PRESERVATION FOUNDATION OF PALM BEACH

LET'S SEE WHAT TRANSPIRES

Pan's Garden Education
Teacher's Manual

A Project of the Preservation Foundation of Palm Beach
386 Hibiscus Avenue, Palm Beach, Florida

"LET'S SEE WHAT TRANSPIRES"

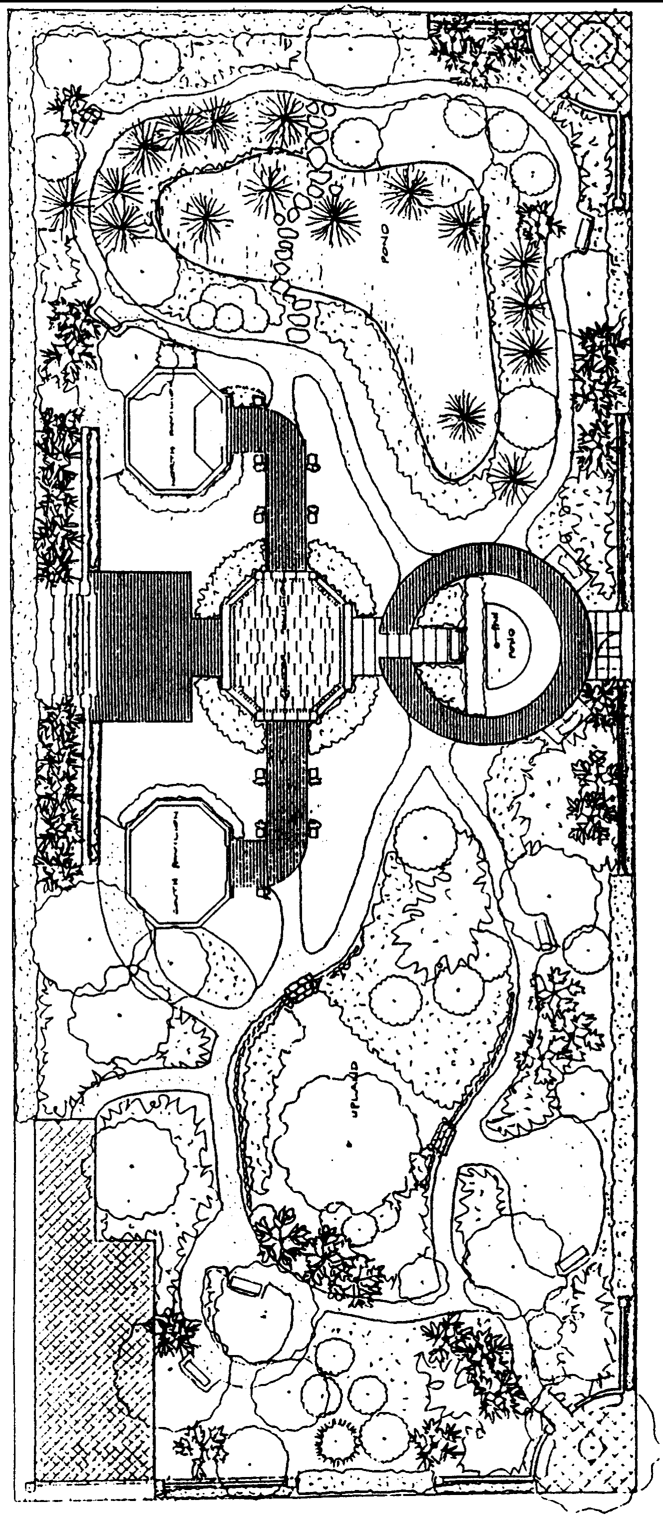
TABLE OF CONTENTS

A special thank you to Ashlyn Pickett who demonstrated extreme patience and utilized her outstanding photography skills to create most of the beautiful pictures of the Pan's Garden plants contained within this manual.

About Pan's Garden

Pan's Garden is a botanical garden devoted to Florida's native plants opened in 1994, and is a project of the Preservation Foundation of Palm Beach. The Garden takes its name from the bronze statue of Pan of Rohallion, designed by Frederick MacMonnies in 1890. In Greek mythology, Pan was the God of Shepherds, whose job was to protect and guard the flocks. The statue graces the Garden's entrance pool and is depicted in idealized human form playing an enchanted flute, called a syrinx, which is an ancient Greek instrument of shepherds.

Pan's Garden's heavily planted area of more than one-half acre showcases more than 300 species of Florida native plants, many of which are endangered. The Garden incorporates upland and wetland areas designed to display indigenous trees, shrubs, grasses and wild flowers in naturally occurring relationships to each other. Varieties of native species are planted in seasonal display areas to highlight possible choices for home and school landscaping. Pan's Garden has also become home to a wide array of birds, butterflies and other creatures which await discovery at every turn.

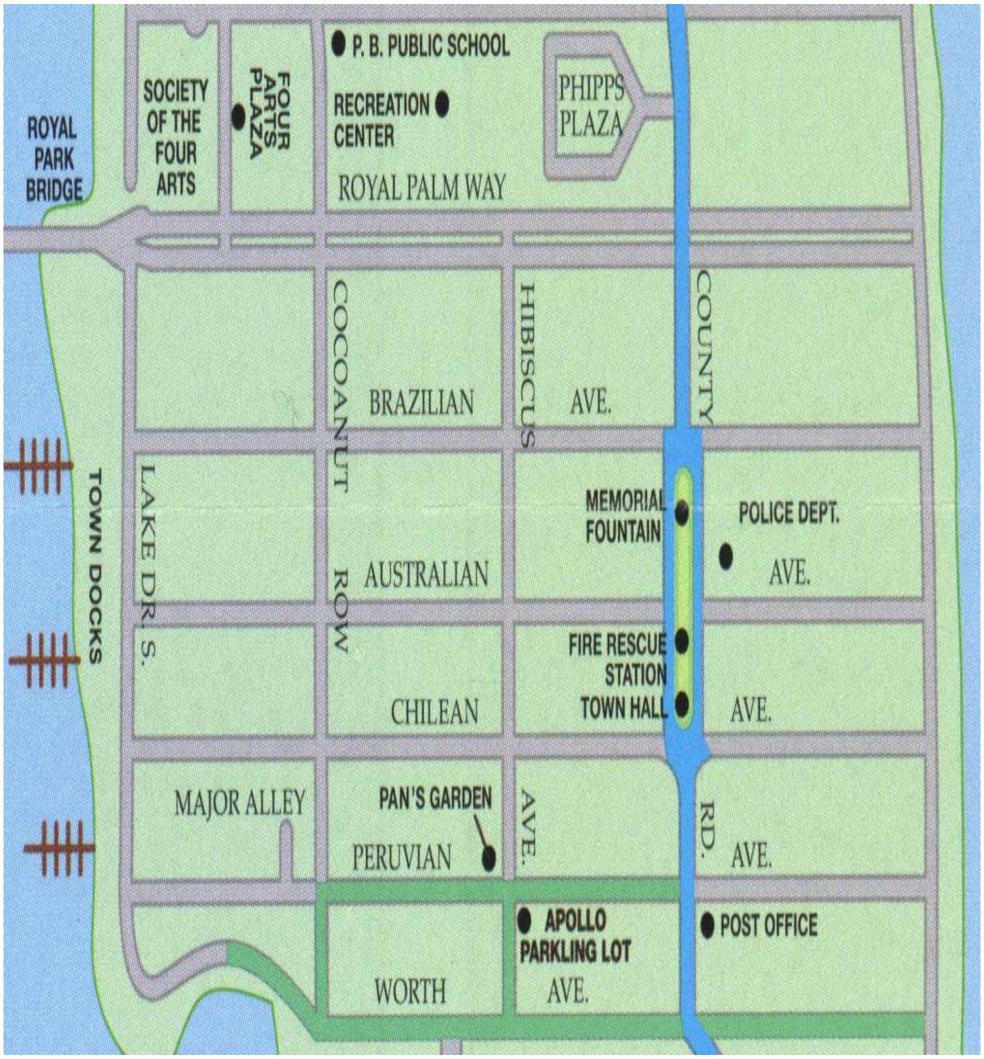


Site Plan of Garden

<u>DIRECTIONS TO PAN'S GARDEN</u>

386 Hibiscus Avenue, Palm Beach

Please make copies of these directions for <u>every driver</u>



Pan's Garden is located in Palm Beach, at 386 Hibiscus Avenue, between Chilean and Peruvian Avenues; one block north of Worth Avenue (see map).

From I-95, take the Okeechobee Boulevard East Exit through West Palm Beach. Cross the Intracoastal Waterway via the Royal Palm Bridge (middle bridge) onto Royal Palm Way.

Travel east on Royal Palm Way to Hibiscus Avenue. Turn right (south) onto Hibiscus Avenue and proceed three blocks. The main gate of Pan's Garden is located on Hibiscus Avenue, just past the Chilean Avenue intersection. The Garden is surrounded by a coral colored wall.

Parking is extremely limited. There is adequate space for one school bus or five vehicles, which may remain parked at the Main Entrance, **directly in front of the Garden**, for the duration of the visit. Additional metered one-hour parking is available on the side streets.

DEPARTURE INSTRUCTIONS

Proceed south to the intersection of Hibiscus and Peruvian Avenues. Turn left onto Peruvian Avenue and travel east one block to South County Road. Turn left (north) onto South County Road and travel to the Royal Palm Way intersection. Turn left onto Royal Palm Way and proceed west to West Palm Beach.

<u>Teacher Information</u>

SCHEDULING:
Reservations are limited and booked months in advance. Please contact the Education Department of the **Preservation Foundation of Palm Beach** at **(561) 832- 0731.**

GROUP SIZE:
Pan's Garden programs are limited to one class from one school per day, approximately 30 students, **one teacher and one chaperone**. Kindly give advance notice of special needs student accommodations.

TIME OF ARRIVAL:
Public Schools -10:00 a.m. until 12:00 noon; Private/Parochial/Home Schools 9:30-12:30. Arrival time affects the length of your program. If you are running late, please contact the Preservation Foundation at (561) 832-0731.

WEATHER:
To ensure everyone's safety and comfort, educational programs will not be held during periods of heavy rain or electrical storms. If these conditions arise the morning of your visit, **<u>please contact us</u>** to determine if we will continue as scheduled. If inclement weather causes a cancellation, every effort will be made to reschedule your group.

COST:
Pan's Garden educational programs are **free of charge.** The only contribution we ask is that your class arrives fully prepared and enthusiastic!

TRANSPORTATION:
Transportation must be provided by the school. **Limited parking** is available for one school bus or five vehicles directly in front of the Garden's main gate at 386 Hibiscus Avenue (see map). **<u>Please make a copy of directions and map for each driver.</u>**

DRESS:
All educational sessions at Pan's Garden are outdoors. Students should wear walking shoes and clothes appropriate for the weather (including light rain).

NAME TAGS:
For identification purposes and to personalize the experience, please have students wear name tags.

RESTROOMS:
Restrooms are available. Teacher/chaperone must monitor students' use.

LUNCH:
We invite you to bring a picnic lunch and enjoy your meal in the Garden **after** the program; lunch is on your own time. There are no vending machines. Please leave lunches/coolers on the bus or in vehicles during the program, as there is no refrigeration available and we have lots of hungry ants!

DISCIPLINE:
Teachers are responsible for students' behavior- please remain with your students at all times. Please inform students that, unless instructed by our staff, they will not be allowed to touch, take, or eat any plant material. It is not unusual for a plant listed as food to also possess poisonous or medicinal properties! Students must walk and stay on paths at all times. For safety reasons, students who do not adhere to these rules will not be allowed to continue participation in the program.

FURTHER INFORMATION:
If you have any questions regarding scheduling or course content, please contact the Education Department at the Preservation Foundation of Palm Beach at (561) 832-0731

Your Visit to Pan's Garden

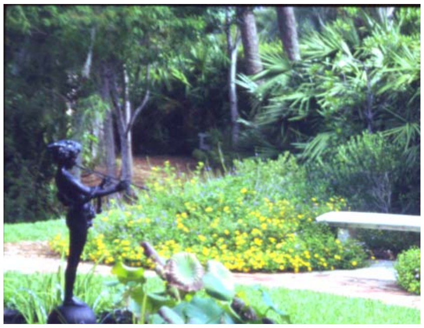
Let's See What Transpires is a hands-on discovery program developed to focus on anatomy, processes and adaptations of plants, as well as the importance of plant transpiration, how it fits in to the water cycle, and the affect it has on the lives of Florida residents. Students gain an increased understanding of the Scientific Method while performing fun and informative hands-on investigations. This entire educational unit was developed using the Florida Sunshine State Curriculum Standards as a guideline.

This manual is intended to assist you in preparing your class for their Pan's Garden visit. It includes background information for teachers (or students, if you wish), pre- and post-visit activities for a variety of grade levels and guidelines for the visit itself. We urge you to spend as much time as you can preparing for the visit, as this will greatly enhance your students' experience.

It is requested that teachers complete a post-visit questionnaire prior to departure. This will assist the Preservation Foundation in its endeavor to constantly refresh and improve its programs, as well as satisfy curricular standards. There is no charge for either the Garden visit or this manual, but we do ask that you help us provide a meaningful experience by preparing your classes thoroughly and by sharing your feedback. We look forward to having your students interact with us through questions and comments during their visit.

TO PREPARE FOR THIS PROGRAM:

Preparation is required in order to participate in the "*Let's See What Transpires*" experience at Pan's Garden.



This Teacher's Guide has been provided for you and your students to prepare for a unique field experience. It is important that students gain a foundation of background knowledge to enhance their Pan's Garden educational experience and to arrive knowing what to expect and what is expected of them.

Included are guidelines for the visit, valuable background information regarding the water cycle, plant anatomy and functions, pre-and post-visit activities for a variety of grade levels, staff development information and much more. The "***Let's See What Transpires***" program was developed utilizing the Florida Sunshine State Standards for Science as reference.

1. Review the water cycle. Students should be familiar with evaporation, condensation and precipitation and the three states of matter; solid, liquid and gas.

2. Review or introduce basic plant anatomy. Students should at the very least know the functions and locations of roots, stems and leaves and the process of photosynthesis.

3. Review or introduce the Scientific Method; our main experiment will reinforce this process.

4. Review how living things develop adaptations that insure survival.

5. Complete at least some of the activities and exercises provided.

6. Review the vocabulary.

The "***Let's See What Transpires***" teacher manual contains a wide variety of information, activities and investigations about the water cycle and plant anatomy, functions, adaptations and processes. The level of knowledge and instruction ranges from introductory to intermediate levels. Also included are an introduction and activities related to the science of classification. Depending on the grade level you teach, you may wish to use parts of this manual as background information for yourself, or copy it and use it as student study guides. However you decide to utilize the teacher manual, please remember that advance knowledge and preparation for the "***Let's See What Transpires***" program ensures your students will realize a more in-depth and educational experience.

What Will Students Experience During Their Visit?

They will . . .

- ✓ Discover an award-winning native plant garden
- ✓ Understand plant anatomy and processes
- ✓ Learn how the water cycle and plants are interrelated
- ✓ Examine plant transpiration, adaptations and functions
- ✓ Understand how plant transpiration fits into the water cycle
- ✓ Learn how plant adaptations affect transpiration rates
- ✓ Understand why transpiration is important
- ✓ Discuss preservation and protection of our native plants and our water supply

To accomplish these goals we will . . .

- ✓ View colorful charts depicting important details of plants and the water cycle
- ✓ Conduct hands-on experiments and activities relating to plant processes
- ✓ Observe plant adaptations
- ✓ Discuss and observe plant and water cycle processes
- ✓ Discuss experiment results and activity findings
- ✓ Sum up and reinforce the plants' importance to the water cycle, and the need to preserve and protect our native plants and our water supply

GARDENS

What is the Purpose of a Garden?

- stimulates the senses and provides a place for relaxation, education and recreation
- creates a green space in towns and cities
- provides habitat for wildlife
- serves as a gene bank for conservation of species
- allows us to learn more about how plants help humans

What is a Botanical Garden?

A botanical garden is an area in which a wide range of plants is grown for scientific, educational and aesthetic purposes. Botanical gardens often include species habitat groupings, such as rock gardens, water gardens and meadow gardens. Collections organized by botanical families, such as roses, orchids or palms, are also common.

One of the earliest botanical gardens for the study of plants was established in ancient Athens about 340 B.C. by Aristotle and his pupil, Theophrastus. The oldest public botanical gardens in the world were founded in Pisa, Italy, in 1543; in Padua, Italy, in 1545; at Paris in 1635 and Berlin in 1679. The first experimental botanical garden in the United States was established by the American botanist William Bartram, near Philadelphia, in1728.

Botanical gardens are extremely popular today. Old gardens are being restored and many new gardens are being established all over the world. This is leading to user-friendly gardens with an increased emphasis on public education and recreational events. Botanical gardens are also major leaders in the struggle to preserve the Earth's environment.

Florida has many botanical gardens. Two world-famous Florida botanical gardens are Fairchild Tropical Garden in Miami and Marie Selby Botanical Garden in Sarasota. Here in Palm Beach County we have Pan’s Garden and Mounts Botanical Garden.

What is Pan's Garden?

Pan's Garden is a botanical garden devoted to showcasing Florida native plants; thereby promoting the environmental heritage of our state. The garden is divided into several distinct areas:

- **Wetlands-** a place where the land is very low, collects run-off water after rainstorms and is usually covered by standing water on a regular basis; plants that grow in the wetlands are adapted to those wet conditions and need a constant source of moisture for their survival
- **Hammocks-** a place where the ground is higher and drier than the wetlands; hammocks are usually forested or wooded and the plants there are adapted to growing in the shade as "understory" plants.
- **Uplands-**a place where water drains through the high and dry sandy soil very quickly and plants there have adapted to grow in almost desert-like conditions
- **Coastal Dune** plants can also be found growing occasionally along the perimeter of the hammocks and uplands in the Garden.

Pan's Garden allows people to see plants in conditions that closely resemble their naturally occurring environment. Threatened, protected and endangered species, which may be difficult to view elsewhere, thrive in Pan's Garden, and serve to remind students and adults alike, the importance of preservation and protection of our native plants.

The soft textures of plants and pleasing sounds of beautiful birds, butterflies and other animals that reside in Pan's Garden's surroundings are a departure from buildings, roads sidewalks, and other "hardscape". The Garden provides a welcoming natural habitat for animals and a "green space" for residents and visitors of Palm Beach and serves as a constant, important reminder of the beauty and purpose our native plants provide.

Why Preserve Florida's Native Plants?

Florida's plants are under threat on many fronts:

- **Habitat loss**: Millions of acres of native habitat have been lost in Florida due to land development. Despite laws enacted to protect these fragile areas, the assault continues. Coastal dune vegetation, central sandhill and wetlands face the highest risk of destruction.

- **Invasion by exotic species:** Today Florida has over 4,000 species of plants growing in the wild- only 2,500 are native! Large-scale introduction **EXOTIC** plants from other parts of the United States and foreign countries has been taking place since the Spanish first landed in 1513. Many of the exotic plants found in Florida's parks and gardens have either managed to "escape" into the wild, or were purposely planted to fulfill a certain need. For example, Brazilian Pepper trees (mistakenly identified as Florida Holly) were imported and planted for their rapid growth and value as a pretty shade tree. Birds love to eat the bright red berries and transport and deposit them, where they grow out of control. Once they are established, they alter the landscape and ecology; making it uninhabitable for native plants and animals, which are adapted for a specific habitat. This upsets the balance of Nature drastically.

- **Poaching:** Some species have been taken from the land illegally in such numbers that they are rarely found in the wild. There are plants such as the cigar orchid and coontie which are more commonly found in gardens but are nearly extinct in the wild.

- **History:** Our native plants are Nature's architecture and every bit as beautiful and important as old buildings, artwork and literature. The history of plant tells us about our ancestors and their ways of life, such as their diets, religious beliefs, tools, medicines and games. In order to understand the future, we must learn from the past. Some ancient Native American remedies made from plants are being used to make new medicines that may cure diseases and improve people's lives.

THE WATER CYCLE

WATER

Water is an **integral** part of life on this planet. It is an odorless, tasteless substance that covers more than three-fourths of the Earth's surface. Of the total water on Earth 97% is salt water found in oceans. We cannot drink salt water or use it for crops because of the salt content. Salt can be removed from ocean water in a very expensive process called **desalination**.

Only about 3% of Earth's water is fresh. Two percent of the Earth's water (about 66% of all fresh water) is in solid form, found in ice caps and glaciers. Because it is frozen and so far away, the fresh water in ice caps is not available for use by people or plants. That leaves about 1% of all the Earth's water in a form useable to humans and land animals. This fresh water is found in lakes, rivers, streams, ponds and in the ground. A small amount of water is found as a gas, (known as water vapor) in the atmosphere.

With such a tiny amount of fresh water available for humans to use, it is vital for our survival to use it wisely. Humans are aware that wasteful and harmful practices are severely limiting the amount of clean, fresh useable water, but to date little has been done to insure our water supply will be able to sustain life on Earth for future generations.

THE WATER CYCLE

The water cycle is an important process that not only gives us water to drink, but also helps form weather patterns, nourishes crops and keeps the lakes and rivers flowing. All of the water in the world is somewhere within the water cycle; its constant cycling between the atmosphere, oceans and land is a very important process that helps **sustain** life on Earth.

Each part of the water cycle drives the other parts-it has no beginning or end. As water **evaporates**, **vapor** rises and **condenses** into clouds. The clouds become **saturated** causing **precipitation** to fall in the form of rain, snow or ice. That water fills streams and rivers and eventually evaporates and begins the process again. Water's state (solid, liquid or gas) is determined mostly by temperature. Although water continuously changes states from solid to liquid to gas, the amount of water on Earth remains constant. There is as much water now as there was hundreds of millions of years ago. Six important processes that make up the water cycle: evaporation, condensation, precipitation, **surface runoff**, **infiltration** and **transpiration**.

EVAPORATION

Evaporation is the process in which water in its liquid state changes into a gas called water vapor. All water eventually evaporates, but temperature plays a big role in how fast: water boiling on the stove evaporates more quickly than water in a fish bowl. Energy from the sun heats bodies of water such as mud puddles, lakes, ponds, the ocean, etc. This heating causes the liquid molecules in water to vibrate faster and move further apart, thereby changing liquid into a gas (water vapor). The heat stored in the water vapor molecules, called **latent heat**, causes the vapor to become less dense (weigh less) than the surrounding air and it rises or evaporates. During the evaporation process **impurities** in the water (salt, pollen, dirt) are left behind, making the evaporated water cleaner than it was on Earth.

CONDENSATION

Condensation is the opposite of evaporation and occurs when water as a gas changes into a liquid. The warmed water vapor (gas) molecules begin to cool when they reach the colder upper levels of the atmosphere. This cooling slows the vibrating molecules down, causing them to move closer together and become more dense- the gas becomes a liquid again. The liquid water droplets formed from condensation are very tiny and remain **suspended** in the atmosphere because they still contain some latent heat. These millions of suspended water droplets cling to each other and tiny particles of dust, pollen, volcanic ash, etc. and form clouds, or when at ground level; fog.

PRECIPITATION

The tiny water droplets suspended in the atmosphere continue to cool-releasing any remaining latent heat. The water molecules, which are attracted to each other, grow larger and heavier-with their heat gone and their weight increasing, **gravity** causes them to fall back to Earth as precipitation. Once precipitation reaches the ground it may take several different paths.

SURFACE RUNOFF

Much of the water that returns to Earth as precipitation runs off, unable to **infiltrate** into hard surfaces such as parking lots, roads or even very dry land. This surface runoff flows downhill finding its way into low-lying areas such as wetlands, streams, rivers, ponds and lakes. Small streams flow into larger streams, then into rivers and eventually that water flows into the oceans. Surface runoff returns much of the water to bodies of water, where the majority of evaporation occurs.

INFILTRATION

The infiltration process occurs when rainwater soaks in to the ground and down through the layers of soil and rock. From there the water can either return to the surface from springs that supply fresh water to bodies of water or remain underneath the layers of rock where it becomes known as groundwater. As the water infiltrates the layers of soil and rock, many impurities are filtered out, cleansing the water. This cleansed water forms **aquifers**, which are underground pockets or rivers that contain enough water to supply wells for drinking water and springs that replenish bodies of water.

TRANSPIRATION

Transpiration is the evaporation of water from plants and is a biological process necessary for plant life. It occurs mainly in the leaves and acts like an engine that pulls water up from the roots and circulates it throughout the entire plant. About 90% of the water absorbed by the roots of a plant is transpired; while only about 10% is used for photosynthesis (making food), tissue growth or is stored within the plant. As water vapor evaporates it cools the temperature around the leaf. About 10 % of all moisture found in the earth's atmosphere is supplied by plant transpiration, making it a very important part of the water cycle. (See Plant Processes for in-depth transpiration information).

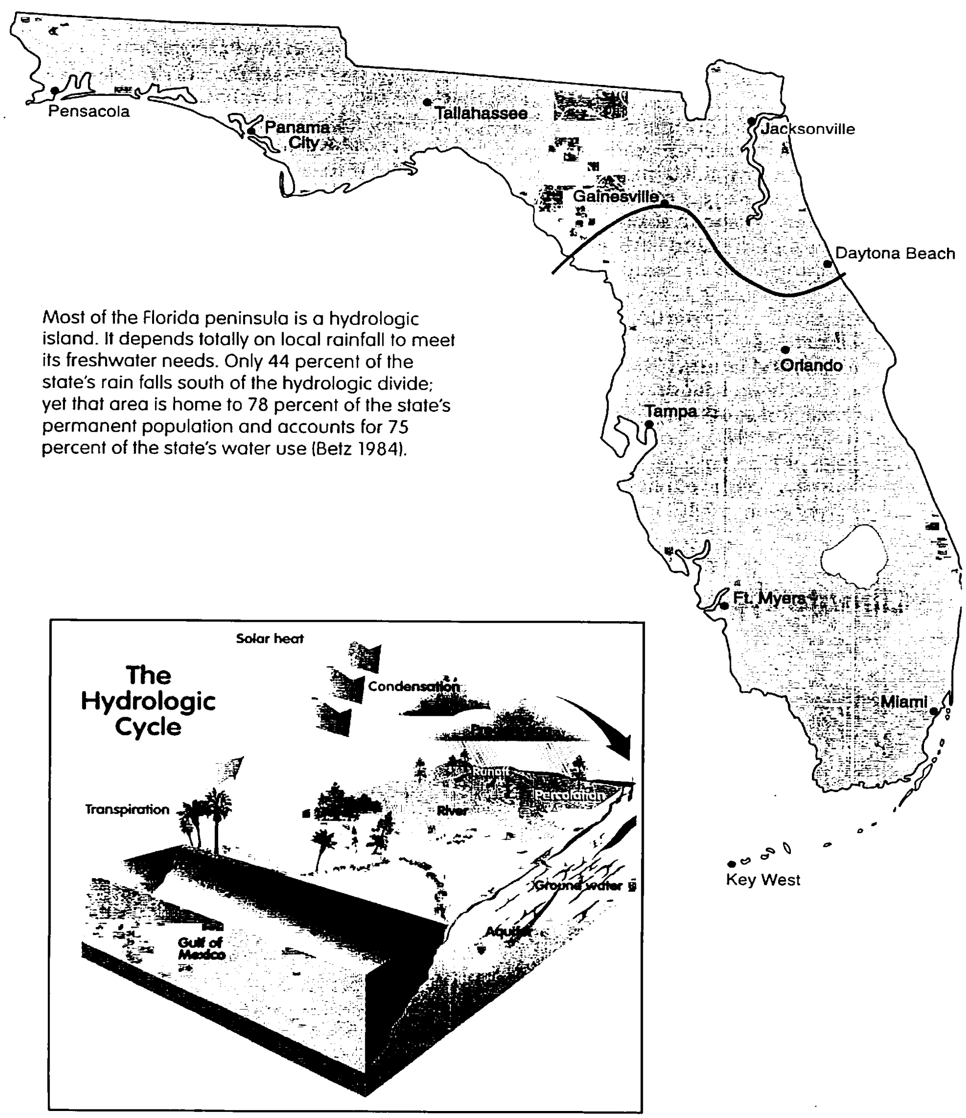
EVAPOTRANSPIRATION

Transpiration is part of a larger process called **evapotranspiration**, which is water vapor that evaporates from the soil and areas surrounding plants, not just from the living plants themselves. Evapotranspiration, or ET, plays a very important role in the water cycle by contributing to it a huge amount of water. The ability of green plants to transpire combined with evaporation from the soil assists in facilitating the continuous motion of the water cycle that supports all life.

HYDROLOGICAL DIVIDE

Most of the Florida peninsula is a **hydrologic** island which depends almost totally on local rainfall to meet its freshwater needs. Only 44 % of the state's rain falls south of the hydrologic divide; yet that area is home to 78% of the state's permanent population and accounts for 75% of the state's water use. These facts underscore the necessity of conserving our water supply and insuring it does not become polluted.

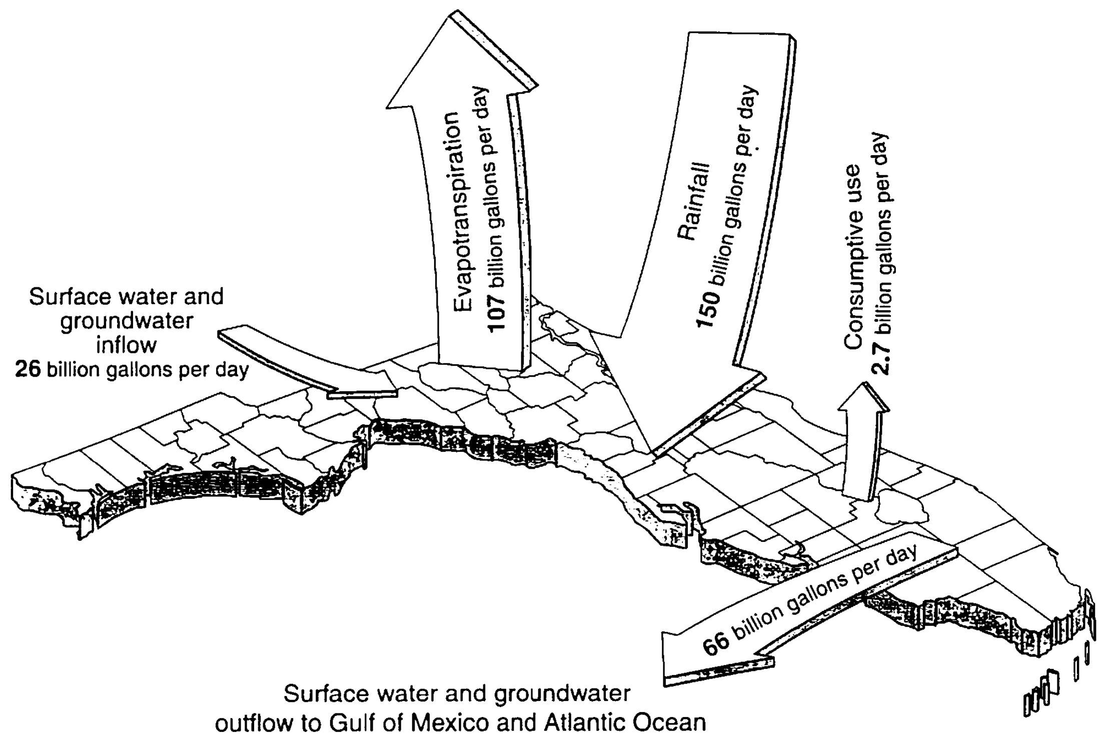
Hydrologic Divide



FLORIDA'S WATER CYCLE

Each day an average of 150 billion gallons of rain falls throughout the entire state of Florida; another 26 billion gallons flow into the state mostly from rivers that originate in Georgia and Alabama. Nearly 70% of the rain, or 107 billion gallons, returns to the atmosphere through evaporation and plant transpiration (evapotranspiration). The remainder flows to rivers or streams or seeps into the ground and recharges aquifers.

Florida's Water Cycle



Source: Fernald and Purdum 1998

An average of 150 billion gallons of rain falls each day in Florida. Another 26 billion gallons flows into the state, mostly from rivers originating in Georgia and Alabama. Nearly 70 percent of the rain (107 billion gallons) returns to the atmosphere through evaporation and plant transpiration (evapotranspiration). The remainder flows to rivers or streams or seeps into the ground and recharges aquifers. Each day in Florida, 2.7 billion gallons are incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate environment (consumptive use).

Each day in Florida, 2.7 billion gallons of water are incorporated into products or crops, consumed by humans or livestock, or otherwise removed for the immediate environment, utilized to flush toilets, wash laundry, clean dishes, fill swimming pools, etc. With each use substances are added to the water in the form of waste or chemicals that pollutes our water supply. While some of that pollution can be removed or cleansed, more and more hazardous additives are showing up in our water supply. As the population increases, water usage increase; many areas of Florida do not have enough fresh water to supply to keep up with demand.

Florida once had **pristine** ecosystems which were abundant with fresh, clean water. Agricultural and urban development have changed the flow of water and exploited it, thereby necessitating its preservation and protection for the future.

In the past 200 years or so the ever-growing population in Florida has consumed huge amounts of water that have had enormous impacts on the water quality and supply. Wetlands have been drained to provide land for agriculture and homes, schools, businesses and roads and **deforestation** continues to negatively affect the environment. Loss of natural ecosystems results in loss of habitat for animals and plants. Humans must create new ways to live in harmony with the land and utilize natural resources without wasting, polluting or exhausting them. We cannot return to the way things were many years ago, but we can restore and protect the valuable resources we have today.

<u>PLANTS</u>

(This may be utilized as background information by the teacher in earlier grades or printed to use as a student study guides in upper grades)

WHAT ARE PLANTS?

Plants…

- are the basis of all life on Earth.
- take in carbon dioxide and give off oxygen.
- help build soil and prevent land erosion.
- are the primary source of food for many living creatures.
- provide habitat for a diverse number of species.
- are usually rooted in place and do not walk around, but they do move.
- continue to grow throughout their lives; animals stop growing at maturity.
- come in all shapes and sizes.

Plants belong to the Plantae Kingdom. They are **multicellular**, have a rigid cell wall and most plants grow in the soil and use energy from the sun to make their own food. Unlike animals, they can't move on their own and they don't have nervous systems.

Plants require water to live. The cell, as the basic unit of life, is 75% water. Therefore if a plant is to live its cells must have enough water. Plants need water to transport nutrients and minerals necessary for photosynthesis and in order. Plants will wilt and eventually die if they do not have enough water.

There are two large categories of plants: vascular and non-vascular plants. Non-vascular plants like moss for example, absorb water only through their surfaces. Vascular plants, like flowers, trees and grasses have tube or vessel-like structures that run the length of the plant's body. Like veins and arteries in humans, the tubes in plants carry and circulate water and nutrients from the roots to the stems and leaves.

Plants absorb large quantities of water; however they lose most of it through transpiration. Transpiration coupled with evaporation of surface water (ponds, lakes, mud puddles) is called evapotranspiration. Evapotranspiration returns water to its gaseous state and allows it to re-enter the water cycle. This process is extremely important because it helps purify water and move it around the planet.

Plant Facts:

- Tree- plants over 15 feet tall with woody tissue
- Shrub- plants under 15 feet tall with woody tissue
- Herb- plants with only soft tissue
- Vines-plants that grow and climb upon other plants or surfaces
- Epiphyte-plants that are rooted on other plants but do not feed on them

Why are Plants Important?

Plants play the most important part in the cycle of nature. Without plants, there could be no life on Earth. They are the primary **producers** that sustain all other life forms. This is so because plants are the only organisms that can make their own food. Animals, incapable of making their own food, depend directly or indirectly on plants for their supply of food. All animals and the foods they eat can be traced back to plants.

The oxygen we breathe comes from plants. Through photosynthesis, plants take energy from the sun, carbon dioxide from the air, and water and minerals from the soil. They then give off water and oxygen. Animals and other non-producers take part in this cycle through respiration. Respiration is the process where oxygen is used by organisms to release energy from food, and carbon dioxide is given off. The cycles of photosynthesis and respiration help maintain the earth's natural balance of oxygen, carbon dioxide, and water.

Leaves are the main food-making part of most plants. They capture energy from sunlight, and turn water and carbon dioxide into sugar and starch. This sugar and starch becomes the food that provides plants with energy to grow, to produce flowers and seeds, and carry on their other life processes.

What Do Plants Provide?

Plants and plant communities are very important to humans and their environment. Here are some of the important things plants provide.

- **Aesthetics-** Plants have great "aesthetic" value which means they add to the beauty of the places that we live. Native grasses and wildflowers provide us with a link to our history.
- **Medicine-** Throughout history plants have been of great importance to medicine. Eighty percent of all medicinal drugs originate in wild plants. In fact 25 percent of all prescriptions written annually in the United States contain chemicals from plants, however only 2 percent of the world's plant species have ever been tested for their medical potential. That means there are many important drugs yet to be discovered.
- **Food-** Although some 3,000 species of plants have been used as food by humans, 90 percent of the world's food comes from only 20 plant species. Three species of grasses--rice, wheat, and corn-are the most important food plants.
- **Industrial Products**- Plants are also very important for the goods they provide. Fibers from plants provide clothing. Wood used to build our homes depends on plants. Some fuel products are made from plants, like ethanol made from corn and soy diesel made from soybeans.
- **Recreation**- Plant communities form the basis for many important recreational activities, including hiking, fishing, hunting, and nature observation.
- **Air Quality-** The oxygen in the air we breathe comes from the photosynthesis of plants. The quality of the air can be greatly influenced by plants. Plants can stop the movement of dust and pollutants. Through the intake of carbon dioxide, plants can also lessen the greenhouse effect caused from the burning of fossil fuels like coal.
- **Water Quality**- Plants are extremely important to the quality of the water we use. A diverse cover of plants aids in maintaining healthy watersheds, streams, and lakes by holding soil in place, controlling stream flows, and filtering sediments from water.
- **Erosion Control**- Plants protect the thin layer of soil from erosion caused by wind and water.
- **Climate**- Regional climates are impacted by the amount and type of plant cover. Forest and marshes, for example, can cool local climates. Natural disasters, such as drought, have been blamed on the destruction of forests and other critically important plant communities.
- **Fish and Wildlife Habitat**- Plants and plant communities provide the necessary habitat for wildlife and fish populations.
- **Ecosystems**- The word "ecosystem" means the way in which humans, plants and animals all live together supporting each other. Every species serves an important role or purpose in their community.

PLANT ANATOMY

UNDERSTANDING PLANT ANATOMY

In order to understand how the transpiration process takes place, one must first understand plant anatomy. **Anatomy** is the study of the parts of living things and how they are put together. Different plants have different structures which are **adaptations** that help them to live and grow within their environment. For example seaweed and other algae do not have roots, flowers, or leaves. They do not have any tubes for water and food. Scientists believe they were the first type of plant to exist. Ferns have leaves and also have tubes in their stems for water and food, but their root systems are simple and do not go very deep. Seed plants, on the other hand, have roots, stems, leaves and flowers. They also have tubes in their stems for carrying water and food. These differences allow each plant to successfully thrive and reproduce in the environments of which they are a part.

ROOTS

Functions of Roots

- Anchor plant into the ground
- Store food
- Absorb water, oxygen and nutrients from soil

The roots of any plant have three main purposes; the first is to anchor the plant into the ground. This is performed by thick, strong roots which fan out from the base of the plant's stem or trunk. The second purpose is to store nutrients during a **dormant** period. Lastly, roots function to absorb water and nutrients from the surrounding soil. Rooting characteristics vary with the species, soil texture, and moisture. Roots, like other parts of the plant, require oxygen to aid in food absorption, respiration, and growth.

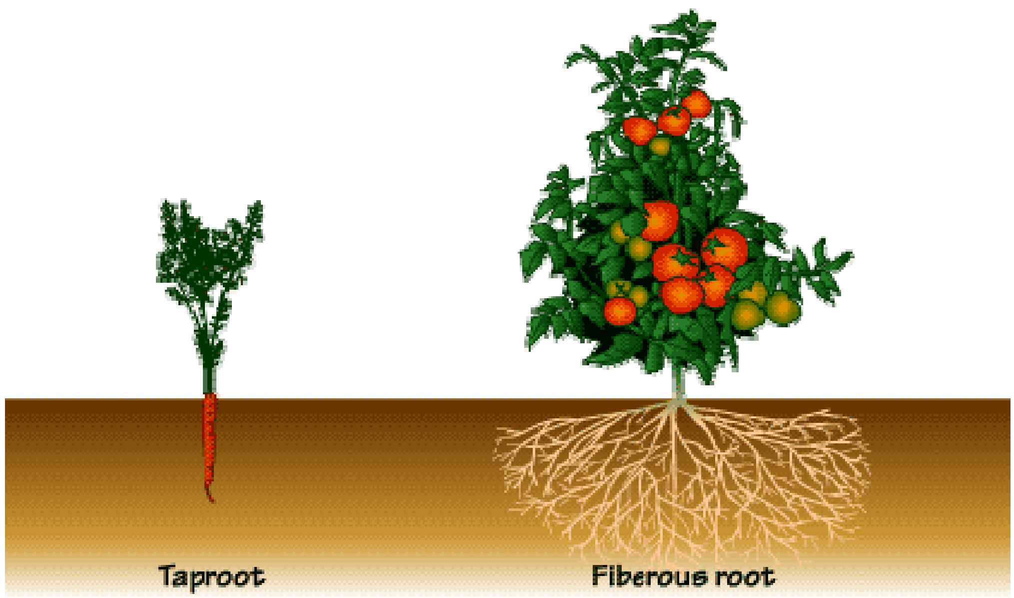
For roots to grow well they require large amounts of oxygen. If the soil is **compacted** or permanently wet, atmospheric air is unable to **penetrate** the soil and the root system can suffocate, leading to the death of the plant. Roots absorb water from the surrounding soil, but if there is no soil moisture available such as during drought or transplanting, root hairs dry out rapidly. Dried out roots are unable to absorb water and nutrients, which results first in **wilting** and ultimately death of the plant if no water is received. Soil that is too wet causes roots to suffocate and lose their absorbing capacity.

Certain species of trees and other plants develop a main supportive **taproot** that travels into the ground until an adequate and continuous source of moisture is found. Fine roots develop from the taproot to gather water and nutrients; good examples of plants with taproots are carrots and beets. However, in wetter areas, the taproot may be very underdeveloped, due to the ample moisture and the lack of oxygen in the water-logged soil; this is one reason trees in wet areas are more likely to blow over in hurricanes than trees growing in drier ground. When the soil surrounding the tree becomes flooded, which happens frequently during the rainy season in Florida wetlands, **submerged** roots can die from lack of oxygen, resulting in the death of the entire tree. Some trees such as the bald cypress have adapted to varying water levels and tolerate flooding over their roots indefinitely; it is thought that the cypress "knees" may contribute to this ability.

Most broadleaf trees and other species of plants have wide spreading fibrous root systems in which there is no main or taproot but are made up of several main roots with many smaller branching roots called **lateral roots**. Lateral roots spread out from the base of the plant and can cover a large area from which to draw water and minerals. As lateral roots grow further away from the plant, they develop finer and much smaller roots called **rootlets**. The rootlets are covered with even finer **root hairs**, which actually absorb the majority of minerals and water for the plant from the soil. The size of a plant's root system usually is about equal to the size (expanse) of its foliage.

Daytime root growth is very slow because the root system supports growth in the parts of the plant above ground. Therefore most of root growth occurs during darkness, using energy that the plant stored during daylight hours.

The picture below shows two different types of roots



Roots we eat: carrot, radish, turnip, onion, sweet potato and beet

STEMS

Functions of Stems

- Support foliage (crown, leaves)
- Store nutrients
- Transport materials (water, nutrients)

Stems, trunks and branches of a plant perform three functions. The first is to support the weight of the **foliage** (**crown**) which allows the leaves maximum exposure to light. Secondly stems, trunks and branches store nutrients. The third function is to provide a **conduit** for water and nutrients from one part of the tree to another.

There are four layers of tissue inside the stem or trunk which contain a network of tubes that runs between the roots and the leaves and acts as the central plumbing system for the tree. These tubes carry water and minerals up from the roots to the leaves, and they carry food (sugar) down from the leaves to the branches, trunk and roots. Cells whose function is the transport of material are called **vascular tissue**. The two types of vascular tissue are **xylem**, which transports water up and **phloem**, which transports food down. There are two main types of stems; **herbaceous** and **woody**.

DIFFERENT TYPES OF STEMS

Examples of stems we eat: Asparagus, Celery, and Rhubarb

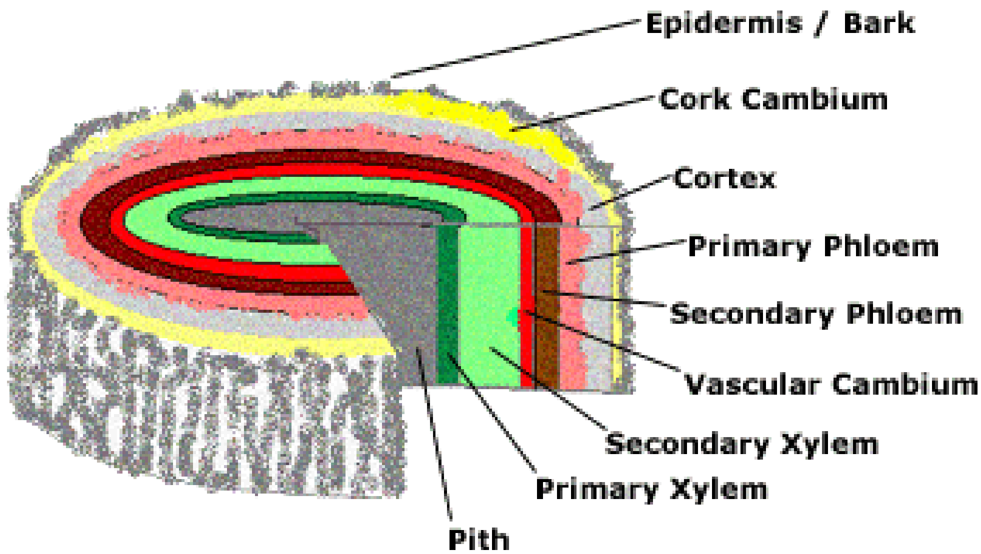
Herbaceous Stems

The herbaceous stem is thin, green, bends easily, and does not get thicker as the plant grows older. Stems such as these are commonly found in plants that usually live only one growing season or die back to the ground after blooming such as grasses, celery, beans, corn, tomatoes and lilies (monocots). Since herbaceous plants do not live more than a few months, the outer protective layer of cells called the **epidermis** is much thinner than found in woody plants. Herbaceous plants have a very different arrangement of cells in their stems. The xylem and phloem are found in groups called vascular bundles. Each bundle has a few large xylem cells and several phloem cells. The bundles also have some cells that help support the stem and are surrounded by **pith** cells that are mostly used for storage. Vascular bundles run up the length of the stem and are the stringy things that get caught in your teeth when you eat celery (which is a stem).

Woody Stems

The other type of stem is the **woody stem**, which grow for two years or more and are usually large plants (dicots). Probably the most obvious example of a woody stem is a tree trunk, which is stiff and does not bend easily and has one main stem. A woody plant with several stems that form a common base at or near the ground but have no main trunk is known as a shrub. The woody stems of trees and shrubs contain growing layers of wood-like tissue which lie just under the outer protective bark layer. The growth in this layer makes the trunk and branches thicker each year.

Xylem cells make up most of what we call wood. In a woody plant everything is arranged in rings and each year a new ring of xylem is formed. Each ring has large xylem cells called spring wood and smaller ones called summer wood. Counting the rings of a tree gives its approximate age; each ring represents one year. Wider rings indicate favorable weather conditions which allow the tree more growth. A year in which drought or colder than normal conditions occur tree growth would be slower and cause rings to appear narrow.



Outside the rings of xylem is one ring of phloem. The phloem is attached to the bark and if you remove a piece of bark from a tree, the inner part of the piece is the phloem. In between the xylem rings and the phloem is a layer of cells called vascular cambium. These cells divide to form new xylem and phloem cells as needed. The very outside of a woody stem is the bark, also called cork, and it is produced by a layer of cells called cork cambium. The term bark includes the cork, the cork cambium and the phloem.

Woody stems have unique parts herbaceous stems do not; **heartwood, sapwood**, and **cork** (bark). Trees have wood but bamboo, which is actually a grass, is woody. Both grass (bamboo) and palms have vascular bundles (xylem & phloem) dotted about in the trunk in a regular pattern. They do not form a continuous ring but are separate sets of xylem and phloem that gets long as the plant grows but not wider in girth.

Tree Trunks are Stems

The anatomy of a tree trunk differs somewhat from that of a plant's woody stem. The woody portion of the tree consists of two types of wood; **sapwood** and **heartwood**. The xylem's network of thick-walled cells brings water and nutrients up from the roots through tubes inside of the trunk to the leaves and other parts of the tree. As the tree grows, xylem cells in the central portion of the tree become inactive and die. These dead xylem cells form the tree's heartwood.

Modified Stems

Some plants have **modified stems** to perform special functions. A white potato is part of an underground stem that is used for storage. It is called a **tuber**. Strawberry plants produce stems that grow sideways along the ground to produce new plants. These are called runners. Many plants have thorns that grow from their stems to protect the plant from a variety of dangers. In most plants the leaves are the major site where photosynthesis is performed. However, the green stems of a few plants such as asparagus and cacti are the main site where photosynthesis occurs; cacti stems also store water for the entire plant.

LEAVES

Functions of leaves

- Photosynthesis
- Transpiration
- Respiration

Examples of leaves we eat: Lettuce, Cabbage and Collard Greens



Leaves make up most of the crown of a tree and are the food-making factories for most plants. Through a process called **photosynthesis**, leaves are able to convert light energy, carbon dioxide and water into food for the entire plant. For this purpose leaves are often broad, flat and thin which exposes a large area to absorb a maximum amount of sunlight and insures that light fully penetrates into the food-producing cells within the tissue.

Leaves provide most of the energy necessary to draw water and minerals up from the roots of the plant in order to transport and distribute water and minerals throughout the entire plant. During this process some water becomes stored in the cells and tissues along the way and some is utilized in the photosynthesis process to make food for the plant. Water not stored or used to make food is pushed out through tiny openings on the underside of leaves where it evaporates into the atmosphere- this process is called **transpiration**. Plants constantly transport and **excrete** large amounts of water, making transpiration a very important process in the water cycle.

Finally leaves also store food and water and serve as protection for the plant. During the day food produced by photosynthesis is temporarily stored within the leaves. At night the food is circulated throughout the stem or trunk and branches to areas of the plant where it is required for growth.

Protective highly **adapted** leaves such as thorns defend the plant from hungry **herbivores**. Leaves of many plants have specialized hairs which release defensive chemicals that deter leaf feeding insects. Plants compete with one another for sunlight, growing space and water; leaves serve to shade **rival** plants in order to weaken them, eliminating a potential struggle for resources.

Leaves are normally colored green, which comes from the **chlorophyll** within the tissues. In **temperate** and dry zones seasonal changes of autumn such as colder temperatures and shorter days cause chlorophyll production to stop which causes the shedding of plants' leaves. Plants that experience seasonal leaf loss are referred to as **deciduous** plants. The absence of chlorophyll's green **pigment** allows other chemical pigments of yellow, bright orange or red to appear- which is why leaves "change colors". Once the leaves are lost, the plants become dormant for the winter and a set of new leaves appear when the longer days and warmer temperatures of spring occur. The leaves that are shed then **decompose** into the soil.

In Florida many plants undergo a quick "leaf change" but these plants do not become dormant. Often a new leaves is produced simultaneously as the old ones are shed, therefore the plants are never totally without leaves.

PITH

Functions of the Pith

- Stores nutrition
- Transports nutrients to outer tissues in the plant
- Allows for the exchange of gases through the intercellular air spaces

Examples of the pith: the white center of the lemon, orange and grapefruit

The word **pith** comes from the old English word *piþa*, meaning substance or the Dutch word *pit*, meaning the pit of a fruit. The pith is the middle core of the stem or a fruit. It is the center around which the initial growth takes place; in mature trees the pith is very thin. Pith consists of soft, spongy cells located in the center of individual fruits and the stems of vascular plants. In stems it is encircled by a ring of xylem (woody tissue), and outside that, a ring of phloem (bark tissue). In some plants the pith is solid, but for most it is soft. Newly formed pith in young new shoots is typically white or pale brown and usually darkens as it ages. In woody plants (trees, shrubs) the pith becomes surrounded by successive annual layers of wood; though sometimes not easily seen, but is always present at the center of a trunk or branch. Inside fruits the pith stores nutrition for growth and reproduction.

EPIDERMIS

Functions of the Epidermis

- Protects against water loss
- Controls gas exchange (oxygen, carbon dioxide and water)
- Absorbs water and minerals
- Protects the underlying tissues

Example of the epidermis (skin) of an orange-the white outer edge of the cut fruit

The **epidermis** is a single-layered group of cells that covers plants leaves, flowers, roots and stems. The epidermis serves to protect against water loss, regulates gas exchange and (especially in roots) absorbs water and mineral nutrients. The epidermis of most leaves is of somewhat different on the top portion than that on the lower surface and in many cases may serve different functions.

XYLEM AND PHLOEM

Xylem and phloem along with other cells are arranged in specific patterns within a stem. These patterns differ depending on whether the plant lives and grows year after year (a woody plant-like trees and bushes) or if the plant is herbaceous; grows for one season and then dies or becomes dormant and starts all over in the spring. Although the cellular arrangement is different in woody stems versus herbaceous stems, the function of both the xylem and phloem is the same in both types of stems.

Xylem

Functions of the Xylem

- Transports water and dissolved minerals from the root system to the stem.
- Thick-walled xylem cells strengthen the stem.

Xylem sap from maple tree trunks is made into candy, butter and syrup



These pictures of celery stalks clearly show the xylem tubes


The xylem is the system of tubes and transport cells connected end to end which enables quick and efficient circulation of water throughout the entire plant. Water and dissolved minerals are first absorbed from the soil into the roots and then travel upward via the stem and out to the leaves. Xylem also serves to strengthen and support the plant. Xylem tissue dies after one year and then develops anew. When an old tree is cut down the interior of the trunk reveals a set of rings which are remains of old xylem tissue; one ring for every year the tree was alive.

Phloem

Function of the Phloem

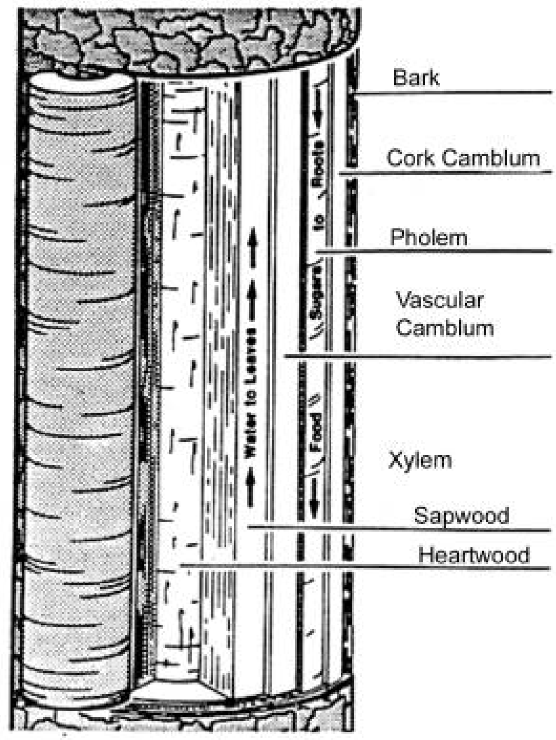
- Transports food made in the leaves during the photosynthesis process to other parts of the plant.

The phloem is living tissue attached to the underside of the bark of a tree. Phloem cells are laid out end-to-end creating hollow tubes that transport food throughout the entire plant. Sugars, which are food for the plant, are manufactured in the leaves during the photosynthesis process and transported via the phloem to every cell in the plant for energy.

Cambium

Function of the Cambium

- Produces new growth



The most important part of a tree is an area of actively dividing cells just below the bark which controls new growth called the **cambium**. This very thin layer of growing tissue produces new cells which become xylem, phloem or more cambium. Every growing season, a tree's cambium adds a new layer of xylem to its trunk and produces new bark and new wood which, when damaged or scraped away, appears green. New layers of xylem and phloem constantly develop and increase the **diameter** of a tree. Each year's growth of xylem forms a dark circle that separates from the old, inactive xylem; these circles or rings can be used to determine the age of the tree.

Inside the cambium layer is another system of tubes known as the phloem, or the inner bark of the tree. Phloem is found between the cambium and the outer bark and acts as a food supply line by carrying sap (sugar and nutrients dissolved in water) from the leaves to the rest of the tree. Like xylem, phloem is also replaced every year. Phloem cells resemble xylem cells, but they do not accumulate as wood. Instead they build up layers that form thick corky bark which can be seen on old trees; the older the tree, the thicker the layer of bark or dead phloem.

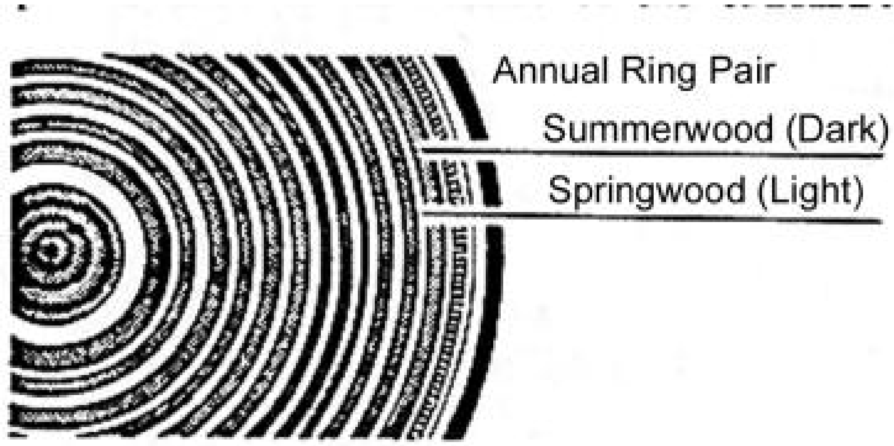
SAPWOOD

Function of the Sapwood

- Absorbs, transports and circulates water and nutrients throughout the entire plant

Sapwood is the living outer portion of the xylem that actively absorbs and transports water and nutrients (**sap)** upward and circulates it throughout the entire plant. New xylem is formed by cells that **elongate** and meet tip-to-tip to form a system of continuous tubes through which water travels. Sapwood is new wood and is usually lighter in color than the heartwood. As newer rings of sapwood are laid down, the inner cells die and become heartwood.

HEARTWOOD



Function of the Heartwood

- Supports the plant

The heartwood is the inner most-dense part of a tree that gives it stiffness; its main function to support the rest of the tree. The heartwood is old, inactive, dead sapwood which constantly forms as the tree ages. Although dead, it will not decay or lose strength while the tree is alive. As it becomes older, inactive xylem becomes clogged with a buildup of chemicals and nutrients and becomes darker in color. Heartwood also stores waste products from the plant, which helps to preserve the wood.

In trees the xylem (both heartwood and sapwood) is replaced by a new layer every season and appears as a series of annual growth rings. Each ring consists of a light band and a dark band of distinctly different types of wood. The lighter- colored, less-dense wood in the annual ring is called **springwood** or early wood. Later in the season, growth slows down, resulting in a darker, more-dense wood called **summerwood** or late wood.

The old, dead xylem becomes part of the heartwood of the tree and which gives structural support for the tree, and gradually widens year after year as the tree becomes taller. A tree's age and growth rate can be determined by counting and measuring annual rings. A wide annual ring indicates an excellent growth year, while a narrow ring indicates a poor year and may be due to such factors as insects, disease, competition from other trees, or weather conditions.

BARK / CORK

Functions of the Bark

- Protects the tree from diseases, pests, extreme temperatures, storms

Examples of different types of bark: Bald Cypress, Red Maple and Southern Magnolia

The trunk, branches and twigs of the tree are covered with cork also known as bark. The outer bark, which is worn out, dead phloem cells that have been shed outward, is the waterproof covering on the outside of the trunk that protects the tree from insects, disease, storms and extreme temperatures. In certain species, such as the Longleaf Pine, the thick, insulating outer bark helps protects the tree from fire.

Some tree species such as the Swamp Red Bay have a highly active **cork cambium** that causes its bark to be smooth, tight and unbroken. Other trees such as the Slash Pine have cork cambiums that do not keep up with the diameter growth from the vascular cambiums; resulting in bark that is a deeply **fissured** or cracked and that breaks into flat chunks.

CROWN

Functions of the Crown

- Light energy assimilation (photosynthesis)
- Energy release (respiration)
- Movement of water to the atmosphere (transpiration)

Branches and leaves make up the crown of a tree and play an important role in filtering dust and other particles from the air. The crown also helps cool the surrounding air by providing shade and reduces the impact of raindrops on the soil below. The crown is the site of active growth of the tree. A tree's height and crown growth occur only from the **terminal bud** at the tips of the branches, therefore a nail driven into a tree trunk will be at the very same height many years later.

In other words, trees do not grow up from the ground; they grow by adding new cells on top of old cells at the branch tips. If the terminal bud is damaged or removed, **lateral buds** will grow to replace the terminal bud and produce a bushier looking plant. Landscapers and Christmas tree growers take advantage of this characteristic and regularly shear terminal buds, producing a fuller tree.

LEAF ANATOMY

LEAF ANATOMY and STRUCTURE

The anatomy or structure of leaves can vary greatly from species to species. Leaves have wide flattened areas called **blades**, where sunlight is absorbed and reacts on photosynthetic cells. A leaf typically consists of the following tissues:

- An **epidermis** that covers leaf surfaces
- An interior called the **mesophyll**,
- and **veins** (vascular tissue)

Epidermis

A leaf is made up of several layers. The top and bottom of the leaf is covered by an outer layer of thick, tough cells called the **epidermis**; its primary function is to protect the underlying layers of leaf tissue similar to the way our skin protects our underlying tissues. The arrangement of epidermal cells makes up the leaf's surface texture. Some leaves, such as those of the Silver Buttonwood, have hairs which are extensions of epidermal cells that make the leaves feel like velvet.

Epidermal cells lack chloroplasts which makes this layer **transparent.** The epidermis is coated on the outer side with a waxy cuticle that protects against water loss and controls the exchange of gases in leaves. Special epidermal cells called **guard cells** open and close in response to environmental conditions such as changes in weather and light. The kidney-shaped guard cells have the ability to open and close and regulate the passage of water, oxygen and carbon dioxide into and out of the leaf through tiny openings called **stomata**. Water vapor passes out of the stomata during transpiration. In most species, the majority of the stomata are located on the underside of leaves. To conserve water the stomata close up during the night.

Cuticle

A part of the epidermis called the **cuticle** prevents water loss with a waxy layer produced on the outer surface. This layer is usually **transparent** because its cells lack chloroplasts. This waxy coating called **cutin** builds up on the leaves with increasing exposure to sunlight. It provides protection from rapid water loss, sunscald, disease and rotting. The cuticle may be thinner on the lower epidermis than on the upper epidermis and is thicker on leaves from dry climates as compared with those from wet climates.

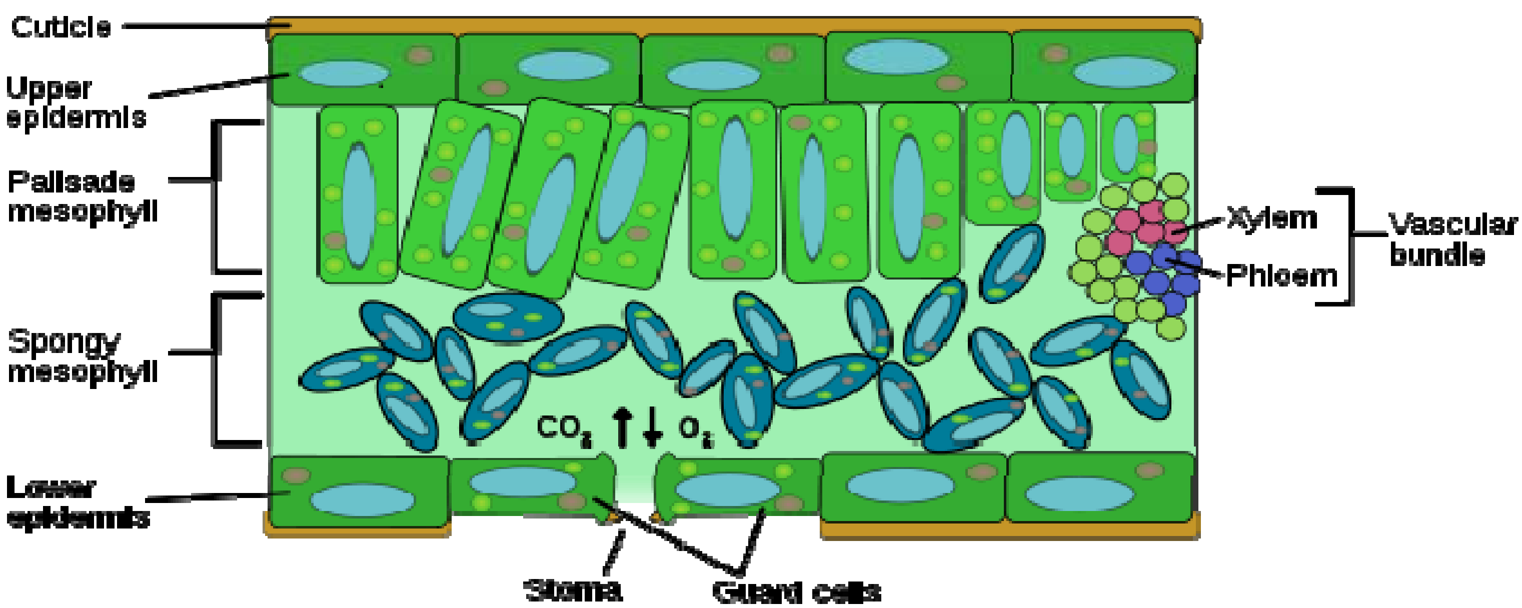
Mesophyll

The tissue that makes up most of the leaf is located in between the epidermal cells and is called **mesophyll** (Greek for "middle leaf"). This middle area of the leaf is divided into two layers: the **palisade parenchyma** and the **spongy parenchyma** both of which are packed with chloroplasts, the factories of photosynthesis.

In the palisade layer, chloroplasts are lined in columns just below the epidermal cells. Chloroplasts capture and store light energy needed to perform photosynthesis and contain chlorophyll, the **pigment** that gives plants their green color. Powered by energy from the sun, chlorophyll uses **carbon dioxide** and water to produce sugar called glucose which is food for the plant. The sugar provides growth energy to the entire plant. This process is called **photosynthesis** which comes from the Greek words ‘photos’, meaning light and ‘synthesis’, meaning putting together.

The spongy parenchyma layer is tissue that also contains chloroplasts and other parenchyma cells, but the cells are more rounded and not so closely packed together which allows air spaces inside the middle of the leaf. Most oxygen and carbon dioxide (gas) exchanges occur within this spongy layer in these spaces between cells. It is to the plant's advantage to maximize the gas exchange and sunlight trapping surface while keeping leaf thickness to a minimum so that gases can pass easily throughout the cells of the leaf, a process that occurs readily only when there are only a few layers of cells present.

<u>Cross Section Diagram of Leaves</u>

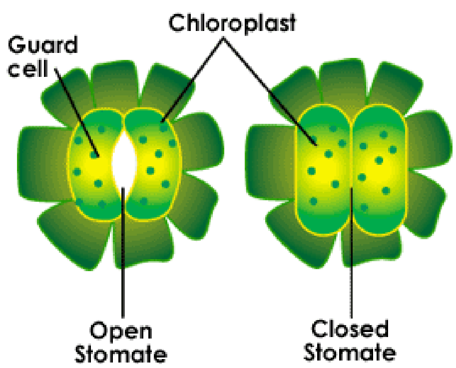


Stomata and Gas Exchange

- The stomata allow gaseous exchange for the processes of respiration and photosynthesis.

Stomata are the structures through which gas exchange occurs in leaves. Each stoma is surrounded by two guard cells, which can open and close depending on environmental conditions. When moisture is plentiful, the guard cells swell with water, forcing the stomata to open, allowing gas exchange to occur. When the plant loses too much water or water in the environment becomes less plentiful, the guard cells deflate, the stomata close, preventing further water loss or gas exchange.

Stomata and Guard Cell Function



When the stomata are open, the plant can take in carbon dioxide from the air for photosynthesis and release oxygen (a byproduct of photosynthesis) back into the environment. While doing so, the plant also loses an enormous amount of water by evaporation. This process is called transpiration. To make up for this water loss, additional water is drawn in from the soil by the roots and passed upward through the plant by the xylem. Conditions that would cause plants to lose a lot of water such as high temperature, low humidity or absence of light stimulate guard cells to close.

Veins

The **veins** are the vascular tissue of the leaf and are located in the spongy layer of the mesophyll called the spongy parenchyma. The veins are made up of xylem which brings water from the stem into the leaf and phloem and moves out the sap, the glucose (sugar) produced by photosynthesis in the leaf. The xylem typically lies over the phloem, and both are embedded in the parenchyma.

PLANT PROCESSES

PHOTOSYNTHESIS

Photosynthesis is the most important process that occurs in plants. The word photosynthesis means "putting together with light" and is a chemical process by which green plants make their own food. Sunlight powers the photosynthetic process that converts water, minerals, and carbon dioxide into sugars, which is nutrition for plants.

Most photosynthesis takes place in chloroplasts inside the plant's leaves. A leaf needs carbon dioxide and water for photosynthesis. When energy from the Sun is absorbed by a chloroplast; stomata open to allow carbon dioxide to enter for photosynthesis and at the same time, for water to exit for transpiration. Inside the chloroplasts is chlorophyll, the pigment that gives the plant its green coloring. Chlorophyll uses the sun's energy to combine carbon dioxide (CO_2) and water (H_2O) (which enters the plant from the roots and is pulled and circulated throughout the entire plant by way of the xylem). This process creates sugar and oxygen (O_2). Plants then use the sugars (glucose) for food and release the oxygen to breathe, which is essential to all animal life.

Here is the equation for photosynthesis:

Chlorophyll (in the presence of light)

6CO2	+	12 H2O →	C6H12O6	+	6O2	+	6H2O
carbon dioxide		water	glucose		oxygen		water

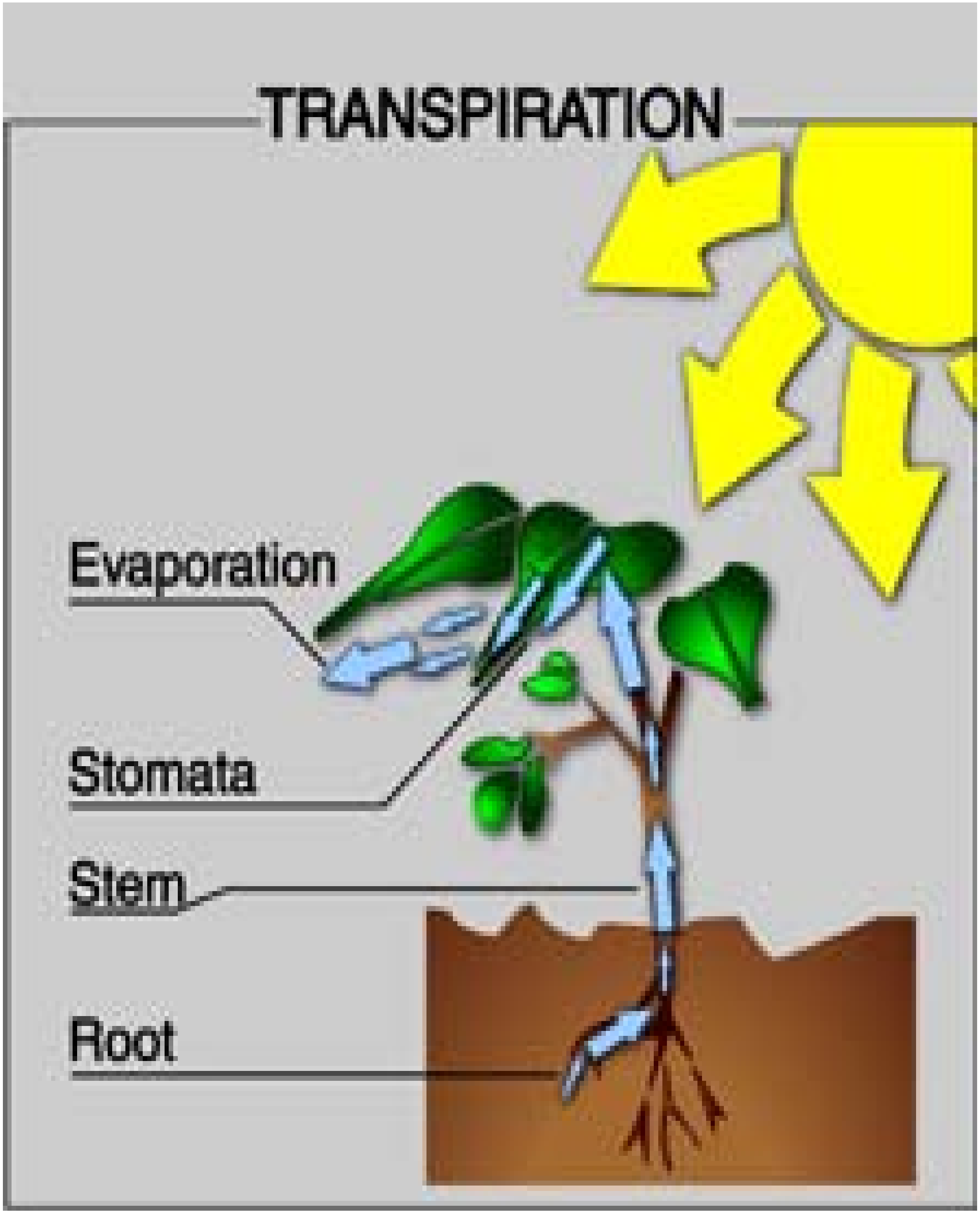
TRANSPIRATION

Overview

All green plants lose water through tiny pores in their leaves called **stomata** in a process called transpiration. Transpiration is the evaporation of water from the leaves of plants. It occurs while their stomata are open for the passage of carbon dioxide and oxygen during photosynthesis.

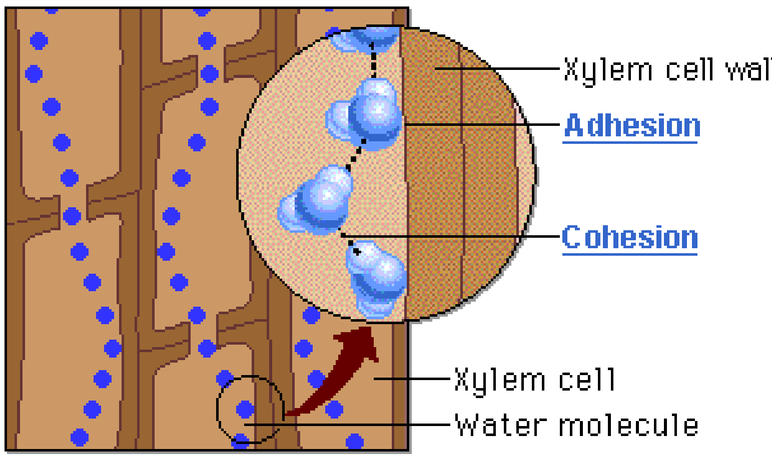
Water and minerals from the soil are absorbed into the roots of plants and circulate throughout the entire plant and finally exit through the leaves. During this process some water becomes stored in tissues and some is utilized during the photosynthesis process to make food for the plant. Excess water, that which is not used to make food or stored, is then pushed out through the stomata in the leaves, where it evaporates into the atmosphere.

Plants constantly transport and **expel** large amounts of water into the atmosphere, making transpiration very important to the water cycle. To give an idea of how much water is transpired by a typical tree growing in a forest, it has been estimated that a Eucalyptus tree around 250 feet in height can lose several hundred gallons of water on a hot day. An average size oak tree can transpire hundreds of gallons of water per day during the summer months. Imagine the volume of water released to the atmosphere in an oak forest growing 150–200 trees per acre. In this way trees act like giant air conditioners, cooling the plant and the surrounding air with water vapor and giving off oxygen.


TRANSPIRATION
Evaporation
Stomata
Stem
Root

How Transpiration Occurs

Water is lost from the stomata of the plant. The stomata act as pumps which pull water and nutrients from the roots throughout the entire plant and out to the leaves where it evaporates into the atmosphere. This force is known as **transpirational pull** and results when forces of **root pressure**, **capillary action**, **adhesion** and **cohesion** combine. The pull created within the plant is strong enough to overcome gravity, drawing water and minerals to incredibly tall heights. In large trees, water may be lifted hundreds of feet from the roots to the canopy.

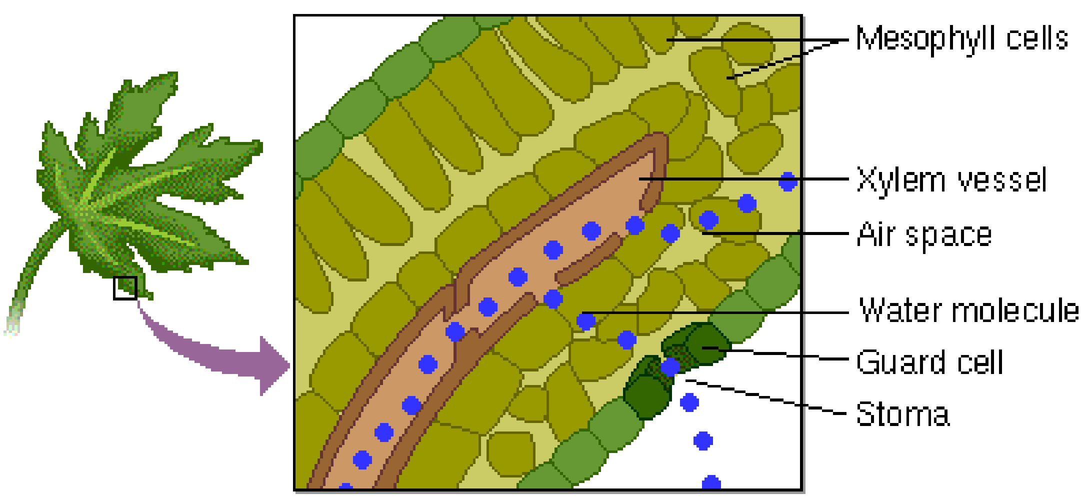


When water enters the roots, water molecules attach first to the xylem (adhesion). Each water molecule then links to other water molecules (cohesion) forming a column of water which is pulled up the thin xylem vessels like beads on a string. The water moves up the plant, enters the leaves and moves into air spaces in the leaf (capillary action). As the water exits the leaf from the stomata, it is heated from the surrounding air which changes it into water vapor (a gas) and evaporates (transpires). As it evaporates, the vapor creates tension which pulls on the remaining water molecules, generating transpirational pull.

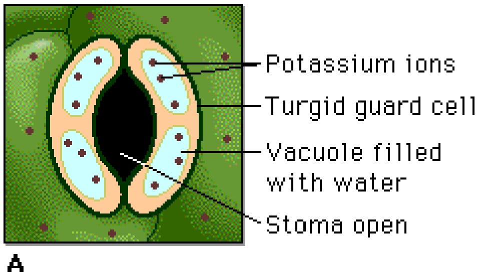
When Transpiration Occurs

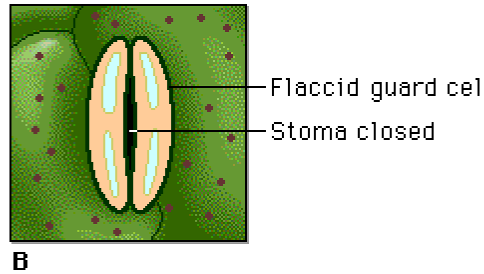
Transpiration occurs during photosynthesis when the stomata are open to allow carbon dioxide to enter. A leaf needs carbon dioxide and water for photosynthesis. Stomata open to allow carbon dioxide into the leaf for photosynthesis, while water vapor escapes through the open stomata and evaporates into the atmosphere. Transpiration is an inevitable consequence of photosynthesis

However, the plant must not lose so much water during transpiration that it wilts. The plant must strike a balance between conserving water and not bringing in enough carbon dioxide for photosynthesis.



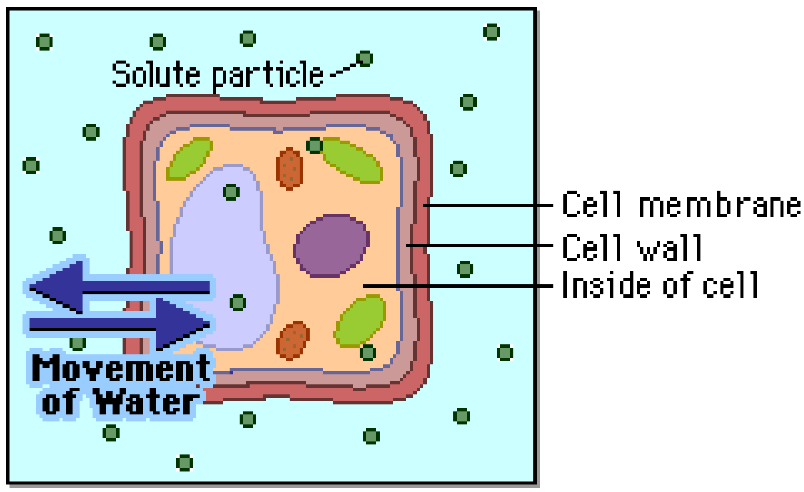
When the guard cells are open water molecules are pulled out through the stomata where they change from liquid to vapor and evaporate.





Why Transpiration Occurs

- ✓ supplies water for photosynthesis
- ✓ distributes minerals from roots for photosynthesis
- ✓ cools the leaf



There are several reasons why plants transpire. Plants need large amounts of water to transport nutrients and minerals necessary for photosynthesis; they will wilt and eventually die if they do not have enough water. The transpirational process moves water and nutrients through the vascular tissues of the plant for photosynthesis. Transpiration also helps to regulate **turgor** pressure in the plant's vascular tissues which keeps the plant from becoming dehydrated. Turgor maintains water pressure within the cells, keeping them rigid so they can support the plant and keeps it from wilting.

Transpiration controls the temperature of the plant. Water circulating throughout the plant for photosynthesis exits from the leaves and eventually evaporates into the atmosphere. As it evaporates the water vapor pulls excess heat with it away from the plant. This reduces overheating and cools the leaves.

Environmental Factors that Affect Transpiration

1. **Light**

Plants transpire more rapidly in the light than in the dark, though there are some exceptions. Light causes the stomata to open more fully which increases transpiration. Light also speeds up transpiration by warming the leaf.

2. **Temperature**

Higher temperatures increase the rate of water evaporating from leaves, which increases the transpiration rate. At 86 degrees F a leaf may transpire three times as fast as it does at 68 degrees F.

3. **Humidity**

High humidity means increased water vapor in the air and surrounding leaves, which results in a lower water **gradient** (from soil to atmosphere) due to less evaporation and results in lower transpiration rates. Water exits and evaporates from a leaf more quickly when the air surrounding the leaf is drier (less humid, contains less water vapor).

4. **Wind**

Wind moves moist air from around the stomata and replaces it with drier air, thereby increasing the water gradient (form soil to atmosphere). Less air movement causes the air surrounding a leaf to become increasingly humid thus reducing the transpiration rate. When a breeze is present, the humid air is carried away and is replaced by drier air and the transpiration rate increases.

5. **Soil water**

A plant cannot continue to transpire rapidly if its water loss is not made up by replacement water from the soil. When the absorption rate of the roots fails to keep up with the transpiration rate, loss of turgor occurs causing the stomata close. This immediately reduces the transpiration rate (and photosynthesis rate). If the loss of turgor continues and involves the leaves and stem, the plant wilts.

6. **Leaf Area**

Larger leaf area leads to larger amounts of water transpired.

FUN TREE FACTS

- The average tree in a city survives only about 8 years.
- The death of one 70-year-old tree would return over three tons of carbon to the atmosphere.
- Trees located along streets act as glare and reflection control.
- Trees are the longest living organisms on earth.
- One tree produces nearly 260 pounds of oxygen each year and one acre of shade trees removes up to 2.6 tons of carbon dioxide each year.
- Shade trees can make buildings up to 20 degrees cooler in the summer.
- One of the tallest soft wood trees is the General Sherman, a giant redwood sequoia of California. General Sherman is about 275 feet high with a girth of 25 feet.
- The 236 feet high Ada Tree of Australia has a 50 foot girth and a root system that takes up more than an acre.
- The world's tallest tree is a coast redwood in California, measuring more than 360 feet.
- The world's oldest trees are 4,600-year-old Bristlecone pines in the United States.
- Dendrochronology is the science of calculating a tree's age by its rings.
- Tree rings provide precise information about environmental events, including volcanic eruptions.
- During a growing season, a leaf will transpire many times more water than its own weight. For example a large oak tree can transpire 40,000 gallons of water per year.

IDENTIFYING PLANTS BY LEAF CHARACTERISTICS

Monocots and Dicots

Traditionally flowering plants, known as **phylum** Anthophyta, has been known as the **angiosperms**, which has been divided into two great subdivisions, or classes, known as **monocots** and **dicots**. Recent studies show that the situation is more complex than that. But for our studies, it still makes sense when attempting to identify a plant to resolve this question first: "Is this a monocot or a dicot?" Nearly all **deciduous** trees and common flowering bushes and vines are dicots, but nearly all grasses and grass like things are monocots.

We can't see inside a seed, but as soon as it **germinates**, we can tell if a plant is a monocot or a dicot. A monocotyledon, monocot for short, has only one seed leaf (cotyledon is a seed leaf; 'mono' means one). This seed leaf is usually the same shape as the adult leaf, long and thin, and the leaf veins nearly always run parallel to the central midrib. Sometimes, the adult leaves are pinnate, as in many palms, but the veins are parallel on each leaflet. Many monocots are easy to identify because they are grasses. Some food plants such as wheat, oats, barley and sweet corn are actually grasses and are all monocots, as are Palms, Orchids and most bulbous plants.

A dicotyledon, dicot for short, has two cotyledons (di means two). The seed leaves are usually rounded and fat, because they are the two halves of the seed. The first true leaves can be many different shapes, from long and thin to rounded or palmate. Most trees and shrubs and many garden annuals and perennials are dicots, and there are many more species of dicots than there are monocots.

Most monocots are small herbaceous plants, meaning they die back every year. Monocots do not often grow into trees, because they do not have any woody tissue to support a great deal of weight. The anatomy of herbaceous plants is designed to provide food for only a very limited time (one growing season). The stems of monocots do not grow like this. In most cases, the whole stem dies down each year, and a new stem grows the following year. The vascular bundles are not organized to form continuous pipes, but are scattered through the stem. The stems do not grow wider each year, but start again so all the growth is new sapwood, which is soft and fleshy. The top of the stem is the only growing point, so branches or side shoots cannot be produced. There is a meal called 'millionaire's salad', which is the heart of the Cabbage Palm. It is expensive because the whole tree must be killed to produce it. Because a Palm does not produce secondary tissue, but can only grow from the tip and cannot grow any new branches.

Dicots come in all shapes and sizes and are usually much larger plants with good support systems provided by the woody stem and root. Woody tissue grows in distinct rings formed by the middle older layers that stop growing called heartwood. New growth forms the part of the stem or trunk that is full of groups of pipes that carry water from the roots to the top of the plant and food to the rest of the plant from the leaves. These “pipes” are called vascular bundles. Old vascular bundles stop carrying water as they become squashed closer together each year as new bundles are made. This makes the middle of the stem tough and strong so it can support the stem. Because new vascular tissue grows each year, the stem or trunk grows wider each year. This is called secondary growth. Because there is growth around the stem as well as at the tip, a dicot can produce new growing points or branches if the tip is cut or damaged.

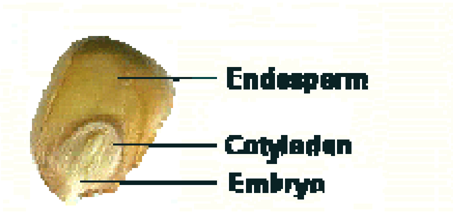
All monocots and dicots are flowering plants however the flowers are not always large and showy. Grasses and cattails are monocots whose flowers are often overlooked because they do not have sepals or petals. Oaks, maples, and sycamore are all dicot trees, but they do not produce obvious flowers. There are also some flowering plants which flower only rarely. Palm trees have no wood and are monocots that rely on overlapping leaf bases, thickened enlarged cells, and prop roots to stay up. This strategy is also used by cycads and tree ferns. P**ine trees** are **conifers**, and are neither monocots nor dicots. Only flowering plants are considered to be members of these two classes.

Monocots include all grasses and glasslike plants, plus lilies, irises, amaryllises, and some other plant types. Usually, but not always, monocots possess parallel-veined leaves as shown at the right.

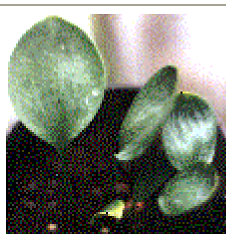
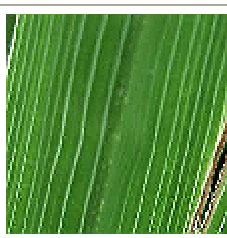
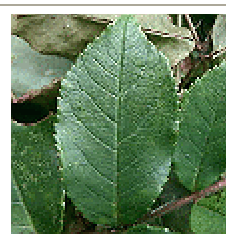
Dicots include nearly all our trees, bushes, vegetable-garden plants (not corn), and most of our wildflowers (not irises and lilies). Dicot leaves usually have veins that look like nets, as in the close-up of the leaf at the right. Notice how the larger veins are thicker and straighter, but as veins get smaller and smaller, they tend to snake around.

This diagram shows many important differences between monocots and dicots; however this is only a rough guide. Not all the differences apply in all cases. Like everything else in nature, plants do not have to follow the rules we have invented to try and classify them!

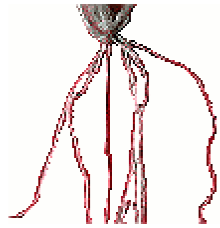
Differences Between Monocots and Dicots

<table>
<tr><th>Monocot</th><th>Dicot</th></tr>
<tr><td colspan="2">SEED</td></tr>
<tr><td>

Monocots have only one seed leaf inside the seed coat. It is often only a thin leaf, because the endosperm to feed the new plant is not inside the seed leaf.</td><td>

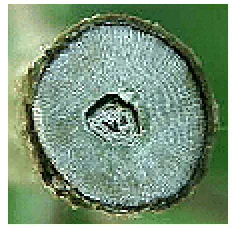
Dicots have two seed leaves inside the seed coat. They are usually rounded and fat, because they contain the endosperm to feed the embryo plant.</td></tr>
<tr><td colspan="2">GERMINATION</td></tr>
<tr><td> 
When a monocot seed germinates, it produces a single leaf. It is usually long and narrow, like the adult leaf. Even when it is quite a round shape, there is only one seed leaf in a monocot.</td><td> 
When a dicot germinates, it produces two seed leaves. They contain the food for the new plant, so they are usually fatter than the true leaves. The first true leaves are often a different shape.</td></tr>
<tr><td colspan="2">LEAVES</td></tr>
<tr><td> 
The leaves of monocots are often long and narrow, with their veins in straight lines up and down the leaf. Sometimes, the veins run from the center of the leaf to the edge, parallel to one another.</td><td> 
Leaves of dicots come in many different shapes and sizes. The veins go from the central midrib to the edge of the leaf, crossing and joining to form a netted pattern all over the leaf.</td></tr>
<tr><td colspan="2"></td></tr>
</table>

STEM & ROOTS



Stem **Root**

The stems of monocots are usually unbranched and fleshy. They do not grow thicker from year to year. New leaves often grow wrapped in a protective sheath formed by the older leaf. The roots of dicots are usually short and stringy. Dicots often have bulbs.



Stem **Root**

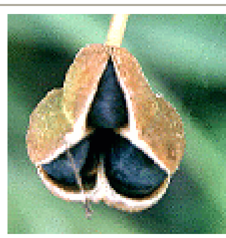
The stems of dicots are usually tough. They can grow wider each year and are often branched. They sometimes have stipules at the base of the leaf. The root is often a single long tap root with smaller roots growing from it.

FLOWER

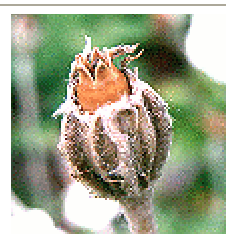
The parts of the flower of monocots are in threes. The sepals are often the same color as the petals, making it look as if the flower has six petals. There are usually the same numbers of stamens as petals.

The flowers of dicots usually have flower parts in fours or fives. The calyx is a separate ring of sepals under the corolla, and is usually green.

SEEDPOD



The seed pods or fruits of monocots usually have three parts. The seeds are often large and fleshy. The largest seed in the world, the Coco-de-Mer, and the smallest seeds in the world, Orchid seeds, are both monocot seeds.



The seedpods or fruits and the seeds of dicots are very variable in shape, size and texture. The seedpod can have any number of chambers, from none to many. There are often more seeds in a seedpod than in a monocot seedpod.

IDENTIFYING PLANTS BY THEIR LEAVES

Leaf characteristics such as shape, margins, hairs or size are important for identifying plant species. At most times of the year, most plants do not have flowers or fruit, but they do have leaves. Therefore, when botanists want to identify a plant, they study its leaves. They look at several things:

- How the leaves are arranged on the stem.
- Whether the leaf is simple or compound.
- What the edges look like.
- How the veins are arranged.
- What the shapes of the leaves are.

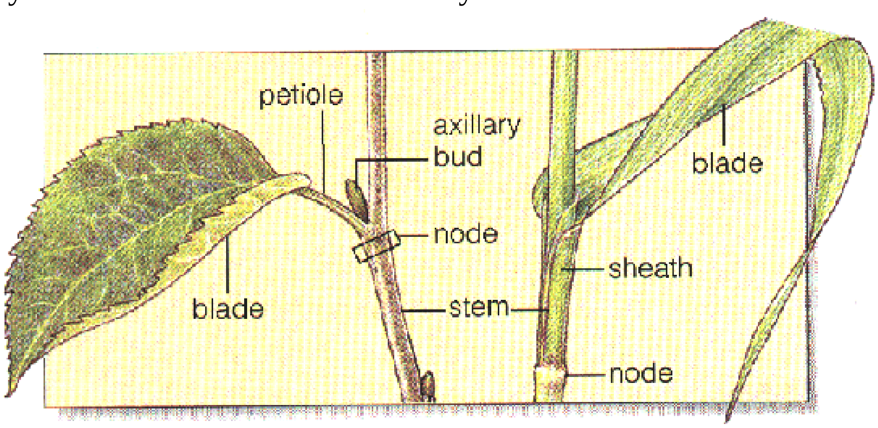
If they know these things and they have a good plant guide, they can usually tell exactly what plant they are observing.

DIFFERENT METHODS of IDENTIFYING LEAVES

Classification and identification of leaves can occur through many different well-defined **schema** (appearance, arrangement), and the type of leaf is usually characteristic of a species. For instance the longest type of leaf is from palm trees which can measure up to nine feet; long needle-like leaves are associated with pine trees; thick pad-like leaves with cacti; large, leathery round leaves with sea grape and so forth.

External leaf characteristics such as shape, margin, hairs, etc. are important for identifying plant species, and botanists have developed specific terminology for describing them. These structures are part of what makes leaves **determinant**; they grow and achieve a specific pattern and shape, then stop. Other plant parts like stems or roots are **non-determinant** and usually continue to grow as long as they have the resources to do so.

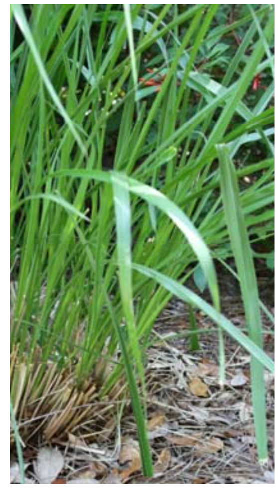
The anatomy or structure of leaves can vary greatly from species to species. Leaves have wide flattened areas called **blades**, where sunlight is absorbed and reacts on photosynthetic cells. Short stems that attach leaves to main stems or branches are called **petioles**. The segments of the stems to which leaves and **axillary buds** are attached are **nodes**. Axillary buds single buds or bud clusters which develop into stems or leaves (next year's growth). In some plants a **petiole** and **lamina** may be absent or the blade is not always flattened.



According to the petiole:

- **Petiolate-** leaves that have a petiole, a stalk; length can differ from one plant to another
- **Sessile**-leaves that do not have a petiole; the blade is attached directly to the stem

Petiolate leaves (leaf stalks) of the Firebush



Sessile leaves of the Yellow Canna & Fackahatchee Grass

According to the blade (lamina):

- **Simple leaf**- has one undivided blade; the leaf shape may have deeply divided lobes, but the gaps between lobes do not reach to the vein.
- **Compound leaf**- has divided blades known as leaflets; each leaflet is separated along a main or secondary vein looks like many, but is actually one

Simple Leaf (Maple)
A simple leaf has one main stalk and one main blade

Compound Leaf (Horse Chestnut)
Compound leaves are divided into leaflets attached to a central stalk. It looks like many leaves, but it is actually only one leaf.

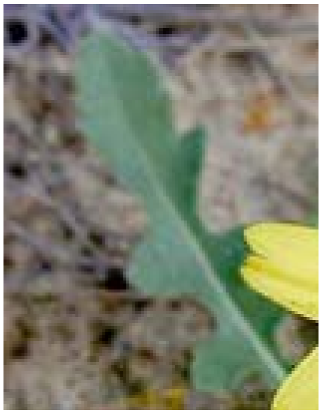
According to the margins (edges):

- **Ciliate**- edges fringed with hair
- **Crenate**- edges are short and rounded, also called scalloped
- **Entire**- edges are smooth, even leaves
- **Lobate**- rounded indentations do not extend deeper than half way to center of blade
- **Serrate**-saw-like teeth pointing forward
- **Spiny**-leaves with stiff, sharp points
- **Undulate**- leaves with deep, curvy, wave-like indentations

Ciliate

Crenate

Entire



Lobate

Serrate

Spiny

Undulate

According to the shape:

- Elliptic-shaped like an ellipse; wider at the center and tapers off at both ends
- Lanceolate-lance-shaped; longer than broad and tapering to a point at the tip
- Acicular- needle-shaped leaves
- Ovate-oval; egg-shaped
- Cordate-heart-shaped
- Hastate-shaped like a spear; triangular; wider at base and tapering toward the tip
- Blade-the main part of the leaf is the blade

Ellyptic

Lanceolate

Acicular

Ovate

Cordate

Hastate

Blade

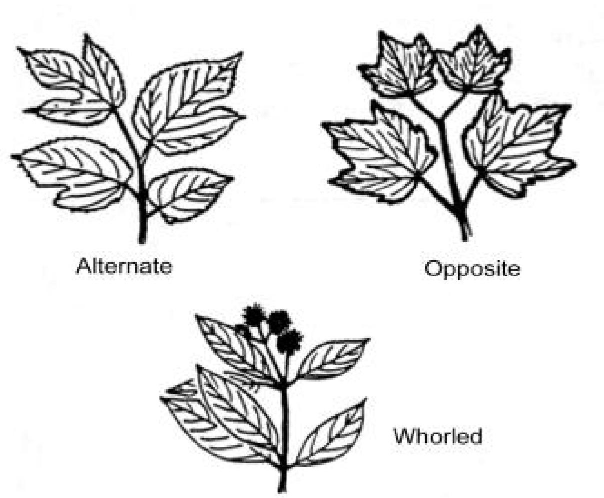
According to veins:

- Parallel-veins run at the same distance to each other most the length of the leaf
- Pinnate-a main vein (called a midrib or mid-vein) with smaller veins branching off; usually somewhat parallel to each other
- Palmate-several main-veins go in different directions from base-such as fingers from the palm of a hand; compound leaves have the leaflets radiating from the end of the petiole

Parallel Veins **Pinnate Veins**

Palmate Veins

According to arrangement along the stem:



- Alternate-leaf attachments spring one node at different/alternate directions/levels of stem
- Opposite-leaf attachments two per node-facing opposite or directly across from one another on stem
- Whorled-three or more leaves attached at the same level on stem (NOTE: sometimes opposite leaves appear whorled near tip of stem)
- Rosulate- leaves form a rosette; a ring around the stem

Leaf Adaptations

Leaves come in many shapes and sizes. There are two main types: needle leaves and broad leaves. Many conifers have needle leaves, which are thin, pointed and very tough. They do not lose much water to the air, which helps conifers survive in dry, cold areas. Many trees that have broad leaves lose their leaves in the winter or in our subtropical Florida climate, undergo a leaf change by shedding the old ones to make way for new robust replacements. Broad leaves are wider and expose more surface area to the sun and are divided into two types: simple and compound.

Sizes and Shapes

The sizes and shapes of leaves are valuable adaptations that assist in the plant's survival. The narrow needles of a Slash Pine can expose a large area of chlorophyll surface to the sun, which increases food production for the tree. Lobes, leaflets and jagged edges of many broad leaves help evaporate the water used in food-making, reduce wind resistance- even provide "drip tips" to shed standing water that could decay the leaf. Most plants can be identified by the shape of their leaves alone. The "sword" shape of saw palmetto is totally different from the round-shaped leaf of the peperomia.

Leaf Coverings

Different types of leaves have allowed plant species to adapt to a wide range of moisture and temperature-extremes and assist in regulating transpiration. Some species such as the Prickly Pear Cactus have a waxy coating and very thick leaves to help conserve water during the winter's dry season or drought conditions. Trees such as the Southern Red Cedar and shrubs like the Yaupon Holly have developed leaf shapes that prevent too much transpiration from occurring during hot, dry weather.

Most silver and grey leaves have dense layers of hairs, which reflect bright sunlight and prevent overheating. Silver Buttonwoods have leaves with fine hairs which prevent wind from disturbing the air around the leaf surface. This allows carbon dioxide to enter more easily, while keeping water loss to a minimum. Hairs hinder insects from devouring leaves by clogging up their mouthparts or making chewing difficult. In some bird-pollinated species of plants leaf hairs increase the visibility of the flower-heads. Some bushes have **denticles** (hairs) so rough that when combined with their branches resemble "barbed wire".

Some leaves are not covered by hairs but instead by fine waxy scales which is another solution to reducing the amount of light reaching leaves. By reflecting light, the silver scales prevent overheating and the wax aids in keeping the leaf surfaces **impermeable** to water. Wax may also hinder herbivores. In plants, young leaves and new growth are soft and full of protein, making them excellent choices for dinner on any herbivore's menu. In order to overcome these problems young leaves must grow quickly and are usually covered by dense hairs and waxy blooms.

Young leaves are often a different color than mature leaves, usually red or yellow. The reason for this is not known, but may serve in reducing heat load; red leaves reflect more heat and thus cuts down on water loss. Many insects cannot see red light, and although brightly colored to humans, red leaves are not easily seen by insect herbivores.

Species such as the Wild Coffee have a thin cuticle (layer protecting the skin) and therefore are adapted to grow in the shady hammocks habitat which is naturally sheltered from the scorching sun and drying winds.

In order to survive in a harsh environment, leaves can adapt in the following ways:

- Hairy leaf surface to lessen water loss
- Waxy leaf surface to prevent water loss
- Small, shiny leaves to deflect the sun's rays
- Thick leaves to store water
- Spines instead of leaves
- Leaves to trap insects

Other Adaptations

A plant spends its lifetime in one location and therefore must have effective survival **strategies**. These strategies have been acquired through **natural selection**-the slow, evolutionary process by which only those organisms best able to adapt to environmental change live on to reproduce. Charles Darwin, one of the authors of evolutionary theory used the phrase “survival of the fittest” to describe that outcome.

Natural selection has led to means by which plants can survive any threat to their existence. Limiting factors such as rainfall, temperature, competition between plants in a struggle for resources (sunlight, nutrients, water and space), pests, diseases and attacks by predators have caused plants to develop adaptations to protect against environmental extremes such as too cold or too hot conditions. For example some plants become dormant during in order to survive such unfavorable conditions; others reproduce just before dying and the resulting seeds remain dormant until conditions for growth become favorable-sometimes for many years pass. This is called **avoidance strategy**.

Many plants evolved with the development of roots, stems and leaves specially adapted to perform unusual functions. For example, herbaceous stems of some plants became compact, frost/freeze resistant, underground bulbs. Cactus stems became the plant's photosynthesizing organs and the leaves modified into protective spines. The Prickly Pear Cactus has a huge mat of shallow fibrous roots that quickly absorb water; the pad-like leaves act as water storage containers-sometimes for many years. Some plants' roots evolved into climbing structures, while others developed aboveground parts to support heavy tree trunks. Some plants, like the Milkweed, even developed pesticide or chemical substances that emit strong, unpleasant odors, cause skin rash or unpleasant tastes to deter predators, while others kill invasive organisms.

Some plants protect against being eaten by sporting spines, thorns or stinging prickles that cause pain or a rash of itchy skin. Epidermal hairs like those of the Silver Buttonwood are difficult for many insects to chew which guards against **defoliation** by a hungry swarm of bugs. Several species of ants live in hollow stems and feed on liquid produced by certain plants. In exchange for food and shelter the ants provide the plant with protection by a mass of ferocious biting ants. Special cells in some plants seal off a wound by forming a waxy substance that stops uncontrollable, deadly water loss; some possess chemicals that provides defense from invading organisms.

Reproductive strategies evolved to insure plant survival. Some plants developed **symbiotic relationships** with birds or other animals which eat and then **disperse** seeds over wide areas. The resulting plant species then germinate and grow over a wide range until stopped by conditions unfavorable for growth. This strategy insures food for the animals and genetic diversity for the plants. Other symbiotic relationships are like that of a bromeliad; its cup-shaped rosette stores water and acts as a drinking source and refuge for small amphibious animals or breeding pool for mosquito larvae-the waste from these animals combined with vegetative matter collect and supply minerals to the plant.

CLASSIFICATION

Background Information on Classifying Plants

Classification means forming groups. We classify everyday things like clothes: clothes for playing outside, school clothes, dress-up clothes and seasonal clothes. Foods can be classified by meats, vegetables, fruits and dairy.

Many things can be classified in more than one way. For instance another way to classify foods could be foods you like and foods you don't like, or foods that require cooking and those that do not, or by color and so forth.

Plants can also be classified in many ways such as woody or not woody; flowering plants are often classified by the color of their flowers. Sometimes it is useful to have several layers in a classification such as woody plants could be divided into trees and shrubs, or those that lose their leaves and those that do not. Non-woody plants may be divided as plants grown for food or those that are considered weeds.

The above classifications are simple and useful when deciding what plants to grow in your garden, but beyond that their value is rather limited. For example, is a woody vine a tree or shrub or should there be another group? To what classification does a plant that does not produce obvious flowers belong? Some people enjoy the taste of dandelion leaves…so is it a weed or a food plant?

Botanists have found the most useful way to classify plants is to consider different characteristics, making groups of those plants that possess like characteristics. This classification system works so well that it used worldwide.

History of Classification

In 1753 a Swedish scientist named Carolus Linnaeus thought of an orderly system for classifying the millions of plants and animals that live in this world. He grouped all organisms according to a two-part name; the first being the overall grouping, or **genus** and the second term is the organism's specific name, or **species.** After many years of further developing classification, Linnaeus's system is still used within a more in-depth form defining organisms.

Recent classifications of organisms go from general to very specific and each level of the organization is based on some biological characteristic of that organism. Here is an example:

Category	Name	Characteristics
Kingdom	Plantae	Organisms that usually have rigid cell walls and usually possess chlorophyll
Subkingdom	Embryophyta	Plants forming embryos
Phylum	Tracheophyta	Vascular plants
Subphylum	Pterophytina	Generally large, conspicuous leaves, complex vascular system
Class	Angiosperm	Flowering plants, seed enclosed in ovary
Subclass	Dicotyledoneae	Embryo with two seed leaves
Order	Sapindales	Soapberry order consisting of a number of trees and shrubs
Family	Aceraceae	Maple family
Genus	Aceraceae	Maples and box elder
Species	Acer rubrum	Red Maple

A **generic** name is a 'collective name' for a group of plants. It indicates a grouping of organisms that all share a suite of similar characters. The specific name, allows us to distinguish between different organisms within a genus.

Latin and Scientific Names

Plants can be classified in many ways using methods that range from scientific, such as structure, to very easy, such as color or size. Everything has to have a name so people easily recognize them. Debbie, Eric, and Becky are common human names, but their scientific name is *Homo sapiens*. Plants also have common names and scientific names. Some plants have more than one common name, depending on location in a state, region or country.

For example, there is a species of tree in Pan's Garden we refer to as Slash Pine. This same tree is also known as South Florida Slash Pine, Southern Pine, Yellow Pine, Slash Pine and Dade County Pine. This might lead to confusion. But by using the scientific name, *Pinus elliottii* variety *densa*, it can only mean that single species of tree. Every plant and animal has only one scientific name.

Scientific names frequently derive from the ancient Latin language. After the fall of the Roman Empire people stopped speaking Latin; it was no longer used. Thereafter Latin became known as a "dead language" and remains unchanged to this day. Scientists, doctors and lawyers all over the world use Latin to assign permanent names to plants and animals, and descriptive meanings or terminology to diseases and procedures. This allows people of different languages to effectively communicate on an academic and scientific level without confusion.

A scientific name consists of two parts, **genus** and **species**. Latin Names for plants are similar to our names- but are written backwards. The first name, the genus**,** is equal to our family name. The last name, the species, is a personal name. When we say *Acer rubrum* it is like saying Maple, Red or Jones, Mary. Plants within a group are more closely related to other members of their own group than to members of another group, just as you are more closely related to your parents and brothers and sisters than you are to families of your classmates.

Most plant genus or plant families are also in Latin and the botanical forms of these names simply end in "*-aceae*," pronounced "aaye-see eye." While names of plant families end in -*aceae*, names of animal families end in *–idae* (id—eye). The family name is usually formed by combining the designated ending with the root of the type genus. Thus, the name of the cat family is Felidae.

Latin names tend to be descriptive. They refer to what a plant looks like, its uses, where it's from or who discovered it. Plant genus (families) may be defined by one single trait or an entire range of characteristics. In this instance "Acer rubrum" belongs to the Aceraceae or Maple family; "Acer" is the Latin name for all Maples and "rubrum" means red for the red color of its flowers. You may also notice that all Latin names are always italicized to distinguish them from other text. Sand pine's scientific name is *Pinus clausa*. *Pinus* is the genus, *clausa* is the species. All of the trees listed below are of the genus called pine trees, but species vary according to individual characteristics, how the pines look.

Pinus (pine) *clausa* (meaning closed-cones appear closed)-Sand Pine
Pinus (pine) *palustris* (of swamps)-Longleaf Pine
Pinus (pine) *elliottii* (named after Stephen Elliot, who wrote about this tree)-Slash Pine
Pinus (pine) *echinata* (spiny)-Short-leaf Pine
Pinus (pine) *glabra* (smooth)-Spruce Pine
Pinus (pine) *serotina* (late-meaning cones open late or when burned)-Pond or Marsh Pine
Pinus (pine) *taeda* (Latin for torch)-Loblolly Pine

PRE-VISIT ACTIVITIES

THE WATER CYCLE DIAGRAM AND ACTIVITY

Objective:
Students will learn that all water on Earth is part of a continuous process driven by natural forces such as the sun and gravity. This activity will explain how water moves and changes from one form to another, as well as how our water supplies are continuously replenished.

Method:
Supply students with an incomplete diagram of the water cycle on which they label and color the different paths and processes of water movement. Either an overhead of the diagram can be used, or it can be drawn on a blackboard, and filled in as students fill in the blanks.

Materials:
Supply each student with:
a blank copy of the un-labeled water cycle diagram
crayons or markers
For teacher use:
an overhead projector
transparency of the water cycle diagram

Procedure:

1. Hand each student a copy of the unlabeled water cycle diagram.

2. Explain that all water on Earth is currently in one stage of the water cycle. Randomly choose a beginning point, stressing that there is no beginning or end to the water cycle. Be sure students understand that the sun is the driving force behind this process.

3. Choose a beginning point; for example, the ocean. Have students label the ocean. Then, have them color the arrow above the ocean blue (for water). Ask them what process the arrow represents, and have students label it: ***evaporation***. Explain that when the sun heats water it turns to water vapor.

4. Water that evaporates from plants and land is called ***transpiration;*** label that arrow and color. Students write water vapor above the arrow labeled Aevaporation@ in the empty space since it's invisible.

5. Next is the atmosphere. Label the cloud, and have students color the appropriate arrow and label it ***condensation***. As water vapor cools, it returns to its liquid state, forming clouds.
6. Have students label the arrow ***precipitation*** and color it blue. Precipitation occurs when clouds become saturated with water-consequently, rain, snow, sleet or ice is released.
7. Briefly explain the concept of topography and how water can do one of two things once it falls on land: flow above ground until it reaches a water body (***runoff***- label and color the appropriate arrow) or percolate down through soil due to gravity (***infiltration***- label and color that arrow).

8. Explain how runoff eventually evaporates, beginning the cycle again. It may reach the ocean before it evaporates, or it may not.

9. The water that soaked into the ground does not stay still. It moves as ***groundwater flow*** and eventually returns to the surface at a spring or water body, allowing the cycle to continue.

Assessment:

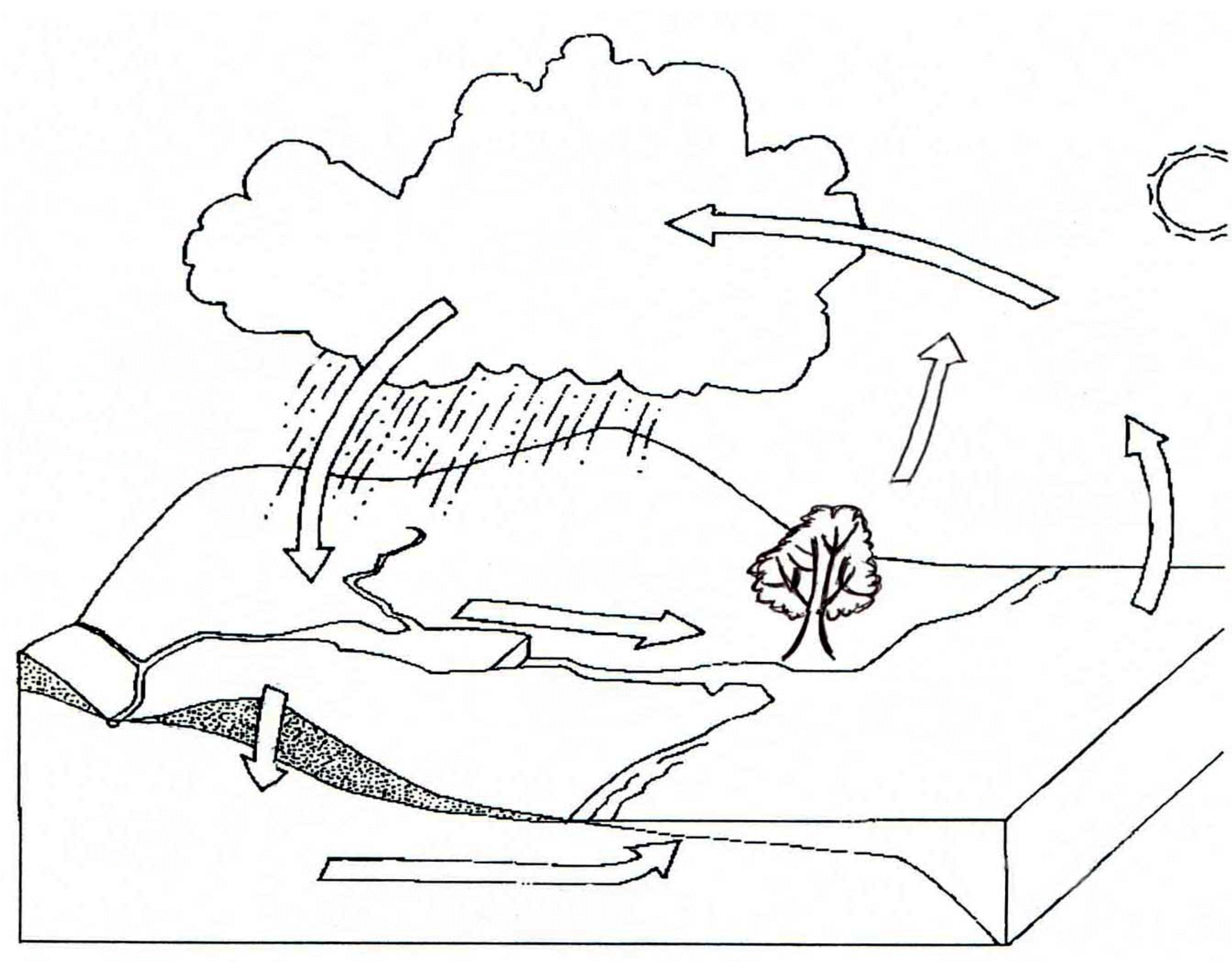
Ask students the following questions to assess their comprehension:

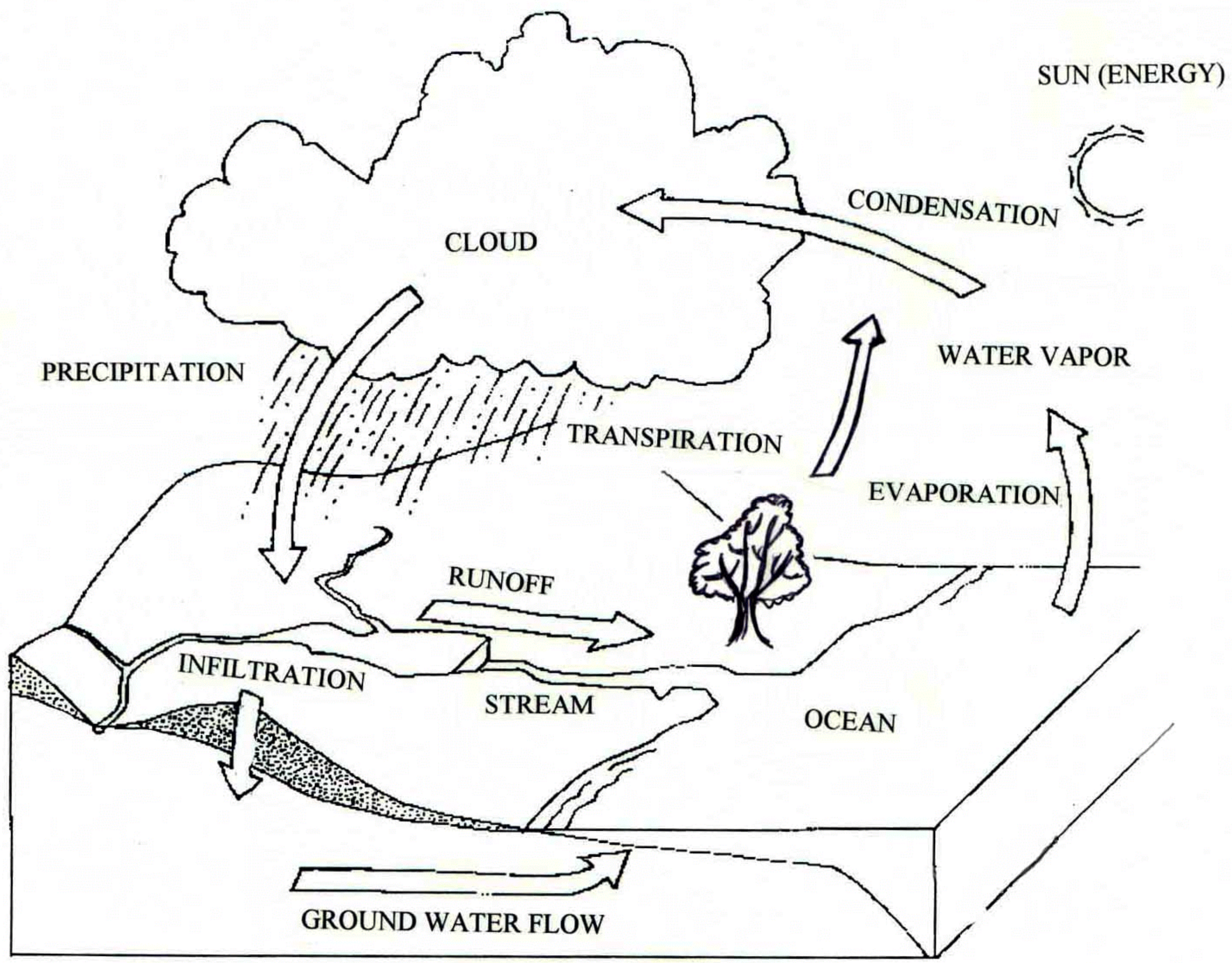
1. Is there a specific point where the water cycle begins and ends?

2. Is water in each stage of the cycle for the same amount of time, or does it vary? Why?

3. What are some structures or events that might change certain parts of the water cycle?

LABEL THE WATER CYCLE DIAGRAM





WATER CYCLE DIAGRAM

TAKING WATER OUT OF THE AIR

Putting water into the air is something you have done often. For example, when you wash your hair, the water doesn't stay on your hair; it evaporates. But have you ever taken water out of the air? Here is a way to change water vapor into liquid water.

Materials:

- empty metal can
- 3 ice cubes
- paper towel
- water
- spoon
- food coloring

Procedure:

1. Fill the can halfway with cold water
2. Put 3 drops of food coloring in the water and stir
3. Add ice cubes to the water
4. Wipe the outside of the can with the paper towel and make sure the can is dry
5. Wait a few minutes

Now answer these questions:

What color is the water inside the can? ____

What forms on the outside of the can? ____

What color are the drops? ____

Where did the drops come from? ____

How do you know? ____

Where did the water drops on the outside of the can come from?________________________

____

What is this process called? ____

HOW LONG DID IT TAKE?

If you leave a cup of water out long enough, the water will evaporate. What happens if you pour the same amount of water into a pie tin or a soda bottle? Does it take the same amount of time to evaporate? Does it take less time?

Materials:

- large paper cup
- soda bottle
- pie tin
- funnel
- measuring cup
- water

1. Put the paper cup, the pie tin and the soda bottle on a table where they can stay for a week. Make sure they are out of direct sunlight and away from drafts. Fill the measuring cup with water. The cup holds 250 milliliters. Pour the water into the paper cup.

2. Pour one measuring cup of water into a pie tin. Using the funnel, pour one measuring cup of water into the soda bottle.

3. The next day, carefully pour the water from the paper cup into the measuring cup. Record the water level on the graph provided. Pour the water back into the paper cup.

4. Do the same thing with the water in the soda bottle. Use the funnel when you pour the water back into the bottle.

5. Ask your teacher to help you pour the water from the pie tin into the measuring cup. Record your measurements on the graph.

6. Every day for one week, measure the water left in each container. Record your results.

HOW LONG DID IT TAKE? RESULTS

Water Level in Paper Cup

250					
200					
150					
100					
50					
0 ml					
	Day	Day	Day	Day	Day

Water Level in Pie Tin

250					
200					
150					
100					
50					
0 ml					
	Day	Day	Day	Day	Day

Water Level in Soda Bottle

250					
200					
150					
100					
50					
0 ml					
	Day	Day	Day	Day	Day

Answer these questions:

Did the water evaporate most quickly from the paper cup, pie tin, or soda bottle? **(circle one)**

How long did it take? ____________

From which of the three containers did the water evaporate most slowly? ______________

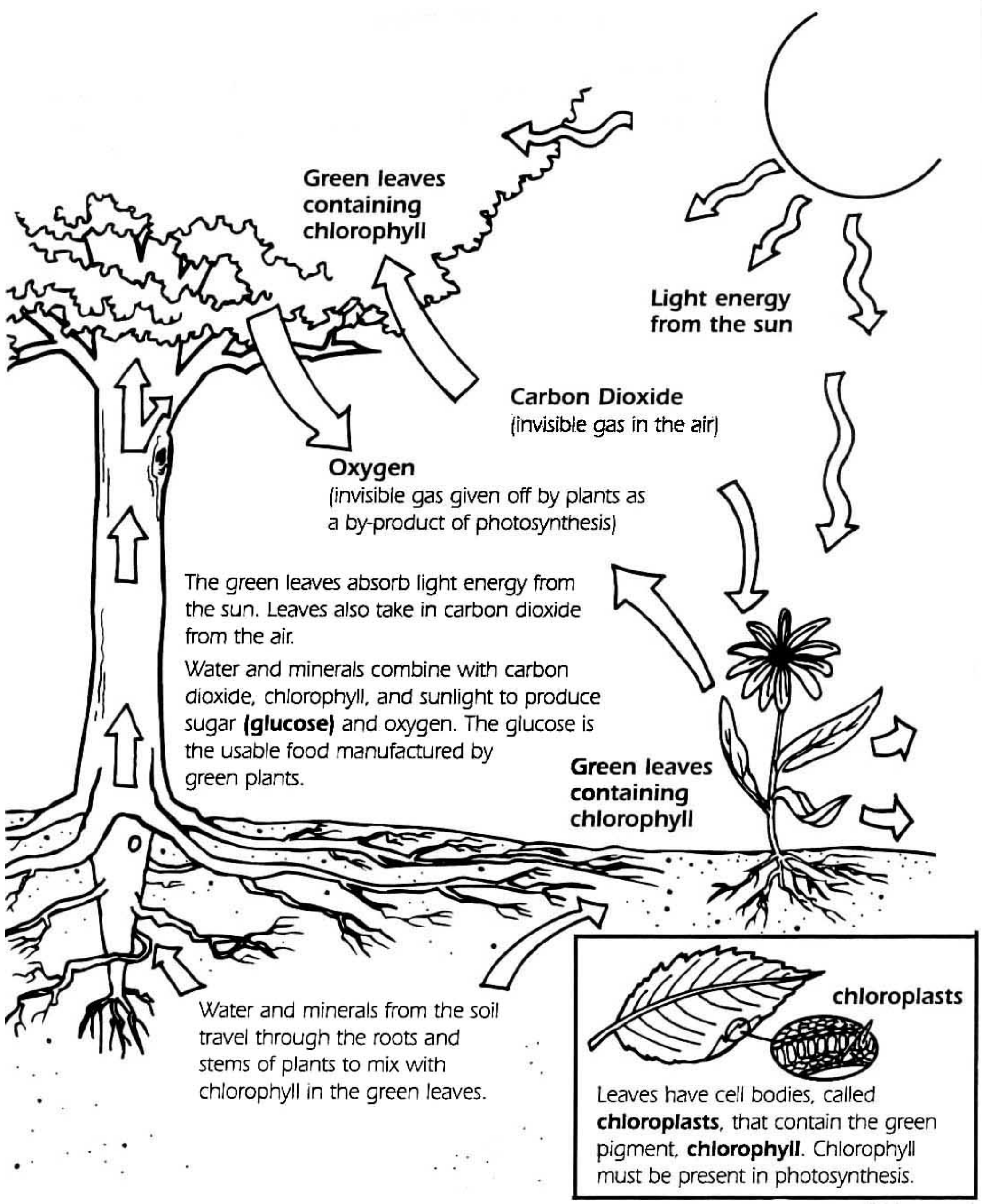
Explain your results.____

____

____

What Do Leaves Do?

Green leaves manufacture food for plants. This manufacturing process is called photosynthesis. "Phot" means light, "synthesis" means to combine, so the word means combine with light. Follow the process in the drawing below.



Coloring Flowers

Overview:

Colored dyes, when absorbed into a plant stem, will color the xylem for easy viewing

Materials:

white flowers (carnations or Queen Anne's Lace work best ---TIP: flowers "drink" up dyes better if they are dehydrated: refrigerate for 1-2 days, then remove and allow to sit out for 2 or more hours prior to the experiment)
water soluble food coloring (blue or red work best)
vase or container (to hold water and flower- one that does not tip over easily)
water
knife (to cut stem of the flower)

Background Information:

The leaves and petals of plants contain many small pores, called stoma. Water evaporates through these pores. As it does, the plant draws water through its stem, and ultimately from its roots from the surrounding soil (or the water in the vase). This process of water transport is called transpiration. It occurs in vascular bundles in the stem called xylem. Blue or red dye is very good for outlining the xylem in the plant as it draws the water and the dye up the stem. You can see it quite clearly if you cut the stem and look at it in cross-section.

Procedure:

1. Place water in vase or other container
2. Add food coloring to water
3. Carefully cut the stem of the flower with a sharp knife to make a new, clean edge on the stem
4. Place flower in the colored water and set aside for 6 to 12 hours
5. Observe. Depending on the length of the stem, the white petals should ultimately turn the color of the dye in the water
6. To further experiment, try cutting the stem of a white flower into 2 or 3 different sections and place each section in a different vase with different colored water in each.

Creating a Class Tree

Overview:

By acting out the parts of a tree students will learn tree anatomy and how a tree works like a factory.

Materials:

Paper
Pencil
Basket
Yarn or string
Large open area

Preparation:

Write the following parts of a tree on separate slips of paper and put them in a basket. There are enough parts for a group of 30 students; however this can be adjusted to the size of the class/group.

Heartwood-1
Sapwood-3
Taproot-1
Lateral root-2
Cambium-5
Phloem-6
Bark-8
Leaves-4

Cut yarn or string in to 6-foot lengths-these are the tree branches; then find a large space where students can "assemble" the tree.

Procedure:

Ask students…What makes up the center of the tree and gives it support? ***(heartwood)***
Student portraying heartwood stands in center of an open area and chants "I support".

Ask students… what tree part transports water to all parts of the tree? ***(sapwood)***
Students portraying sapwood join hands to form a small circle around the heartwood and chant "Gurgle, slurp, transport water" as they raise their hands up and down.
Ask students…where does the water in the sapwood come from? ***(it is absorbed by the roots)***

Student portraying the taproot sits down with his/her back against the sapwood.
Students portraying lateral roots lie down on the ground with feet toward the sapwood and arms and fingers spread out to represent root hairs, making sucking noises.

<u>Ask students</u>…where does the water in the sapwood travel to? ***(to the leaves)***
Student portraying heartwood holds the ends of yarn or string and gives the other ends to students portraying leaves

<u>Ask students</u>…what do leaves do all day? ***(make food through photosynthesis)***
Students portraying leaves flutter their hands and chant "We make food".

<u>Ask students</u>…what happens to the food leaves make using sunlight, air and water? ***(it is transported to the entire tree)***

<u>Ask students</u>…what part of the tree transports the food from the leaves to the entire tree? ***(phloem)***
Students portraying phloem join hands and form a large circle around the tree as they reach above their heads to grab food and squat down, opening their hands releasing food while chanting "Food to the tree".

<u>Ask students</u>…what important part of the tree have we left out? What layer produces new sapwood and phloem to keep the tree growing? ***(cambium)***
Students portraying cambium form a circle between sapwood and phloem while swaying from side to side chanting "New phloem, sapwood and cambium".

<u>Ask students</u>…what final part of the tree is missing-what protects the tree? ***(bark)***
Students portraying bark form a circle that faces out from the center of the tree locking arms, looking tough and marching in place while chanting "We are bark-keep out".

When the tree is completely assembled, have all students act out and chant their parts simultaneously. You may end the session by telling students their tree is old and falls over…let everyone CAREFULLY fall down.

Looking at Stems

Overview:

Why do plants have stems? Are all plants stems the same? Could plants get along without stems? Stems have several jobs to do. Each job is very important to the plant. One job is to separate the leaves and hold them out so each leaf receives sunlight and air. If all leaves of a plant were in a clump, they would not receive much light.

Stems are also used by the plant for storage. Cactus plants have thick stems that store water. The stems of plants such as celery, kohlrabi and white potatoes store food for the plant.

Stems have a third important job. They contain many small tubes (xylem) which transports food, water and minerals from one part of the plant to another.

This activity will demonstrate how this transportation system works.

Materials:

a glass or clear plastic cup
water colored with food coloring (red or blue are best)
one stalk of celery with leaves

Activity:

1. Put water into the glass and add food coloring

2. Cut the bottom of the celery stalk off squarely and place it in the glass of colored water

3. Wait a short period of time and check the celery

<u>Looking at Stems Observation Sheet</u>

1. What do you see? ____
   ____

2. Check the celery at different times. Measure how far the colored water has traveled. Record the times and distances below:

Time	Distance Traveled

3. How long before the colored water reaches the leaves? ______________________

4. Do you find color all through the celery stalk? ______________________

5. Where in the stalk do you find color? ______________________

6. What do the ‘strings’ in a celery stalk do? ______________________

7. Cut cross wise through the stalk. Draw what you see.

Tree Rings of History

Learn the different parts of a tree

Materials:

- white paper plates
- blank sticky labels
- colored pencils or crayons
- pens or pencils

Procedure:

1. Discuss the following tree parts with students:

    - outer bark (protects the tree)
    - inner bark/phloem (pipeline for food to circulate throughout the entire tree)
    - cambium (the growing part of the tree that produces new bark and wood)
    - xylem (pipeline for moving water up to the leaves)
    - heartwood (supports the tree on the inside)

2. Give each student a paper plate and ask them to use crayons to draw the above tree parts so it appears as a cross-section. Each part should be of a different color and labeled.

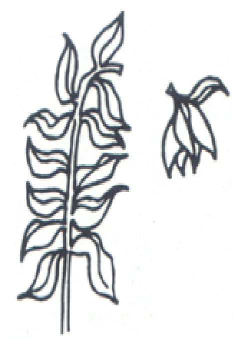
3. Ask students to draw rings on the tree to show its age.

4. Ask students to pretend their life is on the tree cross-section. Give them sticky labels (post-its) upon which they can write events in their own lives and attach them to different years on the tree cross-section.

Photosynthesis Experiment

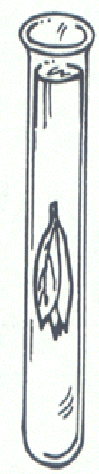
Question:

What are the products of photosynthesis?

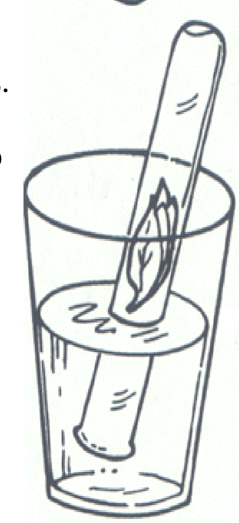


Background Information:

Photosynthesis is a food-making process that occurs in green plants. It is the most important process that goes on in plants. This reaction takes place in the green chloroplasts within the cells of plant leaves and stems. These chloroplasts contain chlorophyll, which absorbs sunlight. Photosynthesis means “putting together with light”.



Carbon dioxide and water in the green chlorophyll of the leaves reacts with sunlight to produce sugar (glucose), oxygen and water. Molecules of glucose are made up of atoms of carbon, hydrogen and oxygen. The carbon comes from the carbon dioxide gas in the air. The air enters a plant through holes the leaves called stomata. The oxygen and hydrogen come from the water in the soil that enters the plant’s roots. The light energy is trapped by a special chemical pigment called chlorophyll. Oxygen is the end product of photosynthesis and is returned to the air.



Most photosynthesis takes place in chloroplasts within the cells of plant leaves. These chloroplasts contain chlorophyll, which absorbs sunlight. All our food comes from this sunlight- converting activity of green plants. Light energy is converted to chemical energy and is stored in the food made by green plants. Light energy splits the water molecules (H2O) into molecules of hydrogen and oxygen. Hydrogen combines with carbon dioxide to make a simple sugar. The oxygen that is left over from the splitting of the water molecules escapes into the air through the stomata (openings in the leaves).

Materials:

Test tube
Plastic cup (transparent)
Water
Aquatic plant…elodea (also called anacharis) works very well
Hand lens
Sunny window ledge

Photosynthesis Experiment Observation Sheet

An important by-product of photosynthesis is the oxygen given off by plants. This experiment will show you that process.

Activity

1. Fill a glass about three-fourth full of water. Break off the growing tip of the plant and place it in the test tube, top first.

2. Fill the test tube with water. Put your thumb over the open end of the test tube. Carefully turn the test tube upside down and place it is the glass of water.

3. Place the glass in the sunlight. Using the hand lens, look at the plants tip.

Observations:

Are bubbles forming? _______________ That means oxygen is being given off.

Wait ten to fifteen minutes and look at the test tube again. What is happening?

____

____

Leave the test set up in the sun for a day. Then check it again. Has a bubble formed in the top of the test tube? ___________________

Conclusion:

The bubble that has formed contains oxygen.

What ingredients must be present in order for the green plant to give off oxygen?

____

____

____

Comparing Sun Leaves to Shade Leaves

Background:

Trees and shrubs need tremendous amounts of water on a daily basis. Even though it may not rain every day, a tree's roots spread though the ground constantly absorbing water. A mature oak tree needs 40-60 gallons of water every day. In order to survive trees and shrubs must have strategies to conserve water. One way in which trees help conserve water is to develop two kinds of leaves: sun leaves and shade leaves. Sun leaves are small with less surface area, which reduces the amount of exposure to the sun and wind. A shade leaf is large with greater surface area, which increases the amount of area exposed to the sun. Remember it is important for a tree or shrub to have its leaves exposed to the sun so that photosynthesis can take place…but not so much that it loses too much water.

Question (listed and to be filled out on activity sheet)**:**
Where would you expect to find a shade leaf; on the top or bottom of a tree/shrub crown?

Hypothesis: (listed and to be filled out on activity sheet)
Students should make their own before continuing

Equipment/Materials:
metric ruler, pencil, clipboard, Comparing Leaves Data Sheet
compass
optional: step stool or small ladder
optional: binoculars
pruning shears

Procedure: This activity is best done completely outdoors and in groups of three, with each member performing a specific task. One member should act as recorder, one member can obtain high sun leaves and the other member can obtain the inner shade leaves.

Visual Observation: A 20-30 foot tree can be used for making visual observations and comparisons between sun and shade leaves. Make sure the tree is out in the open and in direct contact with sunlight so the tree is more likely to produce both sun and shade leaves. Shade leaves will be easier to find on the tree's north side and on interior branches. Binoculars may allow students a closer view of taller crown leaves.

Note: If you can walk through a fairly dense forest, try to locate a young seedling that has just a few starter leaves and note that the leaves may be significantly larger than those found on a more mature tree of the same species. **<u>If there are no trees around the schoolyard or it's too difficult to deal with trees, shrubs are a great substitute for this activity</u>**

<u>To Gather Leaves</u>: To actually obtain leaves for observation and measurement locate a small tree or large shrub about 10-15 feet tall and have one member from <u>each group</u> gather three sun leaves and three shade leaves. Take care if using a step stool or ladder. Another method of collection is to use a pair of long-handled pruners…this should be done safely and taking care not to damage the tree by removing more leaves than necessary.

1. Divide class into groups of three.
2. Each group appoints a recorder; other members will equally share measuring tasks.
3. Locate a small tree in an open field.
4. Have one member of each group obtain three leaves from high on the south side of the tree/shrub.
5. Measure the length and width of all three leaves and request recorder write them in field notes under the heading of "top leaves" (be careful if using a ladder).
6. From the lowest part of the tree crown on the north side of the tree/shrub, have another member of the group obtain three leaves that appear to be growing underneath other branches.
7. Measure the length and width of all three leaves and request recorder to write them in field notes under the heading "bottom leaves".
8. As a class compare each group's measurements and note marked differences.

<u>Timeline</u>: This activity can be done in 30-45 minutes

Sample findings:

	TOP LEAVES		**BOTTOM LEAVES**	
Sample #	Length/centimeters	Width/centimeters	Length/centimeters	Width/centimeters
1	1.8	2.3	2.7	3.2
2	1.9	2.3	2.8	3.5
3	2.1	2.1	3	3.5
	Average length: 1.93	Average width: 2.23	Average length: 2.83	Average width: 3.4

<u>Objectives:</u> Students will be able to:

1. Differentiate between a shade leaf and a sun leaf on a tree/shrub.
2. Understand strategy of tree/shrub for reducing water loss
3. Measure & compare leaves from the lower part of a tree and the upper part of a tree/shrub

Sun Leaf /Shade Leaf Comparison Data Sheet

Page 1

Students' Names____
Tree # _________________________Tree Species_____________________
Tree Location____

Question:

Where would you expect to find a shade leaf; on the top or bottom of a tree/shrub crown?

Hypothesis

Your group's hypothesis is:____

	TOP LEAVES		**BOTTOM LEAVES**	
Sample #	Length/centimeters	Width/centimeters	Length/centimeters	Width/centimeters
	Average length:	Average width:	Average length:	Average width:

<u>Sun Leaf /Shade Leaf Comparison Data Sheet</u>

Page 2

<u>Answer the following questions:</u>

1. Which leaves were consistently larger; leaves from the top or bottom of the tree/shrub?

2. What would these leaves be called?

3. Which leaves were consistently smaller; leaves from the top or bottom of the tree/shrub?

4. What would these leaves be called?

5. Why does a tree/shrub have sun leaves that are small?

6. Why does a tree/shrub have shade leaves that are large?

7. What are the relationships between needing sunlight, needing to reduce water loss and the size of a leaf?

Sun versus Shade Leaves; Which is Toughest?

Question: Are sun leaves tougher than shade leaves and if so, why?

Note: The following are recommended for use in this activity:

Trees	Shrubs
Live Oak or any other type of oak	Cocoa Plum
Southern Magnolia	Pigeon Plum
Sea Grape	Yaupon or Dwarf Holly
Satin Leaf	Simpson's Stopper

Equipment/Materials

Tough-O-Meter (see assembly directions below)
Styrofoam cup
String
Sharp pencil
Paper clips
Paper punch
Water
Scale
Tree or Shrub identification book

A Tough-O-Meter is made as follows: make a "bucket" out of the Styrofoam cup by "drilling" two holes through the rim of the cup and passing a string through. On the outside of the hole at either end of the string, tie a paper clip- this creates a "handle". In the middle of the "bucket handle" tie another string about 25 centimeters (a foot) long. To the other end of the second string tie a paper clip. This is the official Tough-o-Meter.

Background:

Leaves make food for plants using sunlight in a process called photosynthesis. Even thin leaves have layers of cells full of green chloroplasts, the tiny food factories. A leaf in full sun can have lots of chloroplasts because there's plenty of sunlight to penetrate even the undermost layer of cells. However shade leaves do not have as many layers of chloroplasts, so leaves are not colored as dark.

Chloroplasts contain great amounts of water. More numerous chloroplasts equates to more water present in the leaves. Leaves exposed to direct sunlight would dry out more quickly than leaves in the shade, therefore sun leaves have various adaptations to protect from too much water loss. Therefore it would stand to reason that sun leaves are tougher than shade leaves. Students should have some basis for making a hypothesis before going out and observing or picking leaves.

Procedure:

Find tree or shrubs exposed to full sunlight for most of the day. For comparison, also find others that are in partial to full shade throughout the day. If your schoolyard backs up to a wood, trees or shrubs on the edge would be perfect: one side is in the full sun, the other is in the full shade. Otherwise, one could use inner and outside leaves from the same tree on school grounds. Have students pick leaves from a variety of plants, if possible.

- ✓ Have each student pick a sun leaf and a shade leaf (be sure students are not mistaking <u>new</u> leaves for shade leaves)
- ✓ Identify species of leaves and make a chart (see sample chart)
- ✓ Punch a hole in the exact center of each leaf.
- ✓ Pass the paper clip at the end of the Tough-O-Meter cord through the punched hole.
- ✓ Position the paper clip flat along the leaf surface, perpendicular to the midrib, so that the string drops from the middle and through the hole.
- ✓ Invite one student hold the leaf at either end with the Styrofoam cup dangling in the air by its string
- ✓ Request another student to slowly and carefully pour water directly into the Styrofoam cup (NOT on the leaf). This investigation should either be done outside or over a sink or tub.
- ✓ Record how much water can be poured into the cup before the leaf rips and the Tough-O-Meter falls to the ground by placing the cup on the scale to weigh it.

Sample Data

Species of Tree or Shrub	Sun Leaf?	Shade Leaf?	Water Weight
Live Oak	yes	no	4.5 ounces
Live Oak	no	yes	3.2 ounces
Cocoa Plum	yes	no	2.7 ounces
Cocoa Plum	no	yes	1.9 ounces

Sun versus Shade Leaves; Which is Toughest?

Hypothesis: Which species of tree or shrub has the toughest leaves? Why?

____

____

____

Species of Tree or Shrub	Sun Leaf?	Shade Leaf?	Water Weight

Conclusion: The species of tree or shrub with the toughest leaves is:

Invent a New Plant

Objective:

This activity reinforces the use of adaptations as means for survival after students observe live plant adaptations in a garden, park or schoolyard.

Materials:

If drawing-Paper, pencils, crayons, markers
If building- construction paper, string, toothpicks, cloth scraps, clay, foil, pipe cleaners...a variety of art/craft supplies

Background Information:

Most regions support a wide variety of plants. Each species of plant displays a unique combination of characteristics called adaptations that enable it to survive under specific environmental conditions. Examples of plant adaptations are: water-storing cells, sharp protective spines, fire-resistant bark, shallow root systems, waxy leaves, etc.

Procedure:

1. Discuss plant adaptations and have students generate a list on the board
2. Take students outside to observe these and other plant adaptations in the schoolyard, garden or park
3. Invite students to invent by building or drawing a model of a particular kind of plant with special adaptations for its environment. Encourage them to be creative.
4. To help "jump-start" some ideas make suggestions. "Invent a plant that..."

- Has weapons for self-defense
- Can store water
- Can live a the edge of a glacier
- That eats its enemies

5. Students should record their inventions by drawing a picture, label the parts that have special features and give the plant a name.

Follow-up Discussion:

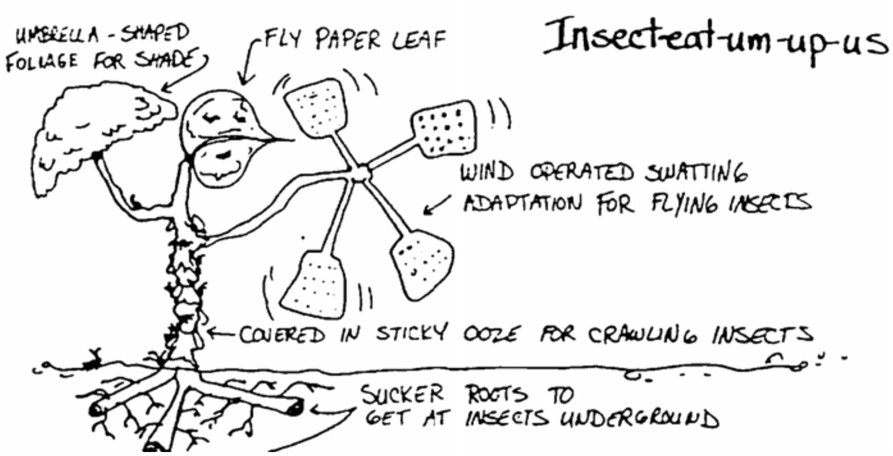
"What specifics help your plant adapt to its surroundings?"

Extensions:

1. Students write a detailed physical description of their plant, including its surroundings (environment), adaptations, etc
2. Students author articles for a scientific journal or newspaper that describe a newly discovered plant and its possible uses (medicinal, building materials, etc)

Question:

"What kind of plant can you design that has special adaptations that insure its survival in a specific environment? Draw a picture of the plant that clearly shows those adaptations and explain/label each one."



CLASSIFICATION ACTIVITIES

<u>What Is All This Latin About? Class Activity</u>:

Ask students to do research on Latin terminology (the internet is a great resource, or make a list of Latin terms for them to choose from). Ask them the below questions and record them on the board.

<u>What Is All This Latin About?</u>

What Latin name would you honor yourself with? ___________________________

Look up some Latin terminology and make up descriptive names for your friends or family.

<u>English Name</u>	**<u>Latin Name</u>**
_________________________	________________________
_________________________	________________________

Every plant has a common name in English and a scientific name in Latin. Many people are confused and have trouble pronouncing these strange words. <u>DON'T PANIC!!!</u>

Students will *<u>not</u>* be expected to know Latin names of plants during their visit, however, we urge you to familiarize them with the importance of using Latin names in science. There is a section in this manual that introduces students to the history and importance of classification using fun exercises. Brainstorming with the entire class may produce the best results for these activities

<u>Answers to the Latin Name Game</u> (game on following page)

1. California Redwood
2. Easter lily
3. Banana
4. Apple
5. Corn
6. Tomato
7. Lettuce
8. Red Oak
9. Dandelion
10. Orange

The Latin Name Game

Your Latin name is *Homo sapiens*, which means “man with sense”. A certain kind of violet is called *Viola canadensis*. Your cat’s name may be Fluffy to you, but her correct scientific name is *Felis domestica*. If your cat were a lion, its scientific name would be *Felis leo*.

Let’s look at your human name *Homo sapien*s. The first name in the classification system is called the genus and starts with a capital letter. The second name is the species and starts with a small letter. Below are the Latin names for some common plants. Each name is followed by a clue. See if you can identify them using their common names from the word bank.

Word Bank

Apple Orange Red Oak California Redwood Corn
Easter Lily Dandelion Banana Lettuce Tomato

LATIN NAME	CLUES	COMMON NAME
1. *Sequoia sempervirens*giant	California tree	______________________
2. *Castalia adorata*	common Easter flower	______________________
3. *Musa paradisaca*	yellow fruit that goes with cereal	______________________
4. *Malus pumila*	keeps the doctor away	______________________
5. *Zea mays rugosa*	you like to pop and eat this	______________________
6. *Lycopersicum esculentum*	red, juicy salad vegetable (actually a fruit)	______________________
7. *Lactuca sativa*	leafy salad vegetable	______________________
8. *Quercus rubra*	grown from acorns	______________________
9. *Taraxaum officialle*	common weed with yellow flower	______________________
10. *Citrus sinensis*	a favorite juice drink	______________________

Classifying Cards Activity

Classifying things can be very logical and be done in many different ways. Suppose you were given a deck of playing cards. How many ways could you separate them into groups? List your ideas.

Example: Separate the 52 cards into two colors: red and black

1. ___________________________________

2.____________________________________

3.____________________________________

4.____________________________________

5.____________________________________

Classify Leaves Activity

Cards are easy to classify. Now you will be given a set of leaves to classify. They will all be broad leaves like maple, elm or oak. They will not include needle-like leaves from pine trees. You do not have to identify them; just separate them into logical groups. Here are some leaf classification ideas that plant scientists use.

VEINS: How many main veins in the leaf?

EDGES: Leaves with notched, lobed, wavy or rounded edges

How many other ways can you find to group your set of leaves?

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

6. ______________________________

Classifying Objects Activity

Objective:

Students will learn the concept of classification and organization with a dichotomous key.

Materials:

Large variety of small objects (paperclips, rubber bands, dice, string, pennies, buttons, keys, etc.)

Procedure:

- Divide students into small groups (three or four per group)
- Distribute a set of objects to each group to classify
- Invite students to sort their objects into **two** primary classification groups based on some logical characteristic and that all members of the group can agree upon
- Ask students to write down a name for each of the two groups based on the characteristic used to split them
- Have students present their results to entire class
- Then ask students to further divide each primary classification and record each sub-classification on paper; do this several more times
- Call on each group to share with the class what characteristics they used to classify their objects. Different groups may have differing criteria, such as use, size, shape, color, composition, etc.

Follow-up questions to ask the class:

How could you use your record/chart/key?

How do you classify in everyday life?

Classifying Trees Activity

Objective:

Students will use dichotomous keys to identify common plants.

Materials:

pencils, paper, clipboards, dichotomous key generated in class beforehand

Procedure:

- ✓Introduce the idea that scientists have classified plants in the same way as the students classified their small objects. Scientists use already-developed keys to help discover the identity of plants. Using keys helps scientists from different regions or countries make sure they are talking about the same plant.

- ✓Tell the class that they are now botanists. What characteristics or clues would they use to classify plants? Generate a list as the students name characteristics, such as needles or broadleaf leaves, cones or flowers, leaves that are fuzzy or waxy, branches that are smooth or have thorns, etc.

- ✓Create a dichotomous key for the plant species in your schoolyard.

- ✓Mark the teaching area with flagging or establish boundaries.

- ✓Divide students into small groups.

- ✓Have each group find a plant and key it out. Rotate groups among different plants for practice using the key.

Follow-up Questions:

Why do people classify things in their world?

What are some problems with classifying?

Should we classify things? Why or why not?

Pan's Garden Plant Listings

Here are examples of how some of the plants in Pan's Garden are listed:

SCIENTIFIC NAME	COMMON NAME
ACERACEAE (Maple Family)	
Acer rubrum	Red (Swamp, Florida) Maple
ANNONACEAE (Custard Apple Family)	
Annona glabra	Pond Apple
APOCYNACEAE (Dogbane Family)	
Asclepias currassavica	Scarlet Milkweed
AQUIFOLIACEAE (Holly Family)	
Ilex cassine	Dahoon Holly
Ilex vomitoria	Yaupon Holly
ARECACEAE (Palm Family)	
Sabal palmetto	Sabal Palm
Serenoa repens	Saw Palmetto
ASTERACEAE (Aster Family)	
Helianthus debilis	Dune (Beach) Sunflower
BORAGINACEAE (Borage Family)	
Cordia sebestena	Geiger Tree
BRASSICACEAE (Mustard Family)	
Capparis cynophallophara	Jamaican Caper
BROMELIACEAE (Pineapple Family)	
Tillandsia usneoides	Spanish Moss
BURSERACEAE (Torchwood Family)	
Bursera simaruba	Gumbo Limbo
CACTACEAE (Cactus Family)	
Opuntia stricta var. dillenii	Prickly Pear Cactus
CANNACEAE (Canna Family)	
Canna flaccida	Canna
CHRYSOBALANACEAE (in a miscellaneous Flowering Plant Family)	
Chrysobalanus icaco	Red-tipped Coco Plum
COMBRETACEAE (Indian Almond Family)	
Conocarpus erectus	Silver Buttonwood
CUPRESSACEAE(Cypress or Conifer Family)	
Juniperus virginiana	Southern Red Cedar
CYCADACEAE (Cycad Family)	
Zamia pumila	Coontie
EQUISETACEAE (Horsetail Family)	
Equisettum hyemale	Scouring Rush
FAGACEAE (Beech Family)	
Quercus virginiana	Live Oak

IRIDACEAE (Iris Family)	
Iris hexagon	Blue Flag Iris
MAGNOLIACEAE (Magnolia Family)	
Magnolia grandiflora	Southern Magnolia
MYRSINACEAE (Myrsine Family)	
Ardisia escalloniodes	Marlberry
MYRTACEAE (Myrtle Family)	
Myrcianthes fragrans	Simpson's Stopper
PINACEAE (Pine Family)	
Pinus elliottii var. elliottii	Slash Pine
PIPERACEAE (Pepper Family)	
Peperomia obtusifolia	Peperomia
POLYGONACEAE (Buckwheat Family)	
Coccoloba uvifera	Sea Grape
POLYPODIACEAE (Polypody Fern Family)	
Acrostichum danaeifolium	Leather-Leaf Fern
PONTEDERIACEAE (Water Hyacinth Family)	
Pontederai cordata	Pickeral Weed
RUBIACEAE (Coffee Family)	
Hamelia patens	Firebush
Psychotria nervosa	Wild Coffee
Randia aculeata	White Indigo Berry
Chiococca alba	Snowberry
SAPOTACEAE (Sapodilla Family)	
Chrysophyllum oliviforme	Satin Leaf
TAXODIACEAE (Cypress Family)\)	
Taxodium distichum	Bald Cypress
VERBENACEAE (Vervain Family)	
Callicarpa americana	American Beautyberry
Stachytarpheta jamaicansis	Blue Porterweed

POST VISIT ACTIVITIES

How Much Water Does a Stem Lose in a Day?

Background Information:
Plants wilt if they do not have enough water. Water moves up through plants by being absorbed by the roots, through the stems and into the leaves. This process happens in all plants; from the shortest blade of grass to the tallest of trees. This water makes the cells stiff and the stem able to stay upright. How much water does a stem lose in a day?

Materials:
- ✓ plant with leaves intact (sunflower, geranium, coleus, celery)
- ✓ 100-ml graduated cylinder
- ✓ medicine dropper
- ✓ modeling clay
- ✓ balance
- ✓ sharp knife or single-edged razor blade
- ✓ small beaker
- ✓ water
- ✓ transparent tape

Procedure:
1. Fill graduated cylinder with about 50-ml of water

2. Carefully and cleanly cut a healthy stem (several leaves and a flower many be included) from the plant and quickly immerse the cut end into the graduated cylinder

3. Use the medicine dropper to add water to the graduated cylinder; add enough water to reach exactly the 100-ml mark

4. Use the transparent tape to seal the top of the cylinder around the stem; make sure the stem is in the middle of the cylinder; be careful not to injure the stem

5. Place a thin layer of modeling clay on top of the transparent tape; carefully mold the clay around the stem, plugging any holes, to form an airtight seal that will prevent any water from evaporating

6. Weigh the setup on the balance; record the weight on the data table

7. Leave the setup undisturbed in a sunny location for 24 hours

8. Weigh the set up after 24 hours; record the weight on the data table

9. Check the water level on the graduated cylinder; record the water level on the data table

How Much Water Does a Stem Lose in a Day?
Data Collection and Analysis Sheet

Initial weight of the cylinder set-up ____________________ (g)
Weight of the cylinder set-up 24 hours later ____________________ (g)
Initial water level ____________________ (ml)
Water level 24 hours later ____________________ (ml)
Apparent water lost ____________________ (ml)

(The loss of weight in grams of the cylinder-stem setup is equal to the amount of transpiration in ml because the density of water is 1 g per ml)

Weight of water lost in 24 hours ____________________ (g)

Making the Connection

1. How can you prevent celery from wilting in the refrigerator?

____

____

2. Predict the amount of transpiration that would occur in 24 hours if a stem had twice as many leaves as the one used in this experiment. Explain.

____

____

Follow-up Activities

1. Repeat the experiment using a plant with a stem and leaves as a control and a plant with a stem but no leaves as the experimental plant. Make sure that both stems come from the same plant and are of the same thickness. Why should you use a control?

   ____

   ____

2. Repeat the transpiration experiment. This time use the stem of a different plant. Compare the amount of water this stem loses with the amount the stem from the first plant lost.

3. Design a series of activities to determine the effect on transpiration of various environmental factors, such as temperature, light, wind.

What Part of the Leaf Transpires?

Materials:

cobalt chloride paper
paper clip
potted plant with large leaf (geranium works well)

Background Information:

Cobalt chloride paper indicates wetness and is blue when dry and turns pink when it becomes wet

Procedure:

1. Carefully place a small square of cobalt chloride paper over the top of one leaf and slide the paper clip over it to keep it attached to the leaf

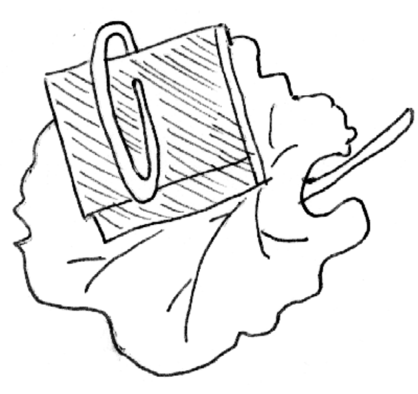
2. Repeat the process; but place the cobalt chloride paper over the bottom of another leaf

3. Observe the paper over a short period of time

Conclusion:

Which piece of paper turned pink fastest?

Leaves transpire through tiny openings called stomates. Which part of the leaf has the most amount of stomates, the top or the bottom?



Collecting Plant Transpiration

Materials:

clear plastic bag
tape
small potted plant

Procedure:

1. Carefully place clear plastic bag over entire potted plant

2. Seal the bag with tape

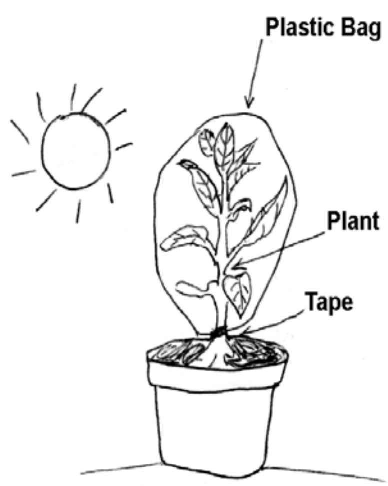
3. Place the bagged plant in direct sunlight

4. Wait 10 to 30 minutes

Conclusion:

Have students describe what they see inside the bag

Where did this come from?



Check Out Plant Transpiration!

Questions:
Do green plants give off water from their leaves?
Can I conduct an experiment to see evidence of transpiration?

Materials:
1 healthy geranium plant
2 glasses that are the same kind and size
water
petroleum jelly
shirt cardboard box
scissors
sharpened pencil
ruler
window area

Procedure:
1. Use the ruler and pencil to measure and mark a rectangle from the cardboard shirt box that is four by six inches. Cut out the rectangle

2. With the sharp tip of the pencil, poke a little hole in the middle of the cardboard rectangle

3. Break off a healthy leaf and stem from the geranium plant

4. The leaf stem is called a petiole. Put the petiole of the leaf in the hole in the cardboard rectangle

5. Fill one of the glasses three-quarters full with water

6. Cut the cardboard on top of the glass with the water in it so the stem is down into the water and the leaf is on top of the cardboard- not in the water

7. Take a little bit of petroleum jelly and put it around the hole. This is to keep evaporated water from the glass seeping up into the top glass

8. Put the second glass upside down over the leaf, resting against the other glass mouth

9. Put the glasses on a table top near a window where there is a good source of sunlight.

10. Let 3 or 4 hours pass and observe what is happening.

Observations

- Do you see little drops of water inside of the top glass?
- Where is the water coming from? (If you plugged the hole around the stem, the water from the bottom glass should not be getting into the top glass)
- What is happening is called transpiration. This is the process by which the leaves on green plants give off water that they do not need, after drawing from the ground, up into the roots, throughout the stem and into the leaves. Look at the bottom of the geranium's leaves. You will see little dots which are called stomates. The stomates give off the excess water the plant does not need.

Conclusion:

Now answer your original questions:

1. Do green plants give off water from their leaves?
   ____
   ____
   ____

2. Can I conduct an experiment to see evidence of transpiration?
   ____
   ____
   ____

How Much Water Does a Tree Transpire in One Day?

Background:

Plants absorb water primarily through their roots. They evaporate water through openings in their leaves in a process called transpiration. Plants transpire vast quantities of water - only one percent of all water a plant absorbs is used in photosynthesis; the rest is lost through transpiration.

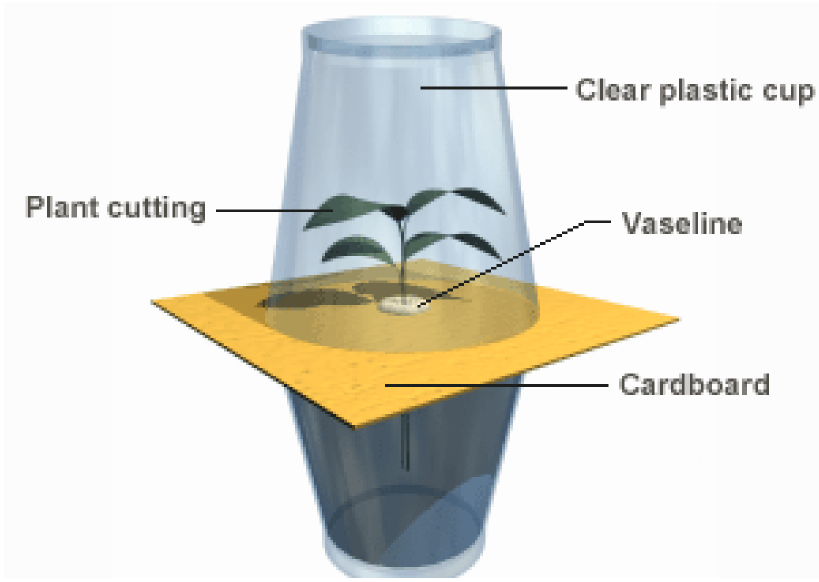
In this activity, you will make a small terrarium that will allow you to observe and measure the water given off through transpiration.

Materials (per team)

- Transparent plastic cup to be used as the top of the terrarium
- Deli container or additional plastic cup for the bottom of the terrarium
- Square piece of cardboard between the two cups
- Small cutting of a house plant
- Petroleum jelly
- Lamp or source of sunlight
- Water
- Scissors

Procedure

1. Using the scissors, make a small hole (just big enough for the plant stem) in the center of the piece of cardboard.
2. Carefully pull the plant stem through the hole and seal around the hole with petroleum jelly.
3. Fill the bottom cup with water and place the stem with the cardboard collar into the cup. Cover with the clear plastic cup as shown.
4. Put the small terrarium in the sun or under a lamp.
5. In fifteen minutes, you should begin to see droplets of water on the sides of the clear inverted cup. More moisture will accumulate with time.
6. If possible, leave the terrarium cups set up in the classroom for several days and measure the total amount of water transpired.
7. Calculate the water loss per square centimeter of leaf area (you can estimate the surface area of a leaf by tracing it onto a piece of graph paper that you have marked into square centimeters and then counting the number of squares the leaf covers).



Observations and Questions

1. Where does the moisture that accumulates along the sides of the top cup come from?
____
____

2. How do you know the water is coming from the plant and not just evaporating from the water in the cup?
____
____

3. Imagine that your small plant was a large tree with a thousand times as many leaves. Assume that this tree transpires just like your plant. Calculate how much water it would transpire over the time you ran your experiment.
____
____

4. Now imagine a small forest with 1000 such trees. How much water would it transpire?
____
____

5. Do you think that the amount of water coming from the forest would affect local climate in any way? If so, how?

Vocabulary

acicular – needle-shaped
adhesion - the attraction and attaching of water (or some other substance) to something else
adaptation – a characteristic, a behavior or any inherited trait that makes a species able to survive and reproduce in a particular environment; a change in the structure and form of a plant to fit different conditions
air space - gaps or spaces between cells within the spongy mesophyll that are filled with gas used by plants **aesthetic** - to add beauty
anatomy - the bodily structures (parts) of a plant or animal
angiosperm - flowering plants that have a vascular system, have covered seeds and are divided into two groups; monocots and dicots
aquifer - a layer of underground rock or sand that stores water
avoidance strategy – a survival method in plants to keep something dangerous away
axil - the angle between the upper side of the stem and a leaf, branch, or petiole.
axillary bud - a bud that develops in the axil
blade - a flat narrow leaf
cambium - the growth tissue of plant stems that produces new xylem and phloem cells
capillary action – the process by which water rises in tubes because of its attraction of water molecules to each other and to molecules on the sides of the tubes
carbon dioxide – a gas in the air that is changed into food for the plant through photosynthesis
cell - the basic unit of structure and function in all living things
chlorophyll – a green pigment or coloring located in chloroplasts that uses energy from sunlight to turn water and carbon dioxide into sugar and oxygen in a process is called photosynthesis chloroplast – a cell in which photosynthesis occurs
ciliate – hair-like
classification – the systematic grouping of different types of organisms by their shared characteristics
cohesion - the attraction and attaching of water (or some other substance) to itself
compacted - pressed or packed tightly together
compound leaf - a leaf that is divided into many separate parts leaflets along a midrib
condensation (condense) - the process by which a gas changes into a liquid
conduit - a tube or pipe for transporting liquid
conifer - nonflowering plants, usually trees with small, evergreen, needle-shaped leaves that reproduce by forming cones
cordate – heart-shaped
cork - the protective outer tissue of bark
cork cambium - a layer of cells in bark
crenate - having rounded teeth.
cuticle – a waxy covering of most plants that prevents too much water loss by slowing down the passage of water vapor through the epidermis
cutin - a protective waxy coating that forms a cuticle layer on leaves
cycle - a series of events or actions that repeat themselves regularly; a physical and /or chemical process in which one material continually changes locations and /or forms

deciduous - plants that shed leaves seasonally
decompose - the process of breaking down dead plant material
deforestation - to clear land of forests, trees
denticles – teeth-like
dermal tissue - cells that form the skin of a plant; the outer covering of all parts of the roots, stems, and leaves
desalination - the process of removing salt from sea water
determinate – limited to a certain growth pattern or size
diameter - a straight line passing from side to side through the center of a circle
dicot (dicotyledon) – an angiosperm having two cotyledons and usually flower parts occurring in multiples of four or five
dormant - a period of inactivity and resting in plants
elongate - make longer
elliptic – shaped like an oval that can be divided into four identical quarters
entire - having a smooth edge with neither teeth nor lobes.
epidermis - the protective outer layer of cells on the surface of a leaf; the outside covering that protects the plant's tissues
evapotranspiration - (ET) evaporation + transpiration; the total loss of water to the atmosphere by evaporation from land and water surface and by transpiration from plants
evaporation (evaporate) - the process by which a liquid changes into a gas
excrete - to expel; get rid of
expel – to force out
fissure - a splitting or separation of bark
flower - the reproductive unit of angiosperms
flower stalk - the structure that supports the flower.
foliage - the leaves of a plant or tree
gas – a form of matter that does not have a definite shape or definite volume and is invisible
generic – of a whole genus or group
genus – a group of animals or plants with common characteristics usually containing several species
germinate – the beginning growth of a seed
gravity - the pull or force that attracts bodies toward the center of the Earth
ground tissue - includes all plant tissue that is not dermal or vascular, has many functions including photosynthesis, food storage, and supports the plant
guard cells - one of a pair of sausage-shaped cells that surround a stoma (a pore in a leaf); guard cells change shape (as light and humidity change), causing the stoma to open and close
hastate – arrow-shaped
heartwood - the central, dark-colored part of secondary xylem in a tree trunk
herbaceous s- soft, green and containing little woody tissue
herbivore - an animal that eats plants
humidity – the amount of moisture in the air
hydrologic - composed or made up of water
impermeable – not able to allow water through
impurities - a foreign or unwanted substance present within another substance

infiltration (infiltrate) - the process by which rain soaks in to the ground, through the soil and underlying rock layers and eventually becomes groundwater or resurfaces in springs in a body of water
integral - necessary to complete a whole
lamina - the blade of a leaf
lanceolate –shaped like a pointed two-edged knife
latent heat - heat stored in water vapor molecules
lateral buds - a small bulging part on the sides of a stem or branch containing an undeveloped shoot, leaf, or flower
lateral roots - roots that spread or branch out to the sides
leaf - part of a plant that grows from a node in the stem; most leaves are flat and contain chloroplasts; their main function is to convert energy from sunlight into chemical energy (food) through photosynthesis
lobate (lobed) - divided into rounded or pointed sections and the incisions (cuts) go less than halfway to the midrib.
mesophyll - the chlorophyll-containing leaf tissue located between the upper and lower epidermis. These cells convert sunlight into usable chemical energy for the plant.
midrib - the central rib of a leaf - it is usually continuous with the petiole
modified stems - plant stems that perform special functions
monocot (monocotyledon) – an angiosperm having one cotyledon and usually flower parts occurring in multiples of three
multicellular - having many cells
natural selection – the action of the environment on organisms to limit or control its survival and reproduction
node – a joint in a plant stem where a leaf is attached
non-determinate – not limited to a certain growth pattern or size
ovate – shaped like an egg or oval
palisade parenchyma (palisade mesophyll, palisade layer) - a layer of elongated cells located under the upper epidermis that contain most of the leaf's chlorophyll, converting sunlight into usable chemical energy for the plant; where most of the photosynthesis takes place
palmate – leaflets arranged from one point at the tip of the petiole; like fingers of a hand
parallel – continuously at the same distance from each other
parenchyma-layers of cells that contain chloroplasts located inside the mesophyll
penetrate-to enter or make a way into or through
petiole - a leaf stalk; it attaches the leaf to the plant
phloem- tiny, hollow tubes that move food made in the leaves in all directions throughout the plant
photosynthesis - the process in which plants convert sunlight, water, and carbon dioxide into food energy (sugars and starches), oxygen and water; chlorophyll or closely-related pigments (substances that color the plant) are essential to the photosynthetic process
phylum- a major division of the animal or plant kingdom, containing species having the same general characteristics
pigment- a natural material that gives a plant or animal its color
pinnate - a compound leaf that is made up of many small leaflets arranged in pairs on both sides of a long central midrib; pinnate means feather-like

pith – parenchyma tissue at the center of a stem
precipitation(precipitate)- any form of water that falls from clouds; rain, snow, sleet, hail, ice
pristine - in its original and unspoiled condition; like new
producer - an organism that captures energy from sunlight and transforms it into chemical energy that is stored in energy-rich carbon compounds; producers are a source of food for other organisms
rival - a plant that competes with another for food, water, space, etc.
root - a plant structure that obtains food and water from the soil, stores energy, and provides support for the plant; most roots grow underground
rootlets - very small roots
root hairs - fine, hair-like roots
root pressure – the pressure inside a root as it fills with water
sap – a liquid containing water and minerals or food that moves through a plant's vascular system
sapwood - the soft outer layers of recently formed wood between the heartwood and the bark
saturate - to soak or make thoroughly wet
serrate (or toothed) - having small, pointy teeth that point toward the tip of the leaf
sessile – a leaf in which the blade is directly attached to the stem
shade leaf - a leaf that is entirely or partially shaded by other leaves on the tree; usually on the lower portion of the crown
simple leaf – leaf blades that develop as single units
species – a group of closely related living things
springwood - the lighter-colored, less dense, faster growing wood in a tree ring formed in spring
spongy parenchyma (spongy mesophyll) - the layer below the palisade mesophyll that has irregularly-shaped, loosely arranged cells with many air spaces between the cells and contain some chlorophyll; spongy mesophyll cells communicate with the guard cells (stomata), causing them to open or close
strategies – methods for survival in plants
stem - the main support of the plant
stipule - the small, paired appendages (sometimes leaf-life) that are found at the base of the petiole of leaves of many flowering plants
stomata (stoma-singular) - pores or openings in a plant's leaves where water vapor and other gases leave and enter the plant; stomata are formed by two guard cells that regulate the opening and closing of the pore; usually more numerous on the bottom of a leaf than on the top
submerged - below the surface of water or land
summerwood – xylem laid down by the vascular cambium in late summer; the darker, slower growing, more dense wood in a tree ring; late wood
sun leaf - a leaf on a tree that is almost always in direct contact with sunlight; usually on the upper crown
surface runoff - precipitation that runs off the land and flows into streams, rivers and other bodies of water
suspended - to keep from falling or sinking in the air
sustain - to keep alive
system - a group of tissues that work together to perform a specific function
taproot- a large, strong root with very small side roots

terminal bud - a small bulging part at the tip of a stem or branch containing an undeveloped shoot, leaf, or flower
temperate - a climate having mild temperatures without extremes of hot or cold
tissue - a group of similar cells that have a common function
transparent - allows light to pass through so that objects behind can be seen clearly
transpiration (transpire) - the loss of water vapor mostly through the stomata of the plants' leaves
transpirational pull - the force exerted by transpiration from leaves that draws water up through a plant
turgor - the pressure developed inside a plant cell as it becomes filled with water; the amount of water also controls the firmness or rigidity of a plant
undulate – leaves that have a wavy appearance
vapor - a gas **vascular tissue -** tissue that contain a system of tubes that transport sap
vascular plant – term that describes a plant with xylem and phloem
vascular system – long tube-like tissues in plants through which water and nutrients move from one part of the plant to another
vein - (vascular bundle) – narrow tubes that transport sap (water and minerals) throughout the plant; xylem and phloem tubes
water cycle – continuous cycling of water between Earth and atmosphere
water vapor - water in its gaseous state
wilt - to become limp; loss or decrease in turgor
woody - a plant that has a tough, fibrous stem and branches enclosed by bark
xylem – vascular tubes that transport water and minerals(sap) upward from roots throughout a plant
xylem sap - consists primarily of water, along with hormones, minerals, and nutrients. Phloem sap consists primarily of water, in addition to sugar, hormones, and mineral elements dissolved within it

Resources

Books

(AIMS)The Budding Botanist
Discover a Watershed: The Everglades (Southwest Florida Water Management District)
Florida's Water Resource Activity Pack (Southwest Florida Water Management District)
Florida Waters (Southwest Florida Water Management District)
Florida Audubon Society
Project WET
Project Learning Tree

Websites

www.kidsgardening.com
www.icogitate.com
www.realtrees4kids.org
www.na.fs.fed.us
www.ncforestry.org
www.botanical-online.org
www.infovisual.info
www.bio-medicine.org
http://www.madsci.org
http://www.eecs.umich.edu
http://mbgnet.mobot.org
http://www.sirinet.net
www.ga.water.usgs.gov

The **Let's See What Transpires**" curriculum and teacher manual were developed using the **Next Generation Florida Sunshine State Standards.**

Science		**Social Studies**	**Language Arts**		**Mathematics**
SC.3.N.1.1	SC.5.L.17.1	SS.4.A.6.1	LA.3.1..6.1	LA.6.5.2.1	MA.3A.4.1
SC.3.N.1.2	SC.6.N.1.1	SS.4.A.8.4	LA.3.1.6.2	LA.6.5.2.2	MA.3.S.7.1
SC.3.N.1.3	SC.6.N.1.3	SS.4.G.1.1	LA.3.1.6.3	LA.6.6.1.1	MA.5.G.5.3
SC.3N.1.4	SC.6.N.1.4	SS.4.G.1.3	LA/3.1.6.5	LA.7.1.6.1	MA.5.S.7.2
SC.3.N.1.5	SC.6.N.1.5	SS.4.G.2.1	LA.3.1.6.7	LA.7.1.6.2	MA.6.S.6.1
SC.3.N.1.6	SC.6.N.1.2	SS.4.G.2.2	LA.3.1.6.10	LA.7.1.6.3	MA.6.S.6.2
SC.3.N.1.7	SC.6.N.3.1	SS.5.G.2.1	LA.3.2.2.1	LA.7.1.6.5	MA.8.A.1.1
SC.3.N.3.1	SC.6.E.7.2	SS.5.G.3.1	LA.3.2.2.2	LA.7.4.2.1	MA.8.A.1.3
SC.3.N.3.2	SC.6.E.7.3	SS.5.G.4.1	LA.3.2.2.3	LA.7.4.2.2	MA.8.A.1.4
SC.3.N.3.3	SC.6.E.7.9	SS.5.G.4.2	LA.3.5.2.1	LA.7.4.2.3	MA.8.A.1.5
SC.3.E.6.1	SC.6.L.14.1	SS.6.G.2.1	LA.3.5.2.2	LA.7.6.1.1	MA.8.A.1.6
SC.3.P.8.1	SC.6.L.14.3	SS.6.G.3.1	LA.3.6.1.1	LA.8.1.6.1	MA.8.S.3.1
SC.3.P.8.2	SC.6.L.15.1	SS.6.G.5.2	LA.3.6.2.1	LA.8.1.6.2	MA.8.S.3.2
SC.3.P.9.1	SC.7.N.1.1	SS.6.G.5.3	LA.3.6.2.2	LA.8.1.6.3	
SC.3.P.10.1	SC.7.N.1.2	SS.7.G.5.1	LA.3.6.2.3	LA.8.6.6.5	
SC.3.P.10.2	SC.7.N.1.3	SS.8.G.5.1	LA.4.1.6.1	LA.8.1.6.11	
SC.3.L.14.1	SC.7.N.1.4	SS.8.G.5.2	LA.4.1.6.2	LA.8.4.2.1	
SC.3.L.14.2	SC.7.N.2.1		LA.4.1.6.3	LA.8.4.2.2	
SC.3.L.15.1	SC.7.E.6.6		LA.4.1.6.5	LA.8.4.2.3	
SC.3.L.15.2	SC.7.P.11.2		LA.4.1.6.6	LA.8.5.2.1	
SC.3.L.17.2	SC.7.L.15.2		LA.4.1.7.1	LA.8.5.2.2	
SC.4.N.1.1	SC.7.L.15.3		LA.4.2.2.1	LA.8.6.1.1	
SC.4.N.1.2	SC.7.L.17.3		LA.4.2.2.2	LA.8.6.1.2	
SC.4.N.1.3	SC.8.N.1.1		LA.4.4.2.2	LA.8.6.1.3	
SC.4.N.1.4	SC.8.N.1.2		LA.4.5.2.1	LA.8.6.2.2	
SC.4.N.1.5	SC.8.N.1.3		LA.4.5.2.2	LA.8.6.2.3	
SC.4.N.1.6	SC.8.N.1.4		LA.4.5.2.3		
SC.4.N.1.7	SC.8.N.1.6		LA.4.5.2.4		
SC.4.N.1.8	SC.8.N.3.2		LA.4.5.2.5		
SC.4.E.6.6	SC.8.N.4.1		LA.4.6.1.1		
SC.4.P.8.2	SC.8.N.4.2		LA.4.6.2.2		
SC.4.P.10.1	SC.8.L.18.1		LA.4.6.2.3		
SC.4.P.10.4			LA.5.1.6.16		
SC.4.L.16.2			LA.5.1.6.2		
SC.4.L.16.4			LA.5.1.6.3		
SC.4.L.17.1			LA.5.1.6.5		
SC.4.L.17.4			LA.5.1.6.6		
SC.5.N.1.1			LA.5.1.6.7		
SC.5.N.1.2			LA.5.1.6.11		
SC.5.N.1.3			LA.5.1.7.1		
SC.5.N.1.4			LA.5.2.2.1		
SC.5.N.1.5			LA.5.2.2.2		
SC.5.N.1.6			LA.5.2.2.3		
SC.5.N.2.1			LA.5.4.2.2		
SC.5.N.2.2			LA.5.5.2.1		
SC.5.E.7.1			LA.5.5.2.2		
SC.5.E.7.2			LA.5.6.1.1		
SC.5.E.7.5			LA.5.6.2.1		
SC.5.E.7.6			LA.5.6.2.2		
SC.5.P.8.1			LA.5.6.2.3		
SC.5.P.8.4			LA.6.1.6.1		
SC.5.P.9.1			LA.6.1.6.2		
SC.5.P.10.1			LA.6.1.6.3		
SC.5.P.10.2			LA.6.1.6.5		
SC.5.P.13.1			LA.6.2.2.3		
SC.5.L.14.2			LA.6.4.2.1		
SC.5.L.15.1			LA.6.4.2.2		

PROFESSIONAL DEVELOPMENT

PRESERVATION FOUNDATION
OF PALM BEACH

<u>Staff Development for "Lets' See What Transpires"</u>

The "**Let's See What Transpires"** program in Pan's Garden has been acknowledged by the Palm Beach County School District as a field trip experience that allows teachers an opportunity to earn in-service points for participation. The Preservation Foundation of Palm Beach strives to provide exemplary programs and is honored to be recognized as a provider of quality staff development in-service credit.

To qualify for in-service points each teacher must complete the ***"How Much Water Does a Stem Lose in a Day?"*** activity, which was developed as a Staff Development opportunity. If you wish to earn Continuing Education Units, please contact the Education Department at the Preservation Foundation of Palm Beach for information and to obtain the necessary forms.