THE DALLAS WORLD AQUARIUM

Plants:

A Resource for Teachers

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.

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 plants and 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.

A 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, including providing food, shelter, medicine, oxygen, and other necessities for the organisms around them. They are also a major contributor of oxygen and rainfall for more temperate climates.

The Layers of the Rainforest

The **emergent layer** of the rainforest can reach heights of 250 feet (76 meters) above the forest floor. All organisms living at this level must be able to handle strong sun, 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 are only one or two emergent trees per rainforest acre (0.41 ha).

Rainforest leaves usually have smooth edges. At the top of the rainforest, leaves are smaller to minimize sun and wind exposure. As you descend through the layers of the rainforest, leaves get bigger so they can collect more of the limited sunlight. The leaves of emergent trees are small, leathery, and are good at holding water. Many leaves are equipped with "drip tips" to allow water to drain off.

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 on plants for food. Most plants can make their own food using a process called photosynthesis. Photosynthesis is the process used by plants to turn carbon dioxide, water, chlorophyll, and sunlight into food.Ninety percent of the photosynthesis that occurs in the rainforest takes place in the canopy.

Carbon Dioxide + Water + Chlorophyll + Sunlight = ENERGY

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 soil. The trees obtain additional nutrients from the thin layer of topsoil. "Buttress roots" grow on some types of canopy and emergent trees, providing additional support.

In the **understory**, the light is dim, 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 decomposing organisms keep the forest floor clean by feeding on fallen organic material from the other rainforest 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 the stem, an "alternate distribution" has leaves in a step pattern up the stem, and a "paired" pattern has leaves arranged in pairs up the stem. All flowering plants share one of the three leaf patterns.

FLOWERS

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, and 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. To conserve energy, epiphytes and vines do not grow a strong stem or trunk, and do not 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 of 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 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 (such as the 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.

Fungus

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 Enemy?

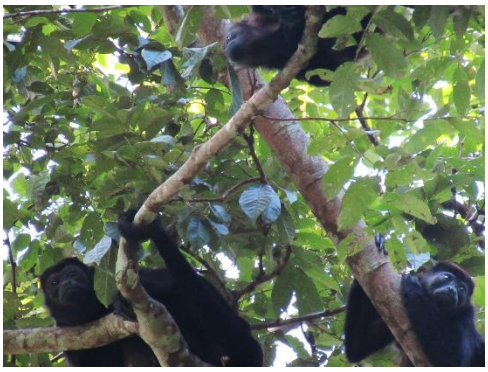
Just like animals, plants also have enemies. Plants have evolved many unique characteristics as adaptations for protection. For example, some plants emit strong odors, taste bad, or are poisonous. These traits are a defense to keep animals and insects from eating the leaves of the plants. Some animals 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 eventually drop their fruits hoping 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) 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 both protects 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 in 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 a rainforest 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, including poverty of the native people, the increasing world population, demand for wood, and international debts. One of the most important things that 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 can be 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 planting 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 a lot of money 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. Selective cutting can vastly reduce the diversity of the ecosystem, and damages other species of trees and plants with the equipment needed to reach the desired tree.

Seed-tree cutting entails clearing most trees but leaving seed-producing trees randomly throughout the site to naturally reseed the area. This method allows a diverse forest to grow in place of the original forest. The remaining trees 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 the 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 affect the entire ecosystem. The runoff of silt and mud clouds 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. Shamans (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. This plant is also used 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 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) 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 can be 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 used as an antibiotic, a laxative, and 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. Indigenous tribes have used the wood for many generations to make their bows and 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.

Plants help to keep our air clean. They absorb the carbon dioxide (CO_2) we exhale and change it 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 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	(flower) the part of the stamen that develops and contains pollen
bacteria	any of a class of microscopic organisms with single-celled (or noncellular) bodies that grow in colonies and live in soil, water, or organic material
biome	a 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	an artificial reservoir for holding liquids
compost	a mixture consisting largely of decaying organic matter
conservation	preservating and protecting something of value
corrode	wear away or deteriorate
crown	the foliage at the top of a tree or shrub
debris	the remains of something that was destroyed
decay	breaking down of organic matter through chemical processes
decompose	to cause something to decay, breaking it down into smaller parts
diverse	differing from one another
ecosystem	a complex ecological community and environment in nature
efficient	productive without making waste
emergent	the tallest layer of the rainforest, ranging between 200-250 feet (61-76 m)
endangered	in danger or peril, organisms in danger of extinction
energy	the strength and vitality required for sustained physical or mental activity
environment	surroundings or external conditions
epiphyte	a plant (usually growing on another plant) that derives its moisture and nutrients from the air
erosion	the process of incremental destruction or wearing away
filament	(flower) the stalk of the stamen bearing the anther
forage	to search for food
forest floor	the lowest level of the forest floor, typically dark and humid
fungus	plants lacking chlorophyll that live on dead or living organic matter
habitat	the place where a organism lives or spends time
herbivore	an animal that eats plants

humid	containing lots of moisture in the air
humus	an organic part of soil made from the decomposition of plant or animal matter
indigenous	a group who has always lived a particular region or environment
latex	milky liquid containing resins and proteins
logging	the practice of cutting trees for lumber
medicinal	used to cure disease or relieve pain
nutrient	nourishment or food necessary to sustain life
organic	derived from living organisms
ovary	(flower) hollow part of the style with contains one or more ovules
ovule	(flower) develops into a seed after fertilization occurs
parasite	an organism which depends on another for survival but doesn't benefit (and may cause harm to) the other
petal	the non-productive part of the flower (usually colored)
photosynthesis	the process used by green plants to produce food
pistil	(flower) the female reproductive organ
poisonous	an organism that can kill, injure, or impair another organism through the use of poison or venom
receptacle	(flower) flat part of the stem from which all parts of the flower grow
recycle	to reuse something rather than disposing of it
reproduce	to generate offspring
resource	an item that is beneficial and available to an organism
ripe	fully grown and developed
root	the part of a plant that usually grows underground and gains nutrition there
sepal	the leaf of a flower, usually green in color
species	a group of organisms with common attributes and designated by a common name
spore	a primitive, unicellular reproductive body produced by bacteria, algae, fungi, and plants
stamen	(flower) the male reproductive part that consists of a filament and an anther
stigma	(flower) the part of the flower that receives pollen grains
style	(flower) elongated part of the ovary that has the stigma on the tip
sustainable	able to be maintained at a certain rate of level
symbiotic	a relationship between two different organisms where both organisms benefit
tribe	a social and political group comprising numerous families, clans, and generations
understory	the plants of a forest that are considered undergrowth and grow to heights of up to 60 feet (18.3 m)
vine	a plant whose stem requires support to climb and grow
waste	leftover matter that is not used