THE DALLAS WORLD AQUARIUM

Plants:

A Resource for Teachers

Whats Growing On?

The rainforest biome forms a band around the earth at the equator. The equator receives more sunlight than any other part of the earth and therefore more energy. This is why the rainforest is one of the most productive ecosystems. More than half of the world's tropical rainforests are gone. The remaining ones cover approximately 7% of the earth. Over half of the existing rainforests can be found in South and Central America. Another 25% are in Asia and 20% are in Africa. The remaining are scattered in some Caribbean and Pacific Islands, India and Australia. Most equatorial or true tropical rainforests have heavy rainfall, tropical heat, high humidity and diverse and interdependent species of plants and animals. Temperatures in the rainforests average 80^0 F (27^0 C) and vary more between day and night than from month to month. Even though annual rainfall varies between 150-400 inches (381 - 1016 cm), rainforests do have dry and rainy seasons. Rainforests are incredibly diverse habitats and home to half of the world's plant and animal species. An acre (0.41 ha) of rainforest may contain over 200 different species of trees, with a single tree being home to more than 1,000 species of insects. The Amazon rainforest is the habitat for about one quarter of all bird species.

In addition to the plants and wild animals, the rainforest is also home to indigenous people. These people have survived in the rainforest for many years without causing permanent destruction. They have great knowledge of the earth, plants and animals and know how to use their resources responsibly.

The lush tropical rainforest is an appealing image. The color and texture of the plants provide a beautiful backdrop for the diverse wildlife. The purpose of plants goes far beyond beauty. Plants perform a multitude of services which include providing food, shelter, medicine, oxygen and other necessities for the animals around them. They are also a major contributor of oxygen and rainfall for more temperate climates and locations.

The emergent layer or pavilion can reach heights of 250 feet (76 meters) above the forest floor. All organisms which live at this level must be able to handle strong sun and heavy wind and rain. The emergent layer is not thick like the canopy. Trees are tall and straight with few lower branches to intercept light. There is only one or two emergent trees per rainforest acre (0.41 ha). Tropical rainforest leaves usually have smooth edges. At the top of the rainforest, the leaves are smaller to cut down on the sun and wind exposure. As you go down through the rainforest layers, the leaves get bigger so they can collect more sun as it is limited the lower you go in the rainforest. The leaves of emergent trees are small, leathery and hold water well. Lower down, many leaves are equipped with drip tips to move water off the leaves quickly to prevent the growth of fungus and epiphytes.

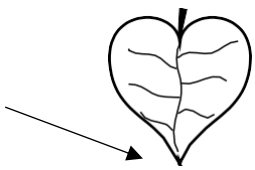
The canopy trees, which form a roof over the rainforest, grow from 70-150 feet (21-46 m) tall. The plants at this level are exposed to many of the same elements as the emergent trees, however, there is some variation in temperature and humidity and more air movement. Plants are our key to survival on planet Earth. Many organisms depend in some way on plants for food. Most plants are able to make their own food using a process called photosynthesis. Ninety percent of the photosynthesis which occurs in the rainforest, takes place in the canopy.

$$CO_2 + H_2O + \text{CHLOROPHYLL} + \text{SUNLIGHT} = \text{ENERGY}$$

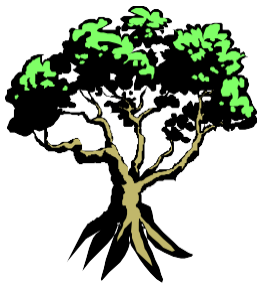
(carbon dioxide + water + chlorophyll + sunlight = energy)

Photosynthesis is the process used by plants to turn carbon dioxide, water, chlorophyll and sunlight into food.

Leaf "Drip Tip"

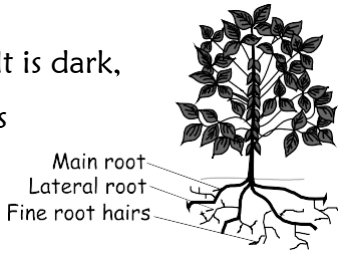


There is a three-foot (0.9 m) gap between the crowns of the trees called "crown shyness" at this level. Differing theories exist on the causes of crown shyness. Some scientists believe the trees keep this distance to prevent damage during high winds and the spread of disease and pests; others explain that the distance between the crowns occurs because the edges of the trees are worn away by regular wind movements.



Buttress roots may grow on the canopy and emergent trees. These roots provide support for these rainforest giants. Although the trees can be over 100 feet (30 m) tall, their roots typically do not grow more than 3 feet (0.9 m) into the native soils. The trees can obtain additional nutrients from the thin layer of top soil.

There is dim light in the understory and the winds are light. Smaller trees with umbrella-shaped crowns make up this layer. The leaves on the trees are large to catch any sunlight possible. Many herbivores reside at this level because the large leaves are less poisonous than some of the leaves found in the canopy.



About 1% of the light received by the canopy reaches the forest floor. It is dark, warm and humid at this level. Fungus, bacteria and other decomposers keep the forest floor clean by feasting on organic material which falls from the other layers. Dense shrubs and grasses grow only where trees have fallen and allow sunlight to hit the forest floor, as well as along the edges of rivers and lakes.

Plants are very diverse, but share many basic parts. The root systems of plants help to collect valuable nutrients from the soil. Rainforest plants have shallow root systems which run horizontally because any nutrients in the soil are located close to the surface. Some plants send roots down from the canopy in search of nutrients and water. This is called adventitious rooting. If these roots manage to hit water, they branch out quickly. The Banyan tree (*Ficus benghalensis*) from India and its relative the "Strangler fig" (*Ficus crassiuscula*) from tropical America are good examples of adventitious rooting.

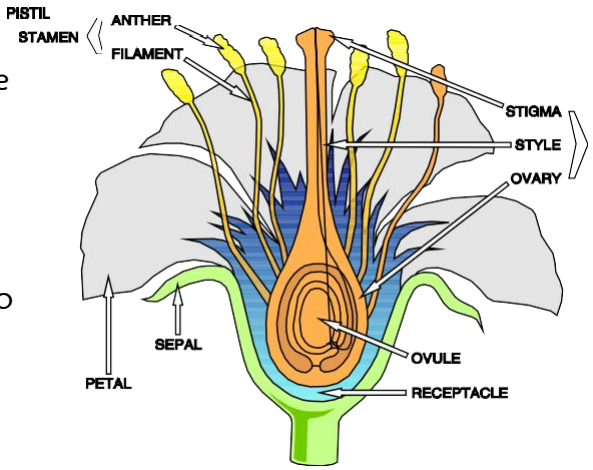
There are three types of leaf arrangement. Plants with a whorled leaf formation have three or more leaves circling around the stem, an alternate distribution has leaves in a stair step pattern up the stem and a paired pattern has leaves arranged in pairs up the stem. All flowering plant share one of the three leaf patterns.



COLORFUL FLOWERS - NOT JUST FOR LOOKS!

The color and scent of a flower give clues about its pollinators. White flowers often have a strong scent to attract bats. Bats are attracted by the odor of the flower instead of the color. Flowers which are pollinated by bats usually have a stronger scent at night because bats are nocturnal. Red flowers often have a weak scent because their chief pollinators, butterflies and hummingbirds, are attracted to color and have a poorly developed sense of smell. The arrangement of the petals is another clue about a flower's pollinator. Large petals provide a landing pad for insects. The nectar of some flowers is found deep inside long thin petals, so an animal which can hover (hummingbird, butterfly) is the main pollinator.

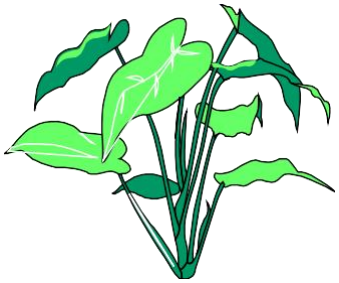
Most flowering plants have male and female parts. The female part, known as the pistil (stigma + style + ovary), receives pollen from other plants. The stamen (anther + filament) is the male part of the flower. The stamen produces pollen which is picked up by pollinating insects and birds and deposited on the stigma of another flower. The male and female parts of the flower usually mature at different times to keep a flower from pollinating itself.



All flowering plant families can be categorized as either monocot or dicot. Monocot plants have only one embryonic leaf when sprouting from a seed. They also have a simple vascular system to deliver nutrients to all the parts of the plant. Close observation of a monocot leaf shows a straight line from the base to the end of the leaf, like a drinking straw moving from the roots to the tips of its leaves. Dicot plants have two

embryonic leaves when sprouting from a seed. Dicot plants have a dendritic vascular system. The leaves of dicot plants have a complex "map" of capillaries moving nutrients through the plant.

In the rainforest there is a lot of competition for sunlight. The tallest trees and plants get the greatest share of the light. Epiphytes and vines use two strategies to reach the light and take a shortcut to the top. Epiphytes and vines do not grow a strong stem or trunk, in order to conserve energy. Neither have roots on the ground; the water and nutrients necessary for survival are absorbed from the air and rainwater.



Vines need support to climb and use several different strategies. Some vines grow around larger plants, twisting and turning their way to the top. Others have special tools to help them climb. Tendrils grow out off the stems looking to attach for support. Once the tendrils touch something, they begin to curl up so the vine may continue its climb.

Some vines have sticky roots which attach to rock or bark to make their way up toward the light. Other, lazier vines, simply grow up and out, hoping to land in the crook of a tree or on another plant for support. Some vines begin with roots in the forest floor. Once they reach the light, the roots begin to wither and they send out new roots and shoots horizontally across the canopy (Philodendron).

Epiphytes, also known as air plants, use a special strategy to grow near the light. They grow on other plants, but are not parasites. Epiphytes absorb water and necessary nutrients from the air and rainwater. Some have leaves shaped like cups or arranged like cisterns to collect water. Composting occurs at the roots of some epiphytes.

Debris is collected as it falls from above and as it decays nutrient-rich humus forms. The humus forms thick moss mats on the limbs of the trees. Other plants share in the rich humus by sending roots over to the base of the epiphyte. Bromeliads, orchids and anthuriums are examples of epiphytes.

The Fungus Among Us

Fungus comes in many shapes, sizes and colors and keeps the forest floor clean by decomposing much of the rainforest debris. Fungi do not gain energy from sunlight and photosynthesis. Instead, they feed on dead organic matter, breaking it down at the same time. Fungus does have specific requirements for growth and will grow only when the appropriate conditions are present. Fungus reproduces by scattering spores. Some rely on the wind, some on insects and others explode. One type of fungus impregnates a certain insect which moves on and dies. The fungus then grows on the decaying insect.

The forest floor is a blanket of efficient fungus and is the key to the recycling system of the rainforest. Fungus becomes more visible when it emerges to reproduce (toadstools, puffballs, etc.). The constant flow of decaying matter from above is transformed by the decomposers into components useful to the green plants. There is no room for waste, for if the cycle is broken, the precious material will leach out of the ecosystem and will be washed away by the rain. The soil is so nutrient poor it cannot support the rainforest by itself.

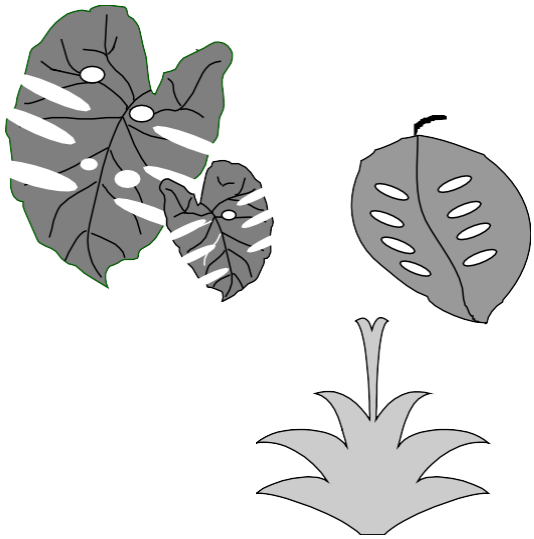
Scientists have learned that most of the nutrients in this ecosystem are locked up in the living components of these areas; that is the plants and animals. As soon as death occurs, the organic building blocks of life are recycled back to the living through rapid decomposition.

Friend or Foe?

Just like the animals, plants also have enemies. Some of the unusual markings or characteristics are actually adaptations for protection. Some plants emit strong odors or contain bad tastes or poisons. These are used as a defense to keep animals and insects from eating the leaves of the plants. Some animals overcome the toxins in the plants but retain their negative impact and use them as their own defenses.

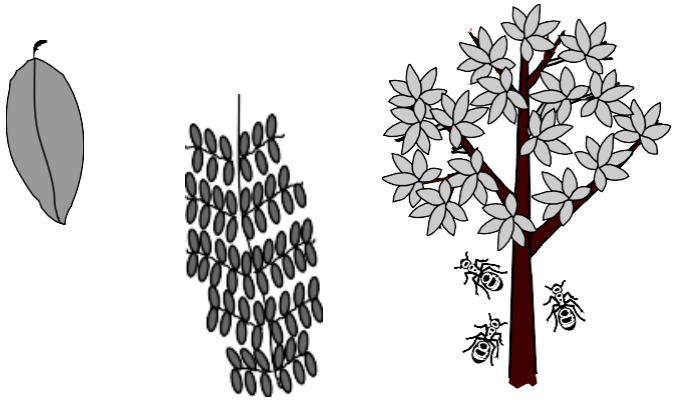
These animals are generally bright colored to warn others of their poisons. Some trees have spikes growing on their trunks to protect their fruit from foraging animals. The trees will eventually drop their fruits in hope that animals will eat and pass the seeds, but the trees need to protect the fruits until they are ripe. Two good examples of this adaptation in the rainforest at The Dallas World Aquarium are the Floss silk (*Chorisia speciosa*), also known as the"Monkey Don't Climb Tree" and the Peach palm (*Bactris gassipes*).

One type of monstera vine has holes in its leaves to help it play a trick on insects looking for lunch. The holes make the plant look sick or like another insect has already been there to eat. Another monstera plant, also known as the Swiss cheese plant, has holes in its leaves to protect it from high winds. The holes prevent the leaves from tearing in high winds. Some bromeliads have spiny edges on their leaves. This offers different types of protection. It keeps foraging animals from pulling the leaves off to eat, as well as, using them for support as they wander through the treetops.

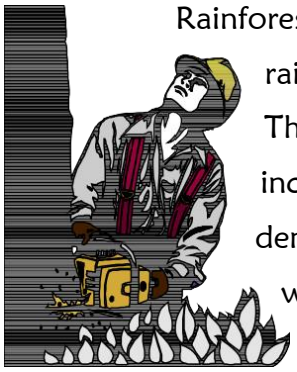


The Cecropia tree (*Cecropia palmata*) is protected and offers protection through a symbiotic relationship with *Azteca* ants. Ants burrow into the hollow limbs of the Cecropia tree and live in the chambers. They use the chambers like rooms in a house; one for food storage, one for the young, etc. In return, ants keep vines and parasites from growing on the tree. If a vine starts to grow up the tree, the ants go to the base of the tree and sever it.

Some plants in the canopy and emergent layers have adapted to the hot, dry conditions. By dividing the leaf into smaller parts, the surface area of the leaves has been minimized to limit exposure to the harsh elements high in the forest. The leaflets are not individual leaves, but all make up one entire leaf. This type of leaf is called a "compound leaf."



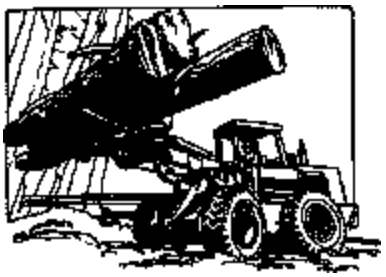
DEFORESTATION



Rainforests are disappearing at an alarming rate. Some estimate that an area of rainforests the size of a football field is destroyed every minute of every hour. The destruction of these ecosystems is due to a variety of reasons which include: poverty of the native peoples, the increasing world population, demands for wood and international debts. One of the most important things which must happen to ensure protection of the rainforests is to change the attitudes of the governments in rainforest countries. Many of these countries sell rainforest land to companies to create money.

The problems facing the rainforests cannot be blamed solely on big companies. Often poor farmers chop down or burn part of the rainforest to make room for their crops. Slash-and-burn farming is less harmful when done in contained portions. As populations rise and money grows scarce, more people turn to slash-and-burn farming for survival. Too many slash-and-burn farmers in an area become destructive to the environment. The soil beneath the rainforest is nutrient poor, very rocky and can only sustain crops for two to five years. This causes farmers to move on quickly to new parts of the rainforest to clear for crops. The land left behind is so poor in nutrients that shrubs and grasses can barely grow. The remaining soil is further depleted by wind and water erosion.

Logging in the rainforest means big business and fast cash for poor countries. Many of these countries have large international debts and can charge top dollar for pristine rainforest land. Four types of logging occur.



Selective cutting cuts specific trees individually or in small groups. This is one of the least destructive methods, but also one of the most expensive. It allows for natural re-seeding by the surrounding trees and makes room for new tree growth. Because only small patches of trees are cut down, there is less threat of erosion. One form of selective cutting known as high-grading, can be very damaging to the wood. Selective cutting can vastly reduce the diversity of the ecosystem, as well as damaging other trees with the equipment needed to get out the specific trees.

Seed-tree cutting entails clearing most trees but leaving seed-producing trees randomly throughout the site in order to naturally reseed the area. This method allows a diverse forest to grow in place of the original forest. The trees which are left on site, help cut down on destruction from wind and water erosion.

Clear-cutting removes all trees, shrubs and grasses from the area. After the forest is removed, the area is re- seeded naturally or by the loggers. If the forest is artificially re-seeded, only one species is planted in rows. This makes it easier to clear cut the area again. This method leads to large amounts of erosion since no roots or grasses are left to hold the soil in place. (This type of harvesting is typical of North American logging operations).

Strip-cutting is less destructive to the rainforest. Strips of forest are clear cut, narrow enough to allow for natural re-seeding. After the original strip begins its regrowth, another strip is cut. This allows for harvesting desirable trees, using a sustainable method. The narrow strips of land are not as susceptible to erosion because they are protected on either side.

Erosion is a factor with any method of logging and may effect the entire ecosystem. The silt and mud which run off from these sites, clouds up river water making it unsuitable for some of its native inhabitants. The buildup of silt in the water can also limit fishing and transportation.

Many view the loss of potential as the most tragic part of rainforest destruction. The rainforest is such a diverse ecosystem and there are many plant and animal species yet to be discovered. Sadly, some of these species may become extinct before we ever learn about them. Scientists believe we may be missing out on potential foods and medicines. Today, physicians use many plant based medicines, but these barely tap the potential of nature's pharmacopeia. Of the known plant species, about one percent have been thoroughly tested by modern science for medicinal applications. Shaman or medicine men in rainforest tribes have been using plants to treat a variety of ailments for many generations. Fifty percent of our modern medicines are plant derived, making the potential truly staggering.

Some of the discovered medicines are:

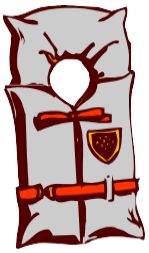
Avenca (*Adiantum capillus-veneris*) is a small fern found in tropical and temperate rainforests throughout the world. In the United States, Avenca is commonly known as the "maidenhair fern". This fern is used medicinally as a remedy for coughs, asthma, jaundice and kidney disorders. The American Indians use this plant to treat chills and fever.

The Brazilian pepper tree (*Schinus molle*) is a shrubby tree with narrow spiky leaves. They produce a multitude of flowers prior to a small berry in December and January. This plant occurs in the tropical and semi-tropical zones of North and South America. All parts of the Brazilian pepper tree have been used to treat a variety of ailments in Central and South America. The plant is used externally as an antiseptic, a treatment for fractures and to soothe toothaches. In South America, a leaf tea is made to treat both colds and depression. All parts of the plant contain high oil and essential oil content. The pepper-flavored berries are used to make syrups and beverages and the plant itself is used as a pepper substitute in Africa.

The Cecropia tree (*Cecropia palmata*) is a fast-growing rainforest tree. It has large leaves that can grow up to a foot (0.3 m) in width. The Cecropia is used for a variety of medicinal purposes throughout South America. In Venezuela, the astringent and corrosive latex from the tree is used to treat warts and calluses. The leaves are anti-asthmatic and also used for liver ailments. In Colombia, it has been used as a treatment for Parkinson's disease and to aid in childbirth.

Graviola (*Annona muricata*) is an evergreen tree with dark, glossy leaves and is found in the warmest tropical regions of North and South America. It yields a yellowish-green fruit which is used to make beverages or can be eaten straight from the tree. Throughout the tropics, the bark, leaves, seeds and fruit of the Graviola have been used medicinally. Ailments including fevers, diarrhea, internal and external parasites and liver dysfunction can be treated with Graviola. It is also used to increase lactation and as a sedative. Recent research has found that Graviola may be a cancer fighting agent. One study showed Graviola to be thousands of times more effective than a commonly used chemotherapy drug.

Guava (*Psidium guajava*) fruit, which are larger than tennis balls, are found in trees high in the rainforest. The Guava fruit is eaten throughout the tropics as it contains more Vitamin C than citrus and is also high in Vitamin A. Many tribes use the Guava to treat upset stomachs, vertigo and to regulate menstrual cycles.



The Kapok (*Ceiba pentandra*) or Silk-Cotton tree is a deciduous tree reaching high into the canopy. Inside the fruit, each seed is wrapped in a silky fiber. This fiber is buoyant and is used as a flotation device. The flowers of the Kapok are fragrant clusters that are pollinated by bats and the seeds dispersed by the wind. It has been used medically as well as commercially. The seed oil from this tree is used in the treatment of rheumatism. Pulverized gum root has been administered to treat dysentery.

The Mango (*Mangifera indica*) is a popular fruit enjoyed throughout the world. The fruit, leaves, bark and latex of the plant are used to treat medical disorders including viruses, parasites, upset stomach and flu-like symptoms.

The Passion Flower (*Passiflora incarnata*) is found throughout tropical and semi-tropical zones in North and South America. The woody vine grows quickly using tendrils to climb through the canopy. The vine yields a delicious fruit. This plant has been used as a sedative to treat depression and convulsions. It has also been used as a diuretic, an anti- inflammatory agent, a disinfectant and an asthma treatment.

Papaya (*Carica papaya*), also known as the Pawpaw tree, is a cultivated fruit known throughout the world. The fruit is eaten raw or cooked and also used as an antibiotic, a laxative and also for upset stomachs.

Pau d' Arco (*Tabebuia impetigenosa*) is a large tree found high in the rainforests of South America. The tree produces large, purple flowers and high quality wood. The South American Indians have used the wood for many generations to make their bows. The tree is used by the indigenous tribes to treat malaria, colds, fever, arthritis, snake bites and rheumatism. Some studies have suggested that the Pau d' Arco, may hinder or stop the growth of cancerous tumors and eliminate toxins found in the bloodstream.

Plant It for the Planet

Plants help to keep our air clean. They absorb the carbon dioxide (CO_2) we exhale and change it back into oxygen. Each time we exhale, drive a gasoline powered car or burn fossil fuels we are adding CO_2 to the atmosphere. We rely on the plants to transform the CO_2 back into oxygen. We are currently increasing our CO_2 emissions and cutting down rainforests at an alarming rate. Rainforests are a major oxygen source for the planet.

We value the rainforest for the knowledge it gives us, the products that come from its bounty, the numerous ways it benefits our health, its invaluable role as an ecosystem and for its beauty and majesty. For many, the forest is home, pantry, arsenal and sanctuary. For all these values, we must protect this important ecosystem before it is too late.

USEFUL VOCABULARY

acre	4,840 square yards (4,047 sq m)
adaptation	adjustment to environmental conditions
adventitious	occurring in unusual or abnormal places
anther	the part of the stamen that develops and contain pollen
bacteria	any of a class of microscopic plants with single-celled or noncellular bodies, growing in colonies living in soil, water or organic material
biome	a distinct ecological community of plants and animals living together in a particular climate
canopy	the largest and most active layer of the rainforest, ranging between 60-200 feet (18.3-61 m)
cistern	1: an artificial reservoir for holding liquids 2: a fluid containing sac or cavity in an organism
compost	a mixture consisting largely of decaying organic matter
conservation	a careful preservation and protection of something
corrosive	wears away or deteriorates a substance
crown	the head of foliage of a tree or shrub
debris	the remains of something broken down or destroyed
decay	breaking down of organic matter through chemical processes
decompose	to separate into simpler compounds
diverse	differing from one another
ecosystem	a complex ecological community and environment forming a functioning whole in nature
efficient	productive without waste
emergent	the tallest layer of the rainforest, ranging between 200-250 feet (61-76 m)
endangered	in danger or peril, with organisms in danger of extinction
energy	the capacity to do work
environment	surroundings or external conditions

epiphyte	a plant that derives its moisture and nutrients from the air and usually grows on another plant
erosion	the process of diminishing or destroying in degrees
extinct	no longer existing
filament	the anther-bearing stalk of the stamen
forage	to wander in search of food
forest floor	the dark, humid, lowest level of the forest floor
fungus	plants characterized by absence of chlorophyll and by living on dead or living organic matter
habitat	the place where a plant or animal naturally lives or grows
herbivore	a plant-eating animal
humid	containing or characterized by perceptible moisture
humus	an organic portion of soil made from the decomposition of plant or animal matter
impregnate	to cause to be pregnated or permeated
indigenous	produced, growing or living naturally in a particular region or environment
latex	milky liquid containing resins, proteins
leach	the removal of nutrients from soil brought about by rainwater washing throughout the soils
logging	to cut trees for lumber
medicinal	tending or used to cure disease or relieve pain
nutrient	nourishment or food necessary to sustain life
organic	characteristic of or derived from living organisms
organism	plant or animal life
ovary	hollow part of the style with contains one or more ovules
ovule	develops into the seed after fertilization
parasite	an organism which depends on another for survival without making a useful or adequate return
petal	the non-productive part of the flower (usually colored)

photosynthesis	the process used by green plants to produce food; Carbon dioxide + water + sunlight = energy- rich sugar compounds used for food
pistil	the female reproductive organ
poisonous	the ability to kill, injure or impair through use of poison or venom
pristine	uncorrupted
rainforest	a very wet, essentially non-seasonal forest
receptacle	flat part of the stem from which all parts of the flower arise
recycle	to reuse something rather than disposing of it
reproduce	to produce offspring
resource	a reserve source of supply
ripe	fully grown and developed
root	the part of a plant (often underground)
sepal	floral leaf (usually green)
serrated	having marginal teeth pointing forward
shoot	the growth or sprout of a plant
species	a class of organisms having common attributes and designated by common names
spore	a primitive, unicellular reproductive body produced by plants and some invertebrates
stamen	the male reproductive part of a flowering plant that consists of a filament and an anther
stigma	the part of a flower which receives pollen grains
style	elongated part of the ovary which has the stigma on the tip
sustainable	to give support or relief to
symbiotic	the positive relationship of two dissimilar organisms
tendril	a coiling, sensitive organ to attach a plant to its support
top soil	surface soil
tribe	a social and political group comprising numerous families, clans and generations

understory	the plants of a forest undergrowth up to 60 feet (18.3 m)
vine	a plant whose stem requires support to climb and grow
waste	matter which is not used.