangement. Finally, more than two leave at a node spaced around the stem is a whorled arrangement. Botanists will also look at the edge of the leaf to distinguish them (see diagram pg 4). Leaves may be whole (smooth edge), dentate (with projections), serrated (with sharp, angled teeth), lobed (divided into sections), etc.



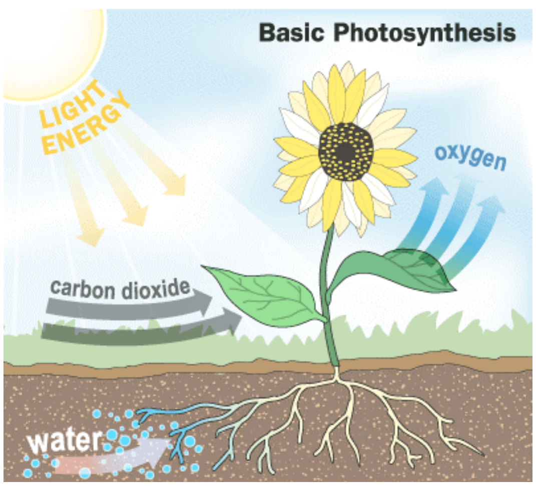
The pattern of veins in the blade of a leaf, is called its venation. The veins are referred to as parallel, pinnate, or palmate. A paralleled veined leaf has veins that are parallel or nearly so and are connected to larger veins. Parallel veins are seen in most monocot angiosperms such as in the lilies and grasses. Pinnate leaves are where all smaller veins arise at multiple points along a single primary vein or midrib like a feather. This pattern is seen in the leaves of some ferns and the Ginkgo tree. Lastly, the palmate veined leaf has several main veins that diverge from a main point. Most dicot angiosperms exhibit this pattern (i.e. maples, oaks & roses).

Leaves absorb carbon dioxide through tiny pores called stomata. These pores are usually on the underside of the leaf, where the chance of clogging is reduced. Monocots, like turf, corn and daffodils have stomata on both sides of the leaf. Stomata also act as the plant’s cooling mechanism. As much as 98% of water intake from the roots can be lost to transpiration, which cools the leaf surface during periods of high heat. If the plant starts to wilt, the stomata will automatically close to conserve water.

II. Photosynthesis

Photosynthesis uses the sun's energy and results in the release of molecular oxygen and the synthesis of glucose, while removing carbon dioxide from the atmosphere. Leaves are the major organs of photosynthesis in plants; light energy is captured by the pigment chlorphyll in the leaves' chloroplasts (chlorophyll gives a plant its characteristic green color). The sun's energy is then used to split water molecules into hydrogen and oxygen molecules. The plant discards the oxygen and mixes the hydrogen with carbon dioxide from the air to produce glucose and in turn other sugars for food. The glucose is only the building block for other compounds in the plant. Starch, fibrous cellulose, proteins, oils, vitamins, pigments are all made from glucose produced during photosynthesis.

The oxygen released during photosynthesis can be used during respiration by both plants and animals. Plants must respire just as animals do; they take in oxygen and give off carbon dioxide. Their photosynthetic activity is however greater than their respiratory activity resulting in an increase in atmospheric oxygen levels. Factors limiting photosynthetic rates include light intensity, water availability, soil nutrient content, concentration of carbon dioxide and temperature (to a certain point). Without the production of a food source and the release of oxygen during photosynthesis, most life on earth would be not be possible as we know it.



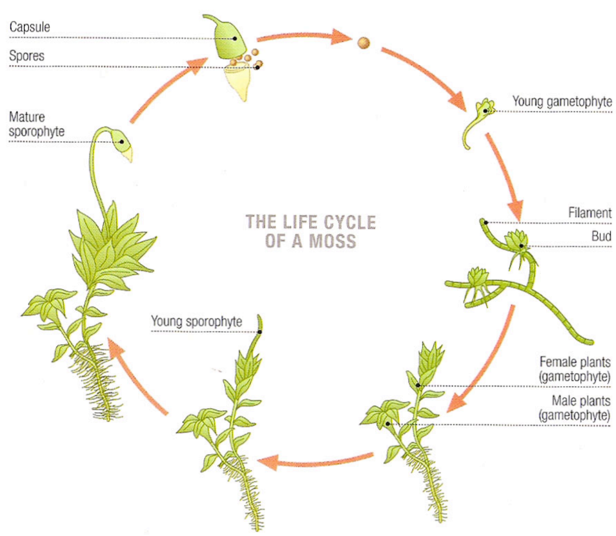
$6CO_2 + 6H_2O$ + light energy = $C_6H_{12}O_6 + 6O_2$
Carbon dioxide in the air combines with the water in plants to produce oxygen and carbohydrates. Photosynthesis involves two stages, the light reactions and Calvin cycle reactions. Water molecules are split during the light reaction and oxygen is produced as well as the formation of high-energy compounds such as ATP and NADPH. The Calvin cycle uses the energy of ATP and NADPH to convert carbon dioxide into sugars.

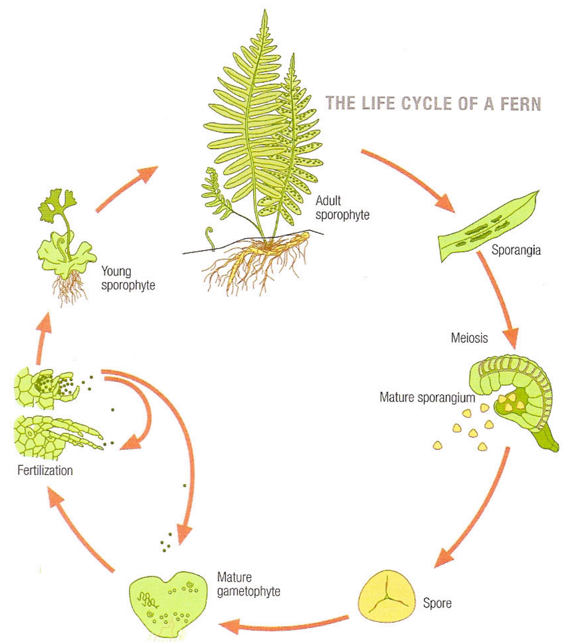
III. Plant Reproduction

Plants are versatile and most can reproduce in a variety of ways, both asexually and sexually. Many plants produce offspring all by themselves by growing underground stems or bulbs that generate new shoots. These new plants are clones of the original plant. If the environment is stable during several lifetimes, it is selectively advantageous for plants to reproduce asexually by budding or sending out runners. If the opposite is true and the environment is not stable, genetic diversity is an advantage as the plant may be poorly adapted to the new conditions and may die out. Having more diversity through sexual reproduction increases the probability that some individuals will still survive under adverse conditions.

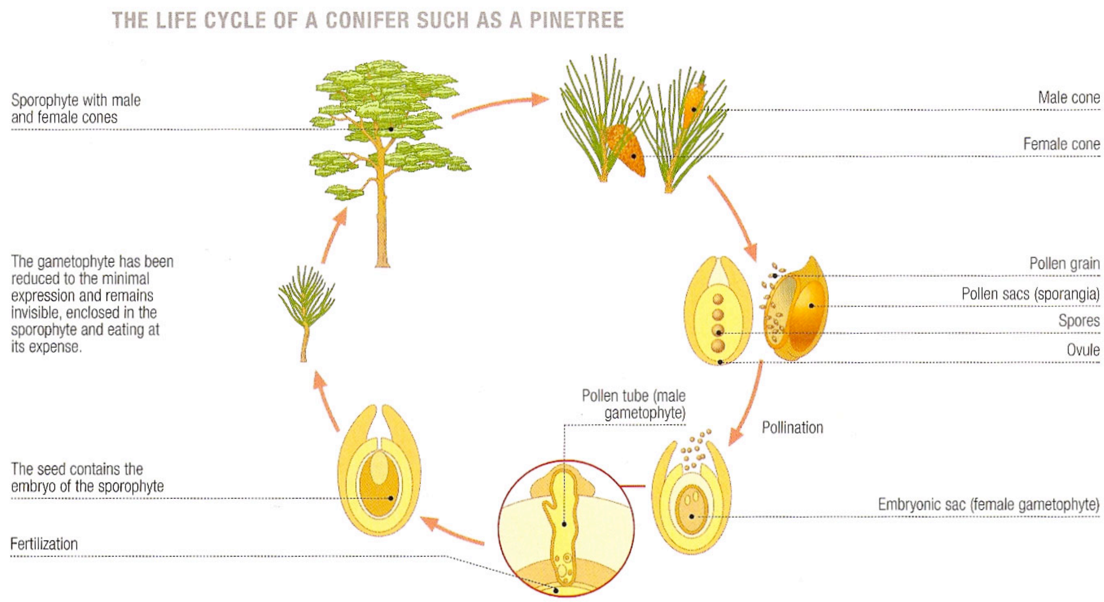
Life cycles of all land plants alternate between two different multicellular bodies, with each form producing the other. This biological life cycle is known as "alternation of generations" as they alternate between haploid (gametophyte) and diploid (sporophyte) phases. The haploid has half the chromosomes as the diploid.

Mosses have a sporophyte, which is dependent on the gametophyte for nutrition. Sporophytes are actually a phase of the moss life cycle that feeds off the green parent plant (the gametophyte). The sporophyte is a stalk that grows after the haploid sperm of one moss plant is able to mix with the haploid egg of a female moss plant. The resulting diploid cell grows into the sporophyte stalk. When ready, spores stored in the sporophyte are released and they grow into new moss plants; spores germinate and grow into a gametophyte. Ferns have a large sporophyte and a small independent gametophyte. The fern gametophyte is not dependent on the sporophyte for nutrition. (see diagram p 7). They too reproduce asexually by spores, which are are produced in tiny but visible sacs called sporangia, which commonly occur in clusters (sori) on the underside of the mature leaves.

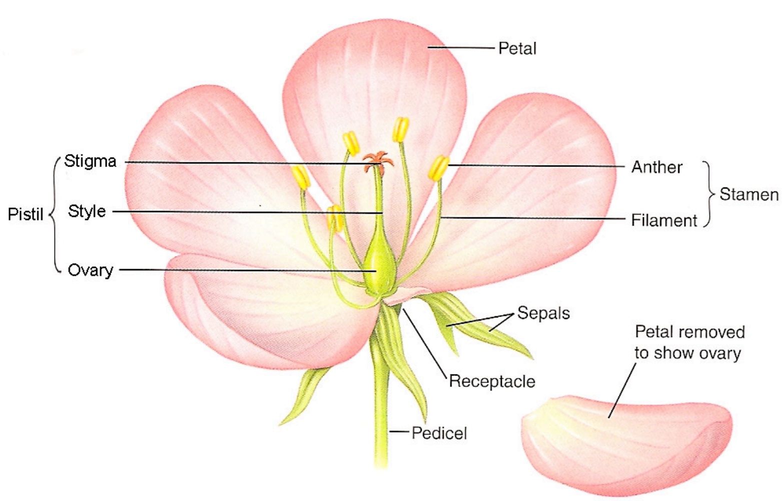




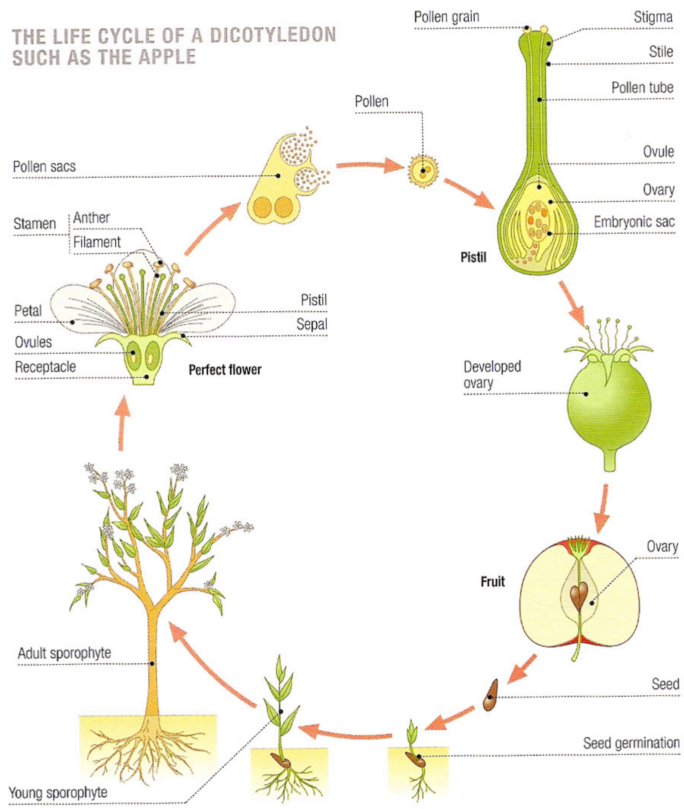
Conifers produce two types of cones (gametophytes) on the same tree. One of the staminate cones gives off pollen (male cone). Ovulate cones (female cone) catch the pollen if the wind is moving in the right direction. The most genetic diversity occurs when the wind blows the pollen to another ovulate cone of the same species. Again, the pollen and megaspore (receiving haploid cell) are haploid and combine to form a diploid cell. That diploid cell grows into a zygote (baby conifer) that eventually lives in a seed. The reduced gametophytes (cones) are dependent on the sporophyte (tree) for its nutrition. (see diagram p 8).



Angiosperms with their showy flowers exhibit the most advanced form of sexual reproduction in plants. These plants are also very dependent on outside help such as insects and animals. Flowering plants put the elements that make and receive pollen in the same structure. Pollen carries and protects the plant's sperm, which comes from the male part of the plant. The female part of the flower contains the ovules with their eggs. Pollination occurs when the pollen reaches the female part of the flower. Fertilization occurs when the pollen releases the sperm and fuses with the egg. In flowering plants, after fertilization, the ovules develop into the seed and the ovaries develop into fruits enclosing the seed. The fleshy fruits attract animals, which then eaten and the seeds are dispersed through the animal's waste. Other fruits are dry and disperse by the wind or hitch a ride on an animal or explode to release their seeds. All these methods result in the embryo of the seed finding a new home in which to take root. The reduced gametophytes (stamen and pistil) are dependent on the sporophyte (plant) for their nutrition.



Most flowers have four types of structures: sepals, petals, stamens and a pistil.
Receptacle: The part of a flower stalk where the parts of the flower are attached.
Sepal: The outer parts of the flower (often green and leaf-like) that enclose a developing bud.
Petal: The parts of a flower that are often conspicuously colored.
Stamen: The pollen producing part of a flower, usually with a slender filament supporting the anther.
Anther: The part of the stamen where pollen is produced.
Pistil: The ovule producing part of a flower. The ovary often supports a long style, topped by a stigma. The mature ovary is a fruit, and the mature ovule is a seed.
Stigma: The part of the pistil where pollen germinates.
Ovary: The enlarged basal portion of the pistil where ovules are produced.



IV. Plant Adaptations

One of the truly amazing things about plants is the way they have specialized in order to survive and take advantage of the conditions in different habitats and even during the changing seasons. Plants are trying to prevent themselves from getting eaten and to pass on their genes through reproduction just like animals. Plants know when to flower, when to go dormant, and when to germinate their seeds. The following are some examples of how plants have adapted to their environmental conditions.

Eucalyptus (*Eucalyptus*) trees are adapted to survive frequent fires by having an extensive deep root system to both find water and store sufficient food reserves. They have lignotubers among their roots that store the food and have dormant buds they can grow back from if the original tree trunk is severely damaged due to fire. Eucalyptus bark is very thick which prevents heat damage to the cambium layer the tree needs for vascular transport and growth. If the cambium is damaged the eucalyptus can regrow from dormant epicormic buds under the bark or from swelling in the root crown (lignotuber).

In order for the grasses to survive the dry season and the periodic fires, they have developed an adaptation that allows them to grow quickly when there is adequate water. When water becomes scarce, the grasses turn brown to limit water loss. They store necessary moisture and nutrients in their roots while they await the return of the rainy season. With food and water reserves stored below ground, the grasses are able to survive the effects of fire as well. Fire actually stimulates new growth and replenishes the soil with nutrients.

Desert plants have to overcome the dry conditions and the extreme temperature changes. Some of the strategies are to have reduced or highly modified leaves. In cacti, leaves evolved into spines, which don't lose water rapidly and protect the plant from grazers. The agave have evolved tough, thick leaves that have a heavy wax coating to prevent water loss. Other such as the desert yam has a tough, protective base, which produces delicate, thin leaves only during the rainy season.

Most desert plants are succulents and are able to store water in fleshy tissue. Cacti store water in their stems, which pleats to allow expansion when water is available. Agave plants have a long root system that can find water under the desert ground. The desert yam stores water in its tough base.

Some cacti protect themselves from overexposure to the sun by long white spines that form a surface barrier over the stem but also the white reflects excess sunlight off the stem. In another strategy, the stone plant allows just the surface of the plant to be exposed. The surface of the stone plant has little clear spots that allow sunlight to enter the plant.

The spongy trunk of the baobab tree is an example of a stem adapted to severe drought in hot arid regions of Africa, India and Australia. It absorbs and stores large quantities of water that may be necessary during long dry periods. The baobab will grow to be only about 30 feet in height but can reach 60 feet in circumference. The leaves of the baobab tree are only produced during the wet season and are in tiny finger-like clusters. Their small size helps limit water loss.

Plants have control systems that enable them to cope with less extreme water deficits. They reduce their rate of transpiration by closing the leaf's stomata and reduce photosynthesis. They will also inhibit the growth of young leaves, slowing the increase in leaf surface. The leaves of many plants will wilt from lack of water and roll into a shape that reduces the surface area to dry air and wind. With severe water losses due to droughts, the plant will die. Shallow roots will not grow but deeper roots that are still in contact with a water source continue to grow. The roots grow in a way to maximize exposure to soil water.

In the rainforest, water is plentiful but plants have a hard time getting enough light and the soil is thin and of poor quality. Plants have evolved buttress or prop roots. These roots grow from and support the stem above the ground in plants (i.e. mangrove). Too much water can be a problem as it may make the leaves too heavy for the plant to support or fungi could grow and attack the leaves. To counteract this, plants have evolved waxy leaves with a pointed tip which helps rid the plant of excess water.

In the rainforest, less than 2% of the sunlight reaches the forest floor. To get enough sunlight in the rainforest, vines such as liana have roots in the soil but then wrap around other plants to grow up to the sun. Other plants such as orchids and bromeliads have adapted the strategy to grow entirely on other plants. In order to get water, orchids have roots with a spongy material that helps collect water and particles in the air. Bromeliads' leaves are wrapped tightly into a cylinder and are used to form a water storage area. The bromeliads catch their own water and store it for their future use. This stored water is also used for homes for tree frogs.

In cold environments, deciduous trees and shrubs loose their leaves to protect themselves against the harsh winter months. The leaves are shed to prevent their water from forming ice crystals, which would destroy them. By the end of the summer, the deciduous plants should have stored extra food in order to form buds. Since trees are dormant during the winter, they don't have the energy to produce these structures during the fall and winter. The buds are the resting stage in the growth cycle of a tree or bush. They contain the embryonic leaves and flowers for the coming year. Most tree buds are covered with very small, modified leaves, which act as protective scales. These scales help seal in moisture to protect the bud from drying out during the long, dry winters when water is frozen and therefore unavailable. In fall, the leaves of deciduous trees turn colors before they are shed. This is a result of the chlorophyll being withdrawn from the leaves and stored in the tree's permanent tissues in preparation for a period of dormancy during the winter. In the springtime, the chlorophyll will be drawn into the new growth and buds of the leaves.

Conifers (spruces, hemlocks, firs) have another way of dealing with cold environments. The needles of these trees are covered with a thick layer of insulating wax and they also have the least possible surface area for exposure to the elements. When winter arrives, their needles dehydrate and will not freeze while the tree goes in a period of winter dormancy like the deciduous trees. By not losing their needles, the conifers are at an advantage over the deciduous plants because they are able to start photosynthesis earlier and also they save energy by not having to produce new needles each year. The larch is one conifer that looses its needles in preparation for the winter. This had an advantage of other conifers that don't loose their needles in that the larch can survive more severe winters such as those that occur in Siberia.

Redwoods can grow to be some of the biggest and oldest trees in the world. This is in part due to the fact that they can reproduce in three different ways; from seeds, from sprouts, and from burls. Redwood trees make small cones hat can hold about 100 seeds each. Only a few grow to become a tree. Redwood seeds need fire to germinate; they are serotinous. Fortunately, redwoods can also reproduce by sprouting new plants growing from stumps, fallen trees, and the bases of living trees. Other adaptations that have allowed them to survive for so long include the soft red bark that can grow up to a foot thick, protecting them from fire and insect attacks. The thick bark also store tannins, which deter insects and animals from breaking the protective barrier. If the bark has been invaded the tree will burn and thus only the healthiest of trees will live on after the fire. The Redwood's needle-like leaves have a special shape, allowing them to catch the moisture from fog and drip it back down to the ground supplying up to 45% of the trees water needs and creating moist ground conditions. Redwood roots are shallow, with the roots of the largest trees penetrating no more than 10-13 feet deep. The shallow roots help make sure that the root system can get oxygen even in a very wet environment. Rather than compete with each other for water, the strong roots of the redwood community form a network to hold water and support each other.

Some plants are carnivorous (i.e. venus flytrap and pitcher plants) and are able to trap and consume animals such as insects and other arthropods. These plants are adapted to grow in places where the soil is thin or poor in nutrients, especially nitrogen, such as acidic bogs and rock outcroppings. By trapping and digesting their prey, they obtain nutrients, such as nitrogen and phosphorus, which are lacking in the soil. Carnivorous plants still obtain their energy through photosynthesis and not from their prey.

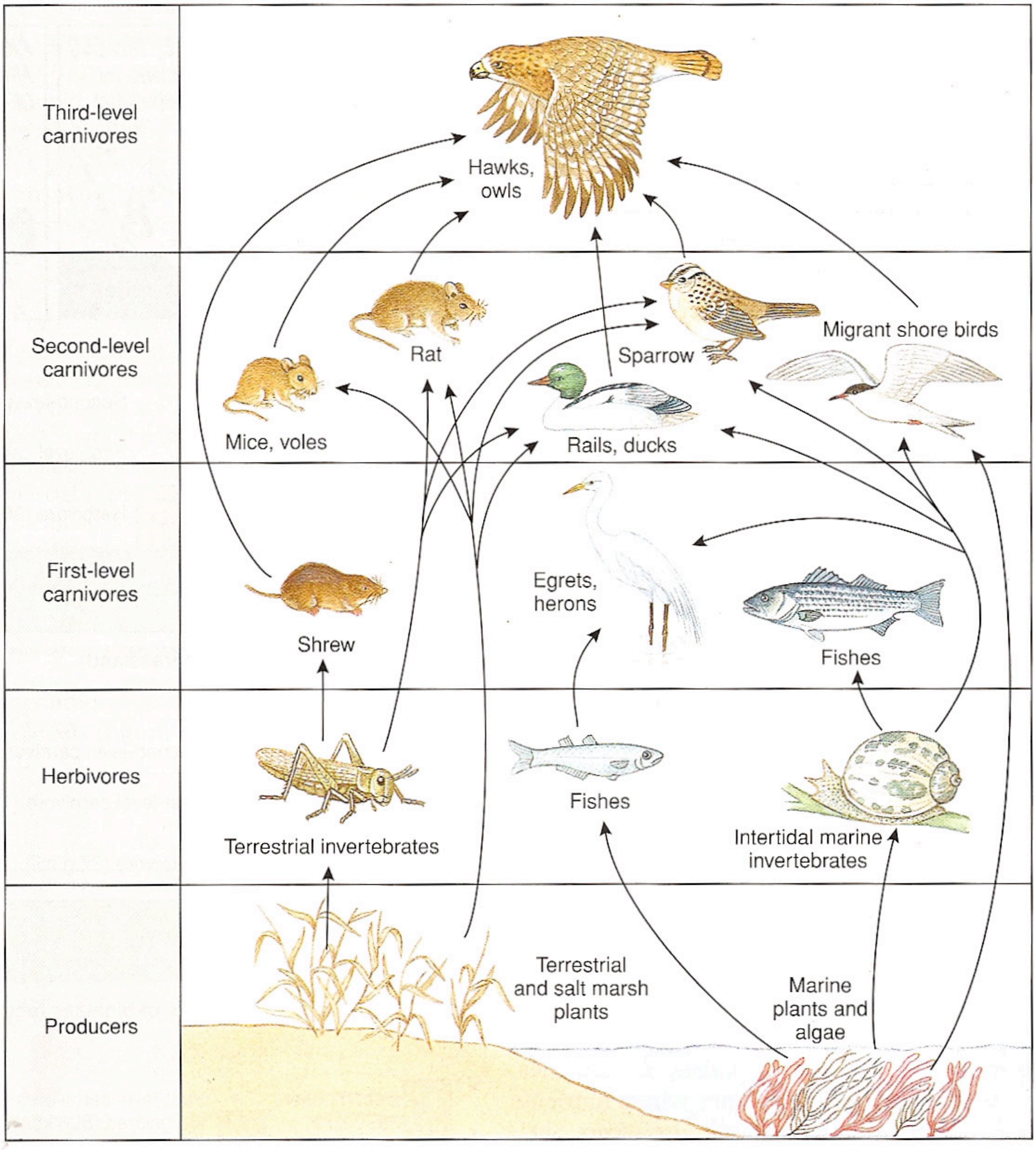
V. Interconnection between Plants and Animals

Plants do not exist in isolation but interact with many other species in their community. Ecology is the study of the interaction of plants and animals within their environment. An ecosystem consists of all living and nonliving things that make up a particular environment. Every species (plants and animals) in an ecosystem plays a central role in that system. The role a species plays in an ecosystem is their ecological niche. All life is interconnected. Organisms depend on each other for food and are impacted by each other's actions. They are interrelated in such a way that balance is maintained.

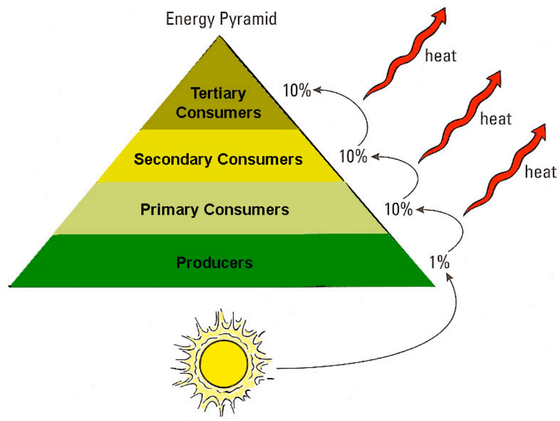
How an organism gets its food is a big part of its niche. The trophic level of an organism is based on how they obtain needed energy and nutrients and is based on the position it occupies in a food chain. Plants derive energy from the sun and nutrients from the earth and are considered at the first trophic level; they in turn supply both to the animals. Several food chains linked together are called a food web. These pathways transfer energy and nutrients among organisms within an ecosystem.

Organisms get their food by being producers (plants), consumers or decomposers. Consumers are considered herbivores, carnivores or omnivores. Herbivores that eat grasses or low vegetation are grazers whereas those that eat woody twigs or leaves from shrubs or trees are considered browsers. Carnivores eat only meat whereas omnivores have a varied diet of meat and plants. If there were no plants, there would be no herbivorous animals and therefore no carnivores. Decomposers recycle organic material by feeding on dead organic material breaking it down into simpler substances, which can be reused by the plants.

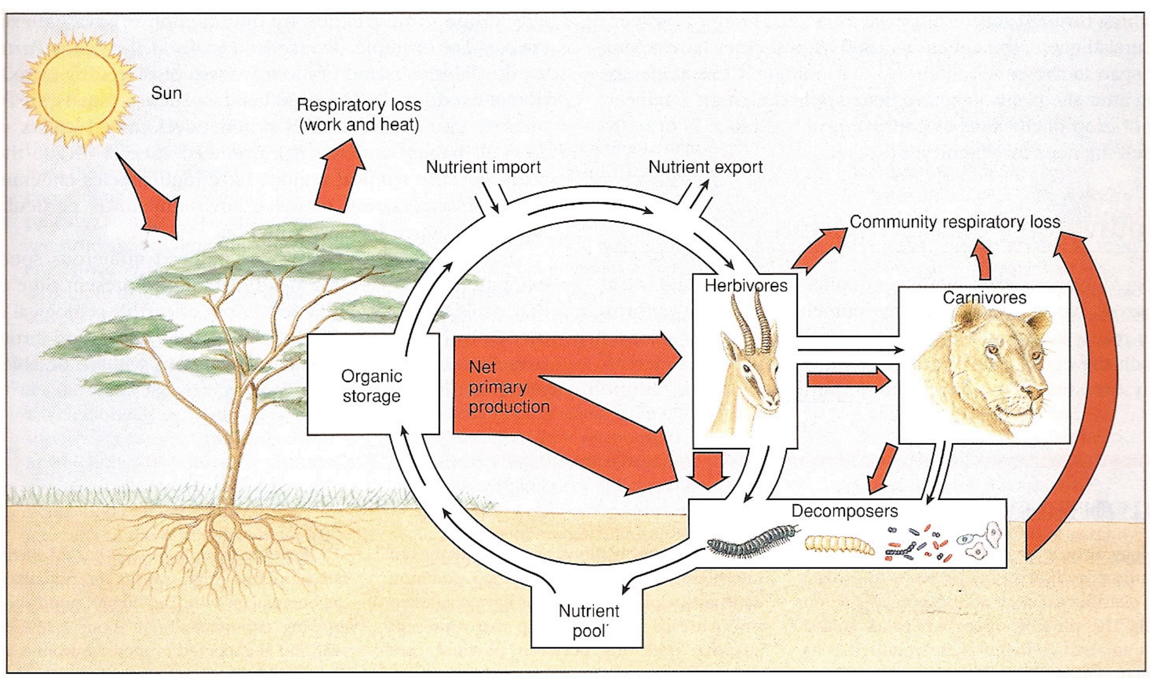
A Food web of the San Francisco area.



An ecological pyramid is a graphical representation, which shows the feeding relationship of groups of organisms, and the flow of energy or biomass through the different trophic levels in a given ecosystem. This energy pyramid shows that the energy transfer from one trophic level to the next is accompanied by a decrease due to waste and the conversion of potential energy into kinetic energy and heat energy. Producers capture only about 1% of the energy available from the sun. The average transfer of energy from prey to predator is only about 10%. This means that about 90% of the useful energy is transformed into heat and is no longer a source of energy for growth. In a stable environment the populations of herbivores are always greater than the populations of carnivores, since energy cannot be created and is transpired at each trophic level. The following pyramid explains why there are more plants than everything else combined; the plant populations support all other populations in the ecosystem, either directly or indirectly.



The transfer of energy and nutrients among organisms within an ecosystem is needed to sustain life and measures an ecosystem's productivity. All energy is transpired as heat, but nutrients and other materials are recycled. These nutrients are inorganic and include phosphorous (in teeth, bones, and cellular membranes), nitrogen (in your amino acids - building blocks of protein), and iron (in your blood). A continuous input of energy from the sun keeps nutrients flowing through and the ecosystem functioning.



Nutrient cycles and energy flow in a terrestrial ecosystem.
Nutrients are recyced, whereas energy flow (red) is one way.

Organisms depend on their surrounding physical environment and on other organisms with which it share this environment. Both plants and animals have adapted in various ways that are interconnected to each other in their struggle to survive. Plants provide nutrients and energy for themselves, herbivores and omnivores and indirectly to all carnivores. Plants also provide homes, refuge for fleeing animals from their predators, and shade & protection from the sun and from any inclement weather.

Some animals camouflage themselves to their surroundings or mimic it helping them to blend in and protect against predators. Phasmids, or leaf and stick insects are among the best-camouflaged animals. They have body shapes and coloring that resemble sticks or leaves and they remain absolutely still, making them extremely difficult to spot. When they do move, their walk is slow and deliberate and they often slowly sway from side to side mimicking being blown by the wind. Some phasmids have mossy or lichen-like outgrowths on their bodies that help camouflage them further. Other species have the ability to adjust their coloring with temperature, humidity and light intensity changes.

Seed dispersal is important for plants existence. If all the plant's seeds landed just underneath the parent plant there would be crowding and the established large plant might not leave the newer seedlings enough light or water for them all to develop properly. Also, dispersing allows a greater diversity in a larger area, which increases the odds for the plants survival. Some seeds are blown by the wind but other seeds have barbs or other structures that get tangled in animal fur or feathers, and are then carried to new sites by the animal. Eventually, the seed may fall off or be rubbed off by the animal.

Other plants produce fleshy fruits that are eaten by an animal. The seeds are dispersed to a new location after they have passed through the animal's digestive system. Raptors may become secondary seed dispersers by preying on frugivores such as birds or lizards. Seeds contained in the gut of these frugivores are passed on to the predator, who in turn discards the intact seeds at their perch or by regurgitating pellets, which contain the seeds. In this case, the seeds are dispersed at larger distances. Some animals (i.e. squirrels) bury seeds such as acorns to save for later, but may not return to get the seed. This seed may grow into a new plant. These methods of seed dispersal are designed to ensure that as many seeds as possible have a good chance of germinating and producing seeds of their own.

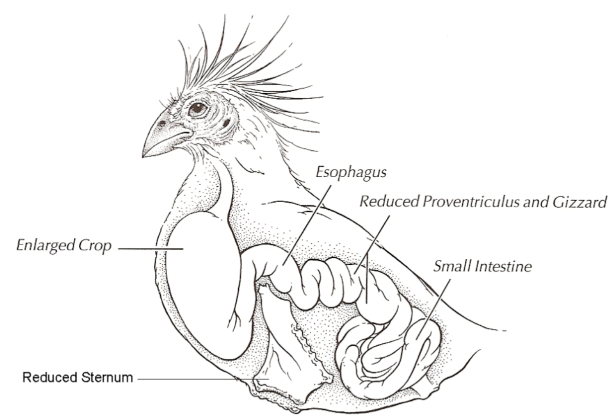
Pollination is an important reproductive processes for the flowering plant and can be accomplished by the wind and water but also by animals. Most of these pollinators are insects. Some plants have developed colored petals and a strong scent to attract pollinating insects such as bees, wasps, and butterflies, birds such as hummingbirds and fruit bats. Plants adapted to using bats or moths as pollinators typically have white petals and a strong scent, while plants that use birds as pollinators tend to develop red petals and rarely develop a scent (few birds rely on a sense of smell to find plant-based food). With the assist of animal pollination, plants are able to reproduce more efficiently.

Ruffed lemurs feed primarily on fruits and nectar. The seeds of the fruit they eat pass through their digestive tract and are propagated throughout the rainforests in their feces, helping to ensure new plant growth and a healthy forest ecosystem. Ruffed lemurs are also significant pollinators of the traveller's tree (*Ravenala madagascariensis)*. They lick the nectar from deep inside the flower using their long muzzles and tongues, collecting and transferring pollen on their snouts and fur from plant to plant. This relationship is thought to be a result of co-evolution.

The Sphinx Moth (Sphingidae), from Costa Rica, has developed a 9” tongue to obtain nectar from a long tubular night blooming flower. They feed by hovering in front of a flower and sipping nectar through the extended proboscis, much like a hummingbird. Their fast flying requires a great deal of energy and creates a lot of heat in the moth's body resulting in a loss of a great deal of water. The sphinx moth will feed exclusively on nectar and seek flowers, which provide large amounts of water but also contain high amounts of sugar to meet their flying demands.

Herbivorous animals do not produce the enzymes that breakdown the cellulose of plant cell walls. In order to eat plants, many animals have large populations of symbiotic bacteria in fermentation chambers in their intestinal tract. These microorganisms have the enzymes that digest the cellulose for the host animal. The most elaborate adaptation for an herbivorous diet is the ruminants, which have four stomach chambers. The ruminant actually digests some of the symbiotic microorganisms, which reproduce rapidly enough to maintain a stable population. This gives the ruminator more nutrients than what the plant contained originally. Many of these herbivores also have specialized teeth (large, flat ridged molars*)*, which aid in the processing of the vegetation they eat.

Seed eating birds usually have crops, which helps to soften seeds and allows controlled passage through the digestive track. The Hoatzin (“WAT-sins”), a bird of the South America Amazon, forages exclusively on leaves (folivorous). It is highly selective in the type of leaves it eats and focuses on the young leaves. In order to help digest the cellulous, the hoatzin has an enlarged two-chambered crop and is the only bird that is ruminator (with foregut fermentation). To accommodate the enlarged crop, the anterior portion of sternum is greatly reduced and there is a decreased surface for muscle attachment. The hoatzin thus have reduced wings and reduced flight capabilities.



Eucalyptus leaves, which are the primary diet of the koala, are low in nutrients, are hard to digest and contain toxins, which to most animals are extremely poisonous. The leaves do however consist of 40 - 60% water, which allows the Koala to get their water requirements from their food. The Koala will eat about 30 of the 650 species of eucalyptus. Using their enhanced sense of smell, they will avoid the most poisonous species. Their liver is capable of detoxifying some of the harmful chemicals in the leaves. They have strong grinding teeth (molars and pre-molars) that grind the tough leaves into a paste. In addition, the koala has developed an enlarged cecum (~6.5 feet in length), which functions as a fermentation chamber where symbiotic bacteria convert the shredded leaves into a more nutritious diet. To get used to feeding on eucalyptus leaves, a young koala (~30 weeks) begins to feed upon "pap" which the mother produces in addition to milk. Pap is a specialized form of droppings, which forms an important part of the young koala's diet, allowing it to make the transition from milk to eucalyptus leaves. It allows the mother to pass on micro-organisms from her digestive system. These adaptations have enabled koalas to eat eucalyptus leaves and allowed the koala to take advantage of an otherwise unfilled ecological niche.

Some plants have physical defenses (i.e. thorns) and/or chemical defenses (i.e. production of distasteful or toxic compounds) that help protect the plant from excessive herbivory. Others "recruit" predatory animals, such as the parasitoid wasp. The wasp injects its eggs into its prey such as the caterpillar feeding on the plant. The eggs hatch within the caterpillar and the larvae eat their way out, killing the caterpillar. A leaf damaged on the plant, by the caterpillar, releases a compound that attracts the wasp.

The acacia tree (*Acacia*) developed long, sharp thorns and a symbiotic relationship with stinging ants. The ants live in acacia thorns they have hollowed out, and they feed on the nectar produced by the tree. When an animal takes a bite of leaves (and thorns), it also gets a mouthful of angry, stinging ants. The ants defend their homes from other insects as well, thus protecting the acacia tree.

Thorny acacias grow straight up first then out laterally and have thorns as a defense mechanism from the browsing of giraffe. Giraffes use their 18" prehensile tongue to avoid the thorns by maneuvering around them to get at the leaves. To deter the giraffe from eating its leaves, the acacia has a chemical defense system that is triggered when the giraffe begins to munch on a leaf. First, a poisonous alkaloid, that is not palatable, is pumped into the leaves. The giraffe only gets a couple of mouthfuls before the remaining leaves become inedible. Then, the tree warns other acacia trees in the area by emitting a chemical into the air. The other acacia trees respond by pumping alkaloid into their leaves. The giraffe has adapted to the chemical release into the air by eating the most downwind leaves of the acacia first and moving around from tree to tree.

Some insects that are protected by chemical defenses from their predators (i.e. birds) get their noxious taste from chemicals they absorb by feeding on chemically defended plants. An example of this would be the milkweed that Monarch butterflies and their caterpillars feed on. Monarch butterflies are specific to milkweed plants. The cardiac glycoside in milkweed is poisonous to humans and livestock but when ingested by the Monarch it makes the monarch's flesh distasteful to most predators, thus protecting it from predation.

Some plants have fragrances for two basic reasons. Leaf, root and bark fragrances defend plants against being browsed or chewed by animals; flower and fruit fragrances attract animals for pollination and seed dispersal. The nature of flower odors vary according to the group of the pollinators the flower attracts. Some pollinators may be attracted from a distance by a combination of color, shape and fragrance. The goals of these two strategies are often diametrically opposed with bad smelling leaves but sweetly perfumed flowers.

The availability of certain plants can affect the behavior of animals. Animals have adjusted to the seasonal availability of plants through migrations. In particular, the zebra and wildebeest graze in harmony as they go in search of food and water. Each of these animals prefers a different part of the same grass so they are not competing for the same food source. Zebra are the first to migrate through an area with their long front teeth, which they use to sheer off the longer grass. They wildebeest follow behind and graze on the shortened grass. Their mouths are shaped so they can grip the more tender shoots. This relationship has developed into a beneficial behavior that allows these animals to survive the dry seasons of the Serengeti without competing for the same food source and without destroying the grass itself.

The primary motivation for many species of birds to undertake a seasonal migration appears to be food. For example, some hummingbirds choose not to migrate if fed through the winter. As the days shorten in autumn, migratory birds return to warmer regions where the available food supply varies little with the season. As the warmer months set in, migration from tropical areas vastly increases the amount of space available for breeding, reduces aggressive territorial behavior and reduces the competition for food.

Hibernation is another response by animals to the seasonal availability of plants. As winter approaches and the temperature drops, food sources become scarce, some animals, like rodents (i.e. ground squirrels) and bats, among others, enter a state of inactivity and metabolic depression. They have a lower body temperature, slower breathing, and lower metabolic rates, reducing their energy requirements. By going into hibernation the animal bypasses winter when their food supply (i.e. nuts and berries) disappears.

In the case of a bear, after feeding heavily in the fall, they too will find a place to curl up in response to plants going dormant, although bears do not go into "true hibernation". During this “denning up”, bears will lower their metabolism to decrease their energy needs, but they require a higher body temperature than true hibernators in order to meet the demands of pregnancy, birth, and nursing. They are easily aroused and may be active during warm winter days. While in this dormancy period, the bear uses the stored energy it accumulated as fat to survive. The hibernation/denning up process is a unique adaptation of nature that allows many animals to survive during the severe conditions of winter.

Some animals may time new births with the wet season or during the spring and summer when plants are most abundant and there is new and succulent growth. From spring through autumn nutrition is good and the living is comparatively easy. This gives the young the best possible chance of survival before the coming of harsher conditions such as the dry seasons and winters. White tail deer exhibit this reproductive strategy. Mating occurs in the fall and the doe has about a seven months gestation period. Fawning comes for the fittest does that have survived the winter. Any fetus that has survived is likely to become a very durable fawn.

Environmental changes can favor certain individuals within the population. Individuals who survive are able to pass their characteristics on to the next generation (natural selection). In the book *The Beak of the Finch: a story of evolution in our time*, scientific research was done on two Galapagos species of Darwin's finches. Results showed that the types of seeds that were available for the finches to eat influenced the beak size of the finch in successive generations. They type of seed available was influenced by year-to-year weather changes. During a severe drought, the vegetation withered and seeds of all kinds were scarce. Birds quickly ate the small, soft seeds, leaving mainly large, tough seeds that the finches normally ignore. Under these drastically changing conditions, the struggle to survive favored the larger birds with deep, strong beaks for opening the hard seed. Smaller finches with less-powerful beaks perished. The offspring of the finches that survived tended to be larger, with bigger beaks. Rainy weather resulted in the opposite; more small, soft seeds were available and fewer of the large, tough ones. As a result of this, the birds best adapted to eat those seeds because of their smaller beaks were the ones that survived and produced the most offspring.

VI. Plants and People

Plants are a major part of our everyday life and we would not be able to exist without them. Much of human nutrition depends on land plants. Staples of the human diet include cereals, corn, wheat, rice, potatoes and legumes. Other human food includes vegetables, fruits, nuts, herbs and spices. Beverages include coffee, tea, juices, wine, and beer. Sugar, cooking oils & flour are all used in preparing a variety of foods.

Plants, in addition to being a valuable source of food and providing us with the oxygen that we breathe, have become an integral part of our everyday existence and brought us comfort in our current lifestyles. Some common plant products include:

- **Wood** for furniture (desks, chairs, tables, lamps), building materials (walls, floors, molding, house frames), tools (ladders, rulers, pencils, handles), paper (writing, wallpaper, decorations, toys, money), fuels (firewood, charcoal), boats, sports equipment (bats, golf clubs, pool cues, arrows, hurdles), musical instruments (pianos, violins, guitars, basses, recorders), machinery parts, looms, spinning wheels.
- **Rubber** for elastic, toys, erasers, tires, boots, seals, machinery parts, rubber bands, surgical gloves.
- **Cork** for bulletin boards, wine stoppers, sound proofing, hot pads, and coasters.
- **Fibers** (from the outer portion of the stem of fibrous plants such as bamboo, flax, hemp, and jute, or from the leaves of plants such as cattail, agave, and yucca) for spinning into filaments, thread, textiles or rope; be chemically modified to create a composite material (e.g., rayon or cellophane); or matted into sheets as with paper.
- **Fossil fuels** (coal, petroleum, & natural gas) were formed from the organic remains of prehistoric plants.
- **Personal care items** including soaps, shampoos, cosmetics such as skin cream and lipsticks, mouthwash, deodorant and fragrances/perfumes.
- **Medicines** including painkillers such as aspirin and morphine, tranquilizers, quinine, steroids, cortisone, anti-cancer drugs, birth control and heart drugs such as digitalis.
- **Herbal supplements** including ginkgo, Echinacea, and St. John's wort.
- Other products such as cleansers, wax, adhesives, chalk, dyes, inks, food and liquid containers, paints, turpentine, varnish, lubricants, linoleum, plastics, and chewing gum.
- Aesthetic uses in landscaping & as indoor decorations, as well as to provide shade, modify temperatures, reduce wind, abate noise, provide privacy, and prevent soil erosion.

Historically, plants are a source of compounds useful for medicinal purposes. For thousands of years early indigenous people used plants as their only form of medicine and healing. Healers used plants to alleviate pain, ease the symptoms of dozens of diseases, and treat complaints of every kind. Today, people still use medicinal plants, whether in traditional roles or as building blocks for new research and innovative drugs. Herbal medicines are used as dietary supplements and provide a healthy alternative to processed foods and pharmaceuticals. Among most popular plants and herbs used are aloe vera, echinacea, ginkgo balboa, garlic and ginseng.

Due to their astonishing biodiversity, rainforests have a huge potential for new plant-derived drugs. Through natural selection, rainforest species have adapted various chemical defenses to ensure survival against predation, infection, pests and disease. These plants have been synthesizing compounds for millions of years that protect against predators, infection, pests, and disease, creating acutely powerful chemical templates with which pharmacologists can create new drugs. Rainforest plants have provided remedies for all sorts of medical problems, from childhood leukemia to toothaches.

In 2010, scientists in Italy developed a way of turning rattan (the name for approximately 600 species of palms) wood into bone. This manufactured bone that is almost identical in properties to the human tissue. The process starts by cutting the long tubular rattan wood up into manageable pieces. The pieces are put in a furnace and heated. In simple terms, carbon and calcium are added. The wood is then further heated under intense pressure in another oven-like machine and a phosphate solution is introduced. The rattan manufactured bone has been implanted in sheep with great success.

Despite the tremendous benefits people obtain from plants, people have had some negative impacts on plants that threaten their existence. Over-consumption is a global problem that is being caused and worsened by a small fraction of the population. Over-consumption is a problem where resource use has outpaced the sustainable capacity of the ecosystem. A prolonged pattern of over-consumption leads to inevitable environmental degradation and the eventual loss these resources.

Forests and grasslands are being converted to deserts. People are cutting trees and shrubs for their personal needs and goats are allowed to eat the remaining vegetation. Without the plants and their root systems, the soil is eroding resulting in a nutrient depletion, making it hard for the land to recover.

Human activity is resulting in habitat loss for animals as well as plants. Natural resources are being harvested for industry production and urbanization. Also large tracts of forest are being cleared for agriculture. As a habitat is reduced, the remaining species must find a way to survive in a smaller environment. If this is too small for a species, they usually become extinct from this area.

Introduced species, non-native to an area, can sometimes thrive and cause damage to the ecosystem they are introduced into. They might proliferate so aggressively, that they crowd out existing native species.

People burn coal, oil, gas and trees causing the buildup of carbon dioxide, which results in global warming and climate changes around the world. Carbon dioxide traps the warm air in our atmosphere and prevents its dispersal into space. The excess heat is causing polar ice caps to melt and these climate changes can alter the circulation of ocean currents and affect the amount and pattern of rainfall worldwide.

In biotechnology, people are altering plants, giving them new traits and characteristics. These changes, with the aid of biotechnology are more extensive and are occurring at a faster rate than the controlled breeding that has been happening with farmers for thousands of years. The debate continues whether these manipulations are safe and worthwhile. There are unknown risks that could potentially harm human health or the environment. There has been no long term studies on the effect of these altered plants and a balanced ecosystem. Once introduced, there might not be able to stop an unanticipated harmful result of a biotech-altered plant that was introduced to the environment.

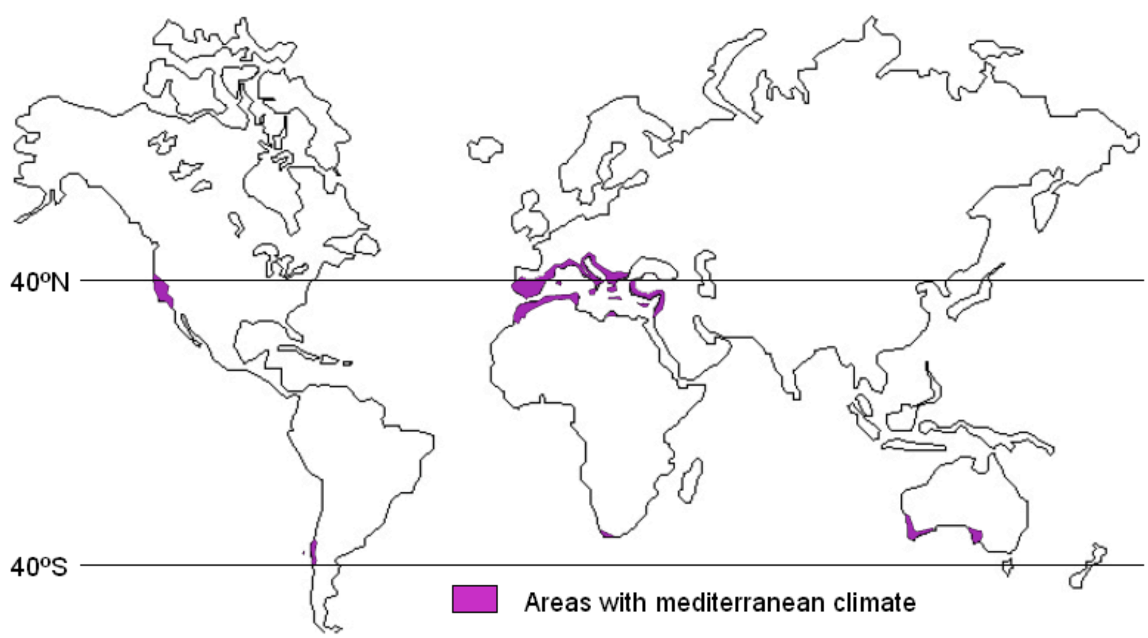
Biodiversity is critical to life on earth and is an indicator of how “healthy” our planet is. Biodiversity is the range of variation found among microorganisms, plants, fungi, and animals.

Each species represents thousands of millions of years of evolution. The diversity of life enriches the quality of our lives in ways that are not easy to quantify. We have much to learn about the interconnection of all life forms; we don't understand the full nature of this interconnection and how loss of various species will affect survival in the future. Species are becoming extinct at the fastest rate known in geological history and most of these extinctions have been tied to human activity.

The human population has had a tremendous influence on the delicate balance of nature. Everything that we need for our survival and wellbeing depends, either directly or indirectly, on our natural environment. Sustainable use practices are aimed at preserving natural resources and creating and maintaining the conditions under which humans and nature can exist in productive harmony. Sustainability is important to making sure that we have and will continue to have, the water, materials, and resources to protect human health and our environment and maintain the biodiversity of our planet. Plants have made a tremendous contribution to the shaping of our terrestrial environment. Life would not exist, as we know it without the presence of plants.

VII. Climate of the San Francisco Zoo

California is in one of the world's five Mediterranean climate zones, characterized by mild, wet winters and dry, hot summers, mitigated in California by frequent fog along the coast. Spring and fall are important growth seasons. With the mix of precipitation, temperature, wind and fire result in the specialized adaptations of many CA native plants.



Adaptations to survive the drought include deep roots, stiff and vertical hard, leathery, evergreen (sclerophyll) leaves to resist wilting and minimize loss of moisture, light colored leaves to reflect away hot sun and aromatic oils to discourage animal browsing. Some leaves remain small and green year round to conserve energy. To survive drought many plants sprout with the winter rains, then must germinate, flower and set seed all before the onset of the dry season. Young seedlings will typically have a rapidly growing taproot that penetrates the soil before the dry season sets in. If they survive the first dry season, they will develop a mat of finer roots near the surface of the soil where there is better access to nutrients and light rain and coastal fog. Perennials may go dormant in the summer drought by dropping leaves or storing moisture underground in bulbs, corns and tubers.

Some plants are adapted to fire by having seeds in a hard cover to remain on the plant for years or lie dormant in leaf litter. Seeds open in fire or are stimulated to germinate in the ash and cleared spaces after a burn. Some sprout from roots or a stump after a fire. (redwood seeds require fire for germination)

Adaptations to strong coastal or alpine winds and other harsh conditions include a deep taproot as an anchor and to find water, a matted or clumped growth pattern, a low profile, growing tips buried in older growth and protective wooly hairs. Species that live in Coastal dune habitats prefer open, sandy habitats with a high degree of disturbance from winds and tides.
The conifers that you see along the California coast and in the zoo are adapted to harsh climate, water stress, and low soil nutrients. They are evergreens with waxy, narrow leaves, a spire shape and their branches are flexible in cold climate. Examples of California coastal species are the Monterey pine and the Monterey cypress.

The San Francisco Zoo, with its year round mild climate can grow a wide variety of plants from all over the world, in addition to our beautiful native plants. The zoo has an amazing plant collection. Plants from Chile, South Africa and Australia do well here naturally. For example the Protea from South Africa and the Kangaroo paw from Australia. They share the same climate as the Bay area with warm, dry summers and rain, mild winters.

Principal Biomes with their Dominant Growth Forms
and some Representative Species

Biome	Dominant Growth Form	Representative Plants (mostly Northern Hemisphere)
Aquatic Systems		
Open oceans	Plankton, fioating algae	Diatoms, plankton (dinofiagellates, etc,)
Estuaries & shores	Multicellular algae, grasses	Seaweeds, eelgrass, marsh grass
Lakes & streams	Algae, mosses, higher plants	Plankton algae, filamentous algae, duck weed, water lilies, pondweed, water hyacinth
Swamps, marshes, bogs	Algae, rushes, etc.	Cattails, water plantains, pipeworts, rushes, sedges, sphagnum moss, tamarack, baldcypress, mangrove
Forests		
Tropical rain forests	Trees, broad leaved evergreen	Many species of evergreen, broad leaved trees (unfamiliar to us), vines, epiphytes (orchids, bromeliads, ferns)
Tropical seasonal forests	Trees, both evergreen and deciduous	Mahogany, rubber tree, papaya, coconut palm
Temperate rain forests	Trees, evergreen	Large coniferous species (Douglas fir, Sitka spruce, coast redwood, western hemlock, white cedar)
Temperate deciduous	Trees, broad leaved deciduous	Maples, beech, oak, hickory, ash, basswood chestnut, elm, sycamore
Temperate evergreen	Trees, needleleaved	Pines, Douglas fir, spruce, fir
Boreal coniferous (taiga)	Trees, needleleaved	Evergreen conifers (spruce, fir, pine), blueberry, oxalis
Reduced Forests		
Scrublands, chaparral	Shrubs, scierophyll, evergreen	Live oak, deerbrush, manzanita, buckbrush, chamise
Thorn woodlands	Spinose trees and large shrubs	Acacia, large shrubs
Temperate woodlands	Small evergreen or deciduous trees, grass or shrubs	Pinyon pine, juniper, evergreen, oak
Grasslands		
Tropical savanna	Grass (and trees)	Tall grasses, thorny trees, sedges
Temperate grasslands	Grass	Bluestem, Indian grass, grama g'rass, buffalo grass, bluebunch, wheat grass
Tundras		
Arctic	Diverse small plants	Lichens, mosses, dwarf shrubs, grass, sedges, forbs
Alpine	Small herbs (grasslike)	Sedges, grasses, forbs, lichens
Deserts		
Tropical warm	Shrubs, succulents	Spinose shrubs, tall cacti, euphorbias
Temperate warm	Shrubs, succulents	Creosote bush, ocotillo, cacti, Joshua tree, century plant, bur sage (in USA)
Temperate cold	Shrubs	Sagebrush, saltbush, shadscale, winterfat, greasewood (in USA)

(10/01)

Botany Glossary

Abiotic: nonliving parts of the ecosystem including sunlight, water, soil, air, and dead materials.
Alternation of generations: the regular alternation of forms or of mode of reproduction in the life cycle of an organism, such as the alternation between diploid and haploid phases, or between sexual and asexual reproductive cycles.
Alternate leaf pattern: one leaf at each node.
Angiosperm: a flowering, fruit-bearing plant or tree, the ovules (and therefore seeds) of these plants develop within an enclosed ovary.
Annual: a plant that completes its whole life cycle in one year. Occurring yearly.
Anther: the part of the stamen where pollen is produced.
Biennial: a plant that completes its life cycle in two years.
Biodiversity: the range of variation found among microorganisms, plants, fungi, and animals; the richness of species of living organisms.
Biome: a biotic region; any of a group of major regional terrestrial communities with its own type of climate, vegetation, and animal life. Biomes are not sharply separated but merge gradually into one another.
Biotic: living components of the ecosystem.
Browser: a type of feeding in which an herbivore feeds on woody twigs and leaves from trees and shrubs.
Bryophyte: a non-vascular plant, due to a lack of vascular tissue. They are commonly mosses, liverworts and hornworts and are restricted to mostly moist environments.
Bud: a baby flower or leaf wrapped up tight, waiting for the right time to grow.
Burl: a tree growth in which the grain has grown in a deformed manner as in an overgrown knot or an outgrowth. It is commonly found in the form of a rounded outgrowth on a tree trunk or branch that is filled with small knots from dormant buds.
Carnivore: an organism that only eats meat.
Chlorophyll: a green photosynthetic pigment found in plants, algae, and cyanobacteria. Chlorophyll is an essential component of photosynthesis, which helps plants get energy from light.
Chloroplasts: are organelles found in plant cells and other eukaryotic organisms that conduct photosynthesis. Chloroplasts are green because they contain the chlorophyll pigment.
Compound leaf: a leaf composed of a number of leaflets on a common stalk.
Cone: a seed container with hard, woody scales.
Conifer: any gymnosperm tree or shrub of the phylum *Coniferophyta*, typically bearing cones and evergreen leaves. The group includes the pines, spruces, firs, larches, yews, junipers, cedars, cypresses, and sequoias.
Consumer: an organism that feeds on other living organisms, i.e. animals and parasitic and insectivorous plants.
Cotyledon: the primary or rudimentary leaf of the embryo of seed plants. A cotyledon contains stored food and serves as a food reservoir.
Deciduous: shedding the leaves annually; a plant, which completely loses their foliage during the winter or dry season as an adaptation to a cold or dry season.
Decomposer: an organism that feeds on dead organic material, breaking it down into simpler substances and bringing about decay. In this way, organic material is recycled as plants can use the products of decomposition.
Dicot: flowering plant whose seed has two embryonic leaves or cotyledons. Dicots have broad leaves with branched veins. (examples: oak, willow, ash, maple, birch, and elm)
Diploid: having two similar complements of chromosomes. Usually one set from the mother and one from the father. Symbolized by 2N.
Ecological niche: the place and role occupied by an organism in a community, determined by its nutritional requirements, habit, etc.
Ecological pyramid: a graphical representation in the shape of a pyramid to show the feeding relationship of groups of organisms, and the flow of energy or biomass through the different trophic levels in a given ecosystem.
Ecology: the study of the relationships between living organisms and the living (biotic) and nonliving (abiotic) factors in the environment.
Ecosystem: a group of living and nonliving things interacting with each other in a particular environment.
Embryo: the rudimentary plant usually contained in the seed.
Endosperm: the tissue within the seed of a flowering plant that surrounds and nourishes the developing embryo.
Epicormic bud: dormant vegetative buds embedded beneath the bark that have a regenerative function after crown destruction, for example by fire
Evergreen: a plant that has leaves in all seasons.
Flower: the part of the plant that can make seeds; the blossom of a plant.
Folivore: an herbivore that specializes in eating leaves.
Food chain: a series of organisms, each successive group of which feeds on the group immediately previous in the chain, and is in turn eaten by the succeeding group.

Food Web: several food chains linked together.
Frugivore: a fruit eater; an herbivore or omnivore where fruit is a preferred food type.
Fruit: the part of the plant that holds and protects the seed.
Germination: the process in which a plant or fungus emerges from a seed or spore, respectively, and begins growth.
Grazer: a type of feeding in which an herbivore feeds on grasses or other low vegetation
Gymnosperm: vascular plant whose seeds are not enclosed by a ripened ovary (fruit). The seeds of many gymnosperms (literally, *naked seed*) are borne in cones and are not visible.
Haploid: pertaining to a single set of chromosomes. Symbolized by N.
Herb: a plant that consists only of primary tissues; lacking wood.
Herbivore: an organism that eats only plants.
Hibernation: a state of inactivity and metabolic depression in animals, characterized by lower body temperature, slower breathing, and lower metabolic rate.
Leaf: one of the expanded, usually green organs borne by the stem of a plant.
Lignotuber: a starchy swelling of the root crown possessed by some plants as a protection against destruction of the plant stem by fire.
Monocots: flowering plant whose seed has one embryonic leaf or cotyledon. Monocots have long, narrow leaves with parallel veins (such as grasses, palm, lily, pineapple, banana and the orchid family).
Niche: the position or function of an organism in a community of plants and animals; the role a species plays in an ecosystem.
Omnivore: an organism that eats both plants and animals.
Natural selection: a nonrandom process by which biologic traits of an individual that make them better adjusted to an environment tend to survive, and reproduce, and therefore are able to transmit and perpetuate their essential qualities to succeeding generations.
Nectar: a sweet liquid made at the base of many flower petals.
Needle: A narrow, stiff leaf, as of firs, pines, and other conifers. The reduced surface area of needles minimizes water loss and allows needle-bearing plants to live in dry climates.
Opposite leaf pattern: two leaves at each node and on opposite sides of the stem.
Ovary: enlarged basal portion of the pistil where ovules are produced.
Ovule: a plant structure that develops into a seed when fertilized.
Palmate: having four or more lobe or leaflets radiating from a single point, as the fingers of a hand.
Perennial: a plant that lives from year to year.
Petal: parts of a flower that are often conspicuously colored.
Phloem: a tissue in a vascular plant that functions primarily in transporting organic food materials (e.g. sucrose) from the photosynthetic organ (leaf) to all the parts of the plant.
Photosynthesis: synthesis of complex organic material using carbon dioxide, water, inorganic salts, and light energy (from sunlight) captured by light-absorbing pigments, such as chlorophyll and other accessory pigments.
Pinnate: having leaflets or primary division arranged on each side of a common stalk.
Pistil: ovule-producing part of a flower. The ovary often supports a long style, topped by a stigma. The mature ovary is a fruit, and the mature ovule is a seed.
Plant: any organism that belongs to Kingdom Plantae, which is characterized by the ability to make its own food by photosynthesis.
Pod: a somewhat elongated, two-valved seed vessel, as that of the pea or bean.
Pollen: the fertilizing element of flowering plants, consisting of fine, powdery, yellowish grains or spores, sometimes in masses.
Primary growth: growth in vascular plants resulting from the production of primary tissues by a primary meristem. Elongation of the plant body is usually a consequence of primary growth.
Producer: an organism that is the first stage in a food chain. Producers include green plants and those bacteria that synthesize organic molecules from inorganic materials by photosynthesis or chemosynthesis.
Receptacle: part of a flower stalk where the parts of the flower are attached.
Root: a part of the body of a plant that develops, typically, from the radicle and grows downward into the soil, anchoring the plant and absorbing nutriment and moisture.
Sclerophyll: type of vegetation that has hard leaves and short internodes (the distance between leaves along the stem).
Secondary growth: growth in vascular plants from production of secondary tissues by a lateral meristem, usually resulting in thicker branches and stems; the increase in diameter of a plant organ resulting from cell division in a cambium.
Seed: a tiny plant and its food source, tucked in a seed coat, waiting for good growing conditions. The fertilized, matured ovule of a flowering plant, containing an embryo or rudimentary plant.
Sepal: outer parts of the flower (often green and leaf-like) that enclose a developing bud.
Serotinous: a pine cone or other seed case that requires heat from a fire to open and release the seed.

Simple leaves: a leaf that is not divided into parts.
Sorus: (pl. **sori**) structures producing and containing spores
Sporophyte: spore-producing phase in the life cycle of a plant that exhibits alternation of generations.
Stamen: pollen-producing part of a flower, usually with a slender filament supporting the anther.
Stem: the stalk that supports a leaf, flower, or fruit or a plant.
Stigma: part of the pistil where pollen germinates.
Stomata: a tiny pore in a plant's leaf surrounded by a pair of guard cells that regulate its opening and closure, and serves as the site for gas exchange.
Sustainable: of, or relating to a state of being maintained at a constant level while no major or severe damage is incurred, such as to the natural resources or environment; the ability of the ecosystem to keep diverse and productive through time despite humans deriving their needs from natural resources.
Tracheophyte: any type of vascular plant
Tree: a plant having a permanently woody main stem or trunk, ordinarily growing to a considerable height, and usually developing branches at some distance from the ground.
Trophic level: a position in a food chain or ecological pyramid occupied by a group of organisms with similar feeding modes. The number of steps an organism is from the start of the chain is a measure of its trophic level.
Venation: pattern of veins in the blade of a leaf. The veins consist of vascular tissues, which are important for the transport of food and water.
Whorled leaf arrangement: more than three leaves are attached at a node
Xylem: a type of vascular tissue in terrestrial plants and is primarily involved in transporting water and nutrient (from the roots to the shoot and leaves) and providing structural support.

Sources:

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