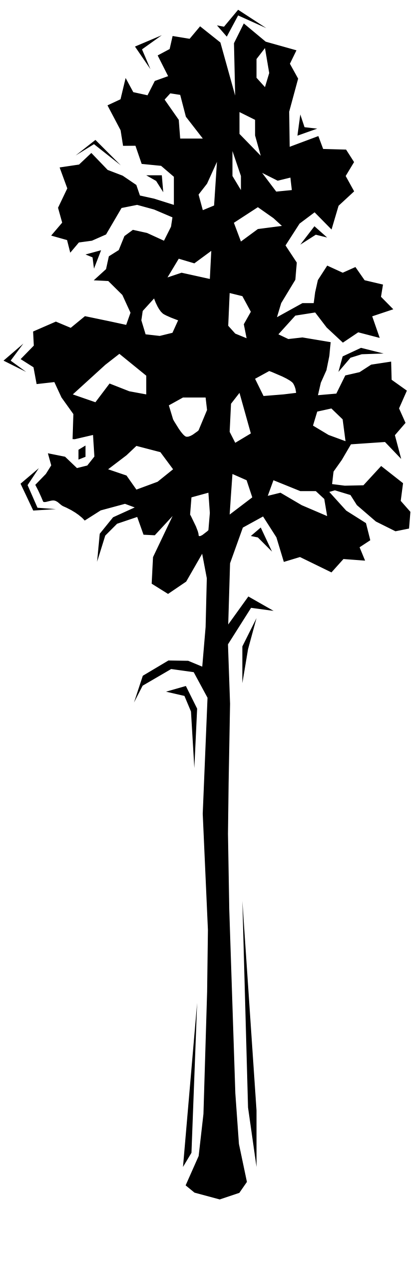
The Power of Trees



Just what is that elusive thing we generically call energy? And how does it transfer from one object to another? Waves crash on the beach, pelicans bob up and down, and sand washes back and forth. A basketball bounces, the players run up and down the court, and people cheer and dance as the net swishes and the ball falls back to the ground. A train sounds it horn, it zooms by with a roar and a blast of wind, and the railroad ties sink into the gravel bed with each passing axle. Clearly, it takes energy to make all of these things happen.

Now let's enter the forest. An occasional bug buzzes by, the wind may choose to raise and lower a few leaves, and a creek trickles its way down the hill. But what about the trees? They stand so still and quiet. Are they here to merely bear witness to the events around them? Guess again! Trees are host to quite an array of energy transformations and ecological functions. Without trees, the world would have a very different environment altogether!

In Virginia, we are stewards of about eleven and a half *billion* trees. From the time the leaves open in April until they turn color in October, each tree is an extremely busy natural factory. Trees use energy from the sun, nutrients and water from the soil, and carbon dioxide from the atmosphere to create "food" for themselves and to store energy as wood fiber. An average tree might pump 10,000 gallons of water from the soil and store 25 pounds of carbon in one growing season. Once inside the tree, water may travel as fast as 150 feet per hour. A large birch can release up to 900 gallons of water in one day through the tiny openings (stomata) on the undersides of its 200,000 leaves. At the same time, that tree will produce enough oxygen to support 10 people.

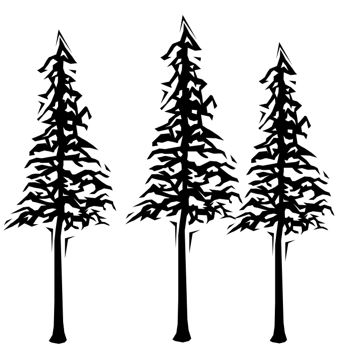
The tree's "food" is glucose, and ants are often seen scouring a tree's bark in search of a hole where they can devour this sweet energy source. Humans tap into sugar maple groves to harvest our share of tree sap, which we boil into yummy maple syrup. If you picnic under a white pine in the summertime, it will seem as though the white pine is trying to add to the feast with drips of sweet sap that fall from its limbs. And trees simultaneously produce food for many other creatures. One oak tree can produce 5000 acorns per year, and a cherry tree can grow 12,000 cherries. In Virginia, 180,000 acres of apple orchards annually produce 8-10 million bushels of apples.

So in one year, that silent tree grows hundreds of thousands of leaves, an entire layer of wood, and thousands of fruit. The really amazing feat is that it also cleans the air of pollutants such as sulfur dioxide and ozone and cleans the water through erosion prevention. Can you think of any other factories that improve the environment while they operate? Multiply the effects of one tree by eleven and a half billion, and the importance of trees to Virginia's environment can boggle the mind.

Just as we don't see our children's growth from one day to the next, the subtle but critical energy transfer in a tree is not obvious to the passerby. This *Love a Tree Activity Book* is intended to make trees and schoolyards come alive for Virginia's students as they learn a tree's role in the grand dance of energy on Planet Earth.

Table of Contents

Powerful Facts About Trees



- Trees help cool the air through evapotranspiration.
- Carefully positioned trees can save up to 25% of a typical household's heating and cooling energy.
- Temperatures in tree shaded neighborhoods can be 3 to 6 degrees cooler than in treeless areas.
- The temperature under a tree can be 25 degrees cooler that the surrounding area.
- Evergreen trees make good windbreaks.
- Trees filter and cleanse our water supply.
- In a year, a large shade tree can produce enough oxygen for 10 people.
- Tree roots reduce erosion by holding soil in place.
- The branches and leaves of a tree are called the crown.
- A young tree with few branches is called a whip.

Activity: *Energy Chains*

Overview: Students will identify the different forms of energy and construct an "energy chain" showing how different energy forms change.

Levels: Grades 5-8

Subjects: Science, Language Arts

Energy Concepts:
- Energy is what powers all activities and cycles throughout the world.
- There are multiple sources of energy.
- The primary source of energy is the sun.
- The sun's energy drives the earth's cycles.

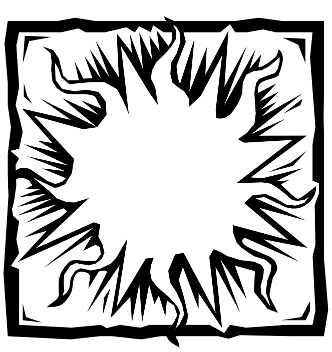
Skills: Discussing, Evaluating, Ordering and Arranging, Identifying Attributes and Components, Identifying Relationships and Patterns

Objectives: Students will:
1. identify the different forms of energy,
2. be able to explain The Law of Conservation of Energy, and
3. trace the energy changes from one form of energy to another by constructing an energy chain.

Materials: Copies of Student Page XX

Background: Everything we do involves *energy.* Energy surrounds us in different forms: *chemical, electrical, mechanical, radiant or light energy, thermal, and nuclear.* Although energy cannot be created or destroyed, it can be changed from one form to another. For example, when wood burns, its chemical energy changes into thermal energy and light energy. Changing energy from one form to another is how we control it for our use.

When you use one form of energy, it changes into one or more other forms of energy. Since energy cannot be created or destroyed, the total amount of energy at the start is the same as the total amount of energy at the end. This is known as the Law of Conservation of Energy. However, it is impossible to convert one form of energy into another without wasting some energy because some energy is always converted into unwanted or unusable forms.



Energy chains are a very visual way of explaining how energy can change from one form to another and how energy is "lost" or "wasted" on the way. The following is an example of an energy chain with the sun as their source and with a child writing a letter at the end.

[sun] Nuclear energy is released during fusion, the combining of two hydrogen atoms. The sun releases a tremendous amount of energy in the form of light or radiant energy.

[plant] Through the process of photosynthesis a plant (orange tree) takes the light energy from the sun and converts it to chemical energy, which is stored in the plant. Some energy is used for the growth of the plant.

[child] A child consumes an orange which contains chemical energy. This energy is used to keep his/her body working and to provide energy to move.

[child writing] The child uses the chemical energy to move his/her hand and write a letter.

An energy chain has three parts; the original source of energy, the changes in the forms of energy, and the final use of energy. In many situations the object or device that is used is an energy converter. The plant listed in the example above takes in radiant or light energy and converts it to chemical energy. The child converts chemical energy into mechanical energy.

Getting Ready: Copy of Student Page XX

Doing the Activity:

1. Ask the students what powers their TV at home. What is the source of the energy?
2. Review with your class the forms of energy. Write them on the board and give examples.
3. Describe the energy chain below to your students. Start with the end use, then the different energy forms, and end with the source.

   Using this energy chain, the source of energy that powers the TV is the sun. Review this process by starting at the source and describe how the changes in energy forms lead to the TV working. In this example the electricity is produced by hydroelectric power. The source of energy for your electricity may be different. Ask the students how energy is "lost" or "wasted" in this example. Have a student touch the back of the TV. They will feel the heat that is lost when the electrical energy is converted to radiant and sound energy.
4. Using the Cycles poster in your Love A Tree box, have students select one of the images and develop an energy chain. In some cases they will begin with an energy source (blackberry) and work toward an end use (kinetic energy for a bird). With other images, students will begin with the end use (squirrel eats an acorn) and work back to the source (the sun). Have students use Student Page XX to create their energy chain. Note that the number of steps in the chain will vary, but all should have the sun as the source, an energy change or changes, and an end use. At each step have students describe how energy may be wasted.

Assesment Opportunity: Have students write a story that describes an energy chain using plants and animals in their community or another ecosystem.

NOTE to Jennifer: DON'T FORGET TO INCLUDE THE SAMPLE ENERGY CHAIN ON PAGE 37 SINCE YOU REFERENCE IT IN #3.-- need to give to Betsy for student copy page

NOTE to Jennifer: Do I have this? – Betsy

Activity: *Web of Life*

Subjects: Science, Language Arts, Visual Arts

Skills: Researching, Discussing, Identifying Relationships and Patterns, Predicting

Objectives: Students will:

1. collect information about various organisms in an ecosystem,
2. create a mural that depicts the interdependence of various organisms with other components in an ecosystem, and
3. create a simulated web of life using a ball of string.

Materials:

- Enough large sheets of cardboard from boxes (or heavy paper) to construct a mural 4' X 8' (1.2m x 2.4m)
- tape
- glue
- pins
- a ball of string or yarn
- resource materials about forest plants and animals, folders (optional).

Overview: In this activity, students will take a close look at a trees and will discover the ways that plants and animals are connected to each other.

Background: A forest is a living community dominated by trees. Each plant in the forest, from tiny mosses to giant trees, has its own specific needs for sunlight, nutrients, and moisture. Because environments vary tremendously, a specific location will better for certain plant species than for others, and those species will grow more abundantly as a result. The most dominant tree species in a forest usually determines the forest's appearance and suitability as a habitat for plants and animals. For example, in some forests, large, dominant trees may reduce sunlight and monopolize soil moisture and nutrients, thus limiting the types of plants that can grow beneath them.

While trees and plants are usually its most conspicuous elements, the forest ecosystem also depends on animals. Animals are vital to most plants because they help pollinate flowers and disperse seeds. At the same time, animals such as deer, rabbits, and insects may eat certain plants, greatly reducing their presence. Some insects can substantially damage a forest ecosystem if their numbers get too high. Insect-eating birds play an important role in keeping insect populations in check.

Another way that forest plants and animals are connected is through a web of eating relationships. One primary function of a forest, like any other ecosystem, is to produce and distribute energy. All life depends on the ability of green plants to use sunlight to synthesize simple sugars from carbon dioxide and water. Through this process, called ***photosynthesis,*** plants take energy from sunlight and make it available to animals. Plant eaters, or herbivores, eat the plants directly; animal or flesh eaters, carnivores, in turn eat both herbivores or other carnivores, thus forming a ***food chain.*** A food chain is a simplified way of showing energy relationships between plants and animals in an ecosystem. For example, a food chain of sun ⇢ sunflower seed ⇢ mouse ⇢ owl shows that a seed is eaten by a mouse, that in turn is eaten by an owl. However, rarely does an animal eat only one type of food. A food web describes the interconnection of the food chains in an ecosystem and gives a clearer picture of how plants and animals in an ecosystem are related to each other.

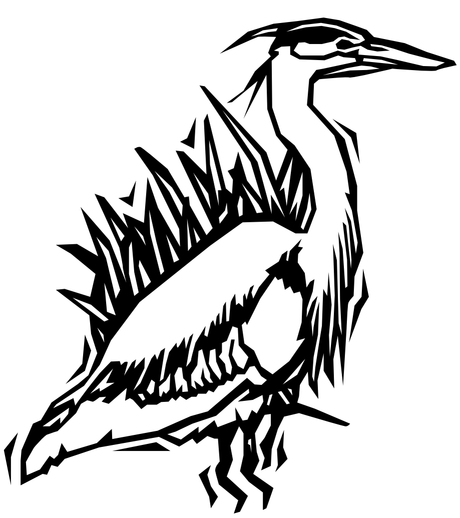
In this activity, students will create a "web of life" to depict the relationships among members of an ecosystem. This web includes eating relationships (as in a food web), but also shows the various other kinds of relationships found in a forest (shelter, reproduction). The web of life suggests that all living things are connected to all others. No matter how unrelated organisms may seem, they are, in fact, connected.

Getting Ready: *(Optional)* For each team, begin a folder of information on a the animals and plants printed on the Love-A-Tree cards and poster. Folders can also include pictures you cut from magazines or calendars, and articles or other information you glean from nature journals or other sources. Students will also need access to resource materials about forest plants and animals.

Doing the Activity:

1. Ask students to work in pairs or teams to brainstorm all the components they think they would need to make a healthy environment to live. Invite them to share their ideas with the rest of the class.
2. Afterward, make a class list of animals that live in Virginia. Some examples are bark beetle, bat, beaver, bear, box turtle, butterfly, chipmunk, deer, earthworm, field mouse, red fox, tree frog, grasshopper, king snake, lizard, mosquito, hawk moth, opossum, barred owl, rabbit, raccoon, skunk, snail, squirrel, tick or woodpecker.
3. Make a class list of plants that can be found in Virginia. Some examples might be azalea, clover, columbine, alder, honeysuckle, lichen, maple tree, pine tree, poison ivy, shelf fungus, or violet. Refer to the poster included in the Love A Tree box.
4. Divide class into teams of two to four students. (You can use the same teams as before.) Have each team select a plant or organism to study. For instance, try to have at least two groups that study each of the following kinds of organisms: mammal, insect, bird, reptile, trees, and other plants.
5. Instruct groups to collect as much information as possible about their chosen organism.

   Animal groups should answer these questions:
   - Where does the animal live? (on the ground, in trees, at the edge of the forest, in the forest)
   - What does it need to survive?
   - What kind of shelter does it require? Where does it perch, hibernate, breed, and sleep?
   - Does it migrate? If so, when and where?
   - Where and how does it get its water?
   - What animals does it prey on? How much does it eat?
   - What animals prey on it?



- With what animals does it live? What plants?
- How does the animal influence its environment?

Plant groups should answer these questions:

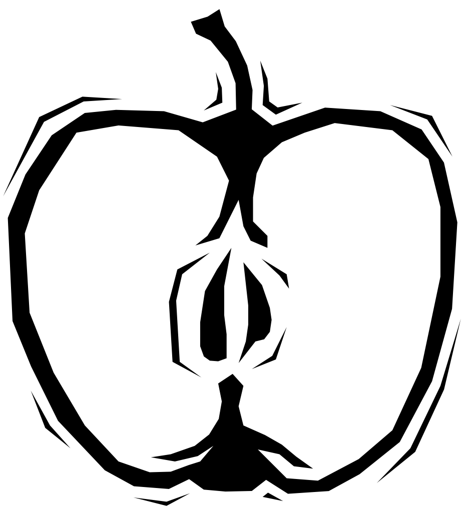
- Where does the plant live?
- What does it need to survive?
- How does it reproduce? Does it have seeds? If so, how are they dispersed?
- How much sunlight and water does it require?
- Does it live near other plants? If so, what kinds?
- What animals are associated with this plant?
- What animals eat this plant?
- How does this plant influence the environment?

6. Ask groups to find photographs or drawings of their plant or animal. (They can draw their own pictures or take their own photos.) If possible, pictures should show the organism in its natural habitat.
7. Ask the class to create a mural on large cardboard or paper sheets. Students can use pictures from magazines or their own drawings to show hills, valleys, streams, homes, plants, animals, and other features. The mural should show important elements like sun, water, soil and atmosphere. The mural can show various environmental areas; wetlands, urban, meadous, or mature forests. Each team can work on a separate panel and focus on a particular type of area.
8. When the mural is finished, each team should send a representative to place a picture of the organism (plant or animal) they studied into its appropriate habitat. The student should explain the team's reasons for placing each organism in a particular spot. When all organisms are in place, you might discuss the following questions:
    - What did you discover about your plant of animal that surprised you the most?
    - Why did you select the species you did? Have you ever seen the plant or animal you selected? Would you know where and when to look for it? Did you know before you studied it?
    - Is it a threatened or endangered species? If so, for what reasons is it endangered? Is anything being done to help or harm it?
9. When all animals are in place, introduce the web of life concept (see previous Background section).
10. Place a push pin next to each plant or animal. Then use yarn to connect each animal to other animals and plants with which it directly or indirectly interacts (for example, "eats," "is eaten by," or "depends on for shelter"). Students can help by acting as experts on the species they researched.
11. Ask each team to make sure that its organism is appropriately attached to other components in the ecosystem depicted on the mural. The completed mural forms a web of life for this ecosystem.
12. Discuss these questions:
    - What would happen if one element of the ecosystem were missing? (You can demonstrate by removing a push pin.) What will happen to other organisms?
    - What important elements are not included in our web?

- What are some webs of life within your school or community? (Students go to school ⇢ teachers teach them ⇢ cafeteria workers feed them ⇢ parents pay taxes so teachers and cafeteria workers can buy food.)
- What are some global webs of life?

Variation – All Tied Up

1. After they research the organisms (in Step 5 above), have the teams (or individuals) each make a name tag for their plant or animal, including a picture. Ask one person from each group to sit on the floor in a circle.
2. Starting with one "plant," ask that student to hold the end of a ball of string. Ask the team that studied the first plant to name another organism in the circle with which that plant interacts (for example, is eaten by or depends on). Pass the ball to the student representing an organism that the second team chooses to connect with. This process will continue until each "organism" is linked to the ecosystem, and the ball is returned to the first student.
3. Now, have student slide back until the string is taut. Tell students to keep still. But if they feel a tug, they should tug in response. When everyone is still, tell the student holding the original end of the string to gently begin tugging. Keep reminding everyone that if they feel a tug, they should tug in response. Through this mechanism, vibration will spread through the food web until everyone is tugging and the whole web is shaking.
4. Ask students how the tugging demonstration might illustrate what happens when one of the links in an ecosystem is damaged through natural or human-made stress. *(Answer: The rest of the ecosystem feels the effects.)*
5. Ask students to pick one organism in the system that seems less important than the others, and have it drop out. Ask if any other organisms should drop out because they depended on that organism. After one or more have dropped out, ask the students again to identify an organism that seems less important, and repeat the procedure. Continue playing for a few more rounds; then ask the following questions:
   - What happens when we remove a link in the ecosystem? *(Answer: Organisms that depend on it are affected.)*
   - Were the changes more dramatic when the system was composed of many parts or when it had fewer parts? *(Answer: Fewer)*
   - What can we say about the relationship between how many parts the system has (its complexity or diversity) and how stable it is? *(Anwser In general, complexity makes it more stable.)*

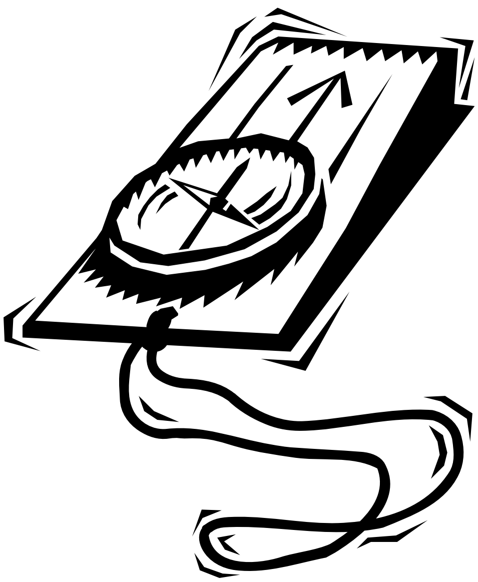


Enrichment: Make food web mobiles. Have each student select a plant or animal that is part of the forest ecosystem or another ecosystem. Students should research their organism's place in the food web and make a cutout of all the food web organisms from construction paper and colored makers. Using a clothes hanger and thread to hang cutouts in the proper arrangement, students can construct a mobile that represents their food web.

Assessment Opportunity: Have teams of students demonstrate (by writing, drawing, or role playing) a web of life in which humans play a critical part.

Activity: *Mapping Your Schoolyard*

Overview:	Students investigate their schoolyard by drawing a map. Students can use this map to organize spatial data regarding the location of structures, trees, signs of wildlife, and opportunities for conservation projects.
Grade Level:	2-8
Subjects:	Science, Math, Geography
Skills:	Evaluating, Formulating Questions, Comparing and Contrasting, Representing, Translating, Organizing Information, Analyzing, Interpreting, Predicting, and Verifying.
Objectives:	Students will: 1. draw the major features of their schoolyard including: terrain, structures, plants, and signs of habitats, and 2. use their maps to describe what they observed in their schoolyard and environmental conditions.
Site:	Outdoors
Time Format:	1 class session to do mapping activity; 1 or more for wrap up and extensions
Materials:	• Tape measure • Graph Paper • Markers • Pencils • Compass • Clipboards • Aerial photographs (optional)
Advanced Preparation:	1. Gather necessary materials. 2. Walk schoolyard before lesson and identify possible safety hazards. 3. Sketch an outline of the school building or “foot print” onto graph paper. 4. Make enough copies of the base map for your class. 5. Review map concepts such as compass points and key as appropriate.
Background:	Scientists map research sites as a first step in documenting the living and non-living aspects of an ecosystem. The map also establishes the boundaries of the research site. You’ll use your map for a variety of projects: showing your data collection locations; comparing features of your schoolyard to other schoolyards; and comparing changes to the schoolyard over time. Your map will serve as an inventory of the physical elements, natural features, ecological systems and human influences present at your school.



Part 1:

1. Organize students in a circle and explain that they are going to make a map of the schoolyard. Ask the students to imagine that they are flying over their schoolyard when they are making their maps. This is called a "map view."
2. Ask the following questions:
   - What are some of the things we should consider putting on our maps?
     Teacher prompts:
     - Vegetation: Trees, Lawn, Shrubs, Flowerbeds
     - Terrain: Hills, Creeks, Ponds, Drainage Swales
     - Structures: Buildings, Fences, Gates, Parking lots, Playgrounds
   - Where is North?
   - Where does the sun rise and set? Explain to students that a map has a heading direction (North, South, East, West) normally noted some where on it.
   - Why would it be important to include compass points on the maps?
3. Review safety with students and ask them to identify some safety issues.
4. Split the class into pairs. Assign each pair to an area to look for the list of features noted below (Alternately each team can be assigned a particular feature to map, e.g. trees.)
   - Direction (North should be noted on each map)
   - Human-made structures (sidewalks, playing fields)
   - Water sources
   - Topography (slope) and drainage
   - Traffic patterns of wildlife, people, and vehicles
   - Path of sun and wind exposure
   - Plant locations and type (grass lawn, flower beds, etc.)
   - Scale
   - Animals or evidence of animals
   - Soil type (wet, dry)
5. Give students 20-30 minutes to work to measure the distances from the school building and plot features on the map.

Part 2:

Have students work together to draw a map that represents all of the things outlined in step 1.

1. Ask students to share their maps with everyone and explain some of the major features or things they found as they explored.
2. Compile individual maps onto one collective map
3. Do they notice anything about where certain plants are located? Ask questions and record observations. Do they notice any patterns, such as...
   - Why are cattails next to the creek?
   - Why is there lawn around the buildings?
   - Where do people walk, sit, and play?
   - Where would animals live?
4. Record the students' observations and questions about what is around their schoolyard.
   - Which areas have more dirt patches?
   - What percentage of the area is covered with grass? With trees?

- With parking lots?
- What is the coolest place on a hot day?

The class can return to and add to their maps as they learn more about living systems, energy flow and cycles in their schoolyard.

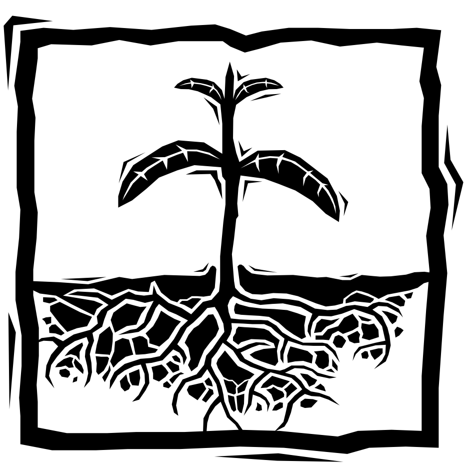
Part 3: Have students investigate one or more of the following questions:

1. ***Research Question:*** How can a tree affect its surroundings?
   Discuss the following questions with the class:
   - How can a tree affect the temperature around it?
   - Predict how far from the tree you will still be able to see some effect. What features of the tree would affect this?

   On a sunny day, have students measure the temperature at 1-meter intervals from the base of the tree by placing a thermometer face up on the surface of the ground. Have different groups do this along different directional lines from the tree, or from other trees. Provide them with the "Trees and Temperature" data sheets. Back indoors, proceed with the following questions:

   Describe the effect of the tree on temperatures around it, using the following questions:
   - How far away from the tree did you see any effect? How does this compare with your predictions?
   - Did the effect differ depending on the direction away from the tree?
   - What would happen if you planted more trees or had to remove trees from the schoolyard?

2. ***Research Question:*** How might the temperature variation you observed affect where plants and animals are likely to be found?
   Discuss the following questions with the class:
   - What happens to you when you run around on a hot sunny day? Why do you become thirsty?
   - Are other organisms affected by exposure to sun and heat in similar ways?
   - Can organisms simply go get a drink when they need water?
   - Predict some areas in your schoolyard where you think water would evaporate the fastest/slowest.



   At this point, stop the lesson for the day, and let students know that you will test their predictions in another activity in your next lesson, Thirsty Plants. After conducting the Thirsty Plants activity, discuss the following questions with your students:

   - Which locations showed the most evaporation? Which showed the least? How do the results compare to your predictions?
   - What affected the amount of evaporation?
   - How could the information you gathered help explain where you might find plants and animals in your schoolyard?

3. ***Research Question:*** Ask students to describe the features a plant or animal would need to live in a place where temperature and evaporation are high. To follow up further, have them research the adaptations of desert plants and animals.

4. ***Research Question:*** How does the tree affect the amount of light that reaches the ground underneath it?

   Consider having some students use a deciduous tree to pursue this line of inquiry, while other students use an evergreen tree.

   Measure the area covered by the tree's shadow at different times of the day. Make a chart or graph to record and summarize the data. Discuss the following questions with your class:
   - How does the area affected by the shadow change during the course of the day?
   - How might plants living under the tree respond to these daily changes? How might animals respond?
   - How will this tree's shadow change with changing *seasons?* How could you measure this?

5. ***Research Question:*** What effects do trees have on ground surface temperature? *Start by having students make predictions about the effect of trees on the temperature of the ground surrounding the tree, and how this will vary with distance from the tree. Then, on a sunny day, have students measure the temperature at 1-meter intervals from the base of the tree by placing a thermometer face up on the surface of the ground. Have different groups do this for different transects or directions from the tree.*

   Make a graph showing the temperature changes, and describe the patterns you observed. Discuss the following questions with your class:
   - How might the temperature variation you observed affect where plants and animals are likely to be found?
   - How would you expect the temperatures you observed to change during the day?

Research Question 1 Data Sheet – Trees and Temperature in the Schoolyard		
Distance from Tree	**Under Shade? (Mark Yes or No)**	**Temperature on Ground**

Activity: *Thirsty Plants*

Setting: Classroom and schoolyard

Vocabulary: Capillary action, xylem, stomata, transpiration, evapotranspiration, xeriscaping

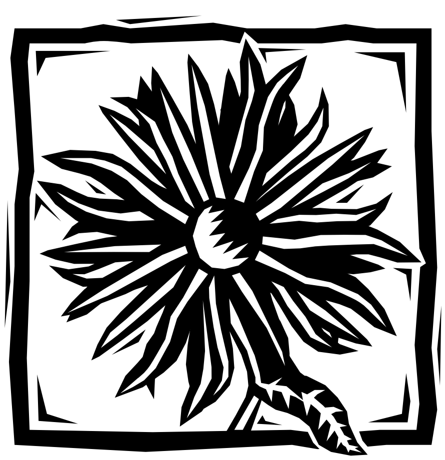
Objectives: Students will:

1. explain how plants transport water through transpiration,
2. describe the importance of plants in the water cycle, and
3. recognize that certain plants are appropriate for xeriscaping.

Materials:

- Copies of the student activity sheet, Water Cycle Diagram
- Celery stalks or white carnations
- Clear container with water colored with red or blue food coloring (Place celery or carnation in water for several hours, until leaves or petals are colored with the dye.)
- Paper towel tube
- Paper that is cut into a series of connecting circles (See diagram; the circles are inserted through the paper towel tube. If possible, the width of the circles should equal the diameter of the tube so that the tube holds the paper in place. An alternative is to thread Popbeads – the kind that lock into each other, used in children's necklaces through a straw)
- Clear plastic bag and twist tie for each group
- Balance or scale (optional)
- Forceps or tweezers

Background: Plants require water to live. Plants need water to transport nutrients and minerals necessary for plant metabolism and use water in photosynthesis. Since most photosynthesis takes place in the leaves, and the leaves of plant can be many meters above ground level, how does water from the soil get to these leaves?



Transpiration (evaporation of water from pores, or stomata, on trunk, stem, and leaf surfaces aids plants to transport water upward through their tissues. Root pressure, the cohesive and adhesive qualities of water (capillary action), and evaporation all contribute to water's circulation through a plant.

Many plants have a vascular system: narrow tubes or vessels that run the length of the plant's body. Like veins and arteries in humans, these tubes in plants carry nutrients and liquids. The vascular tissue through which water travels up a plant is called xylem. Xylem begins in the roots and ends as stomata in the leaves.

Through the process of osmosis (filtering of water into plant cells), water enters the roots and exerts an upward pressure (root pressure), that prevents it from flowing backward down the xylem. The cohesive and adhesive characteristics of water help support its placement in the tubing. Cohesion is water's attraction to itself – i.e., the formation of hydrogen bonds between water molecules. Adhesion is water's attraction to other materials, such as the inside of the tubing. This process called capillary action essentially creates a column of water in the xylem. Since the molecules are attached (or bonded) to each other, a tension is created among the molecules in the column.

However, root pressure and capillary action alone are unable to push water many meters above ground level. Evaporation is likely the main process whereby water is pulled up the tubing.

When water molecules reach the stomata, they are exposed to air and the sun's energy. The exposed molecules receive heat energy from the sun and begin to move faster. This motion makes it easier for the molecules to break away and become water vapor. However, because of capillary action, a tension still exists among water molecules in the xylem. Therefore, as on molecule is drawn away, it pulls on water molecules still boned to it, bringing those molecules closer to the surface.

Plants can absorb large quantities of water; however, they lose most of this water through transpiration. Transpiration coupled with evaporation of surface water is called evapotranspiration. It plays a crucial role in the water cycle. Evapotranspiration returns water to is gaseous state, in which it can be carried by winds through the atmosphere until it condenses and returns to Earth as precipitation. This process helps purify water and move it around the plant.

The rate transpiration from plants depends on humidity and the nature of the plants. Water evaporates readily in dry, warm air because room is available for more water. Some plants, such as Rocky Mountain juniper, Russian sage, and golden currant, require little water to survive. Frugal water users such as these have smaller leaves, deeper root systems, thick waxy surfaces and other qualities that limit water loss. (A method of landscaping called xeriscaping entails garden layouts incorporating plants that require little water.) In addition to plant selection, xeriscaping also involves specialized placement plants, watering techniques, and monitoring garden ****** patterns. Many communities promote xeriscaping, especially those that experience water shortages.

Procedure...Warm Up:

Distribute copies of the Water Cycle Diagram student activity sheet. Ask students to share what they know of the water cycle and then draw arrows indicating how water moves through the environment represented in the diagram. Note whether or not they included plants

Show students the celery that has been soaking in blue- or red-dyed water. Ask them to make a list of possible explanations for how the water traveled through the cutting.

Procedure...The Activity...Part 1:

1. Ask students to consider a 20 foot-tall tree; how do its leaves get water? Students may think that plants suck water up to the leaves. Do they think they could draw water up a straw that length?
2. Show students the paper towel tube with the cutout circles inserted. See diagram below. Explain that the tube represents part of the tissue inside a plant (xylem), similar to veins inside our bodies. The paper circles represent water molecules. Explain that in plants, water molecules remain inside the tube because they

are attracted to each other and to the sides of the tube.

3. Point out the water molecule near the top of the tube. Explain that this represents a molecule at the stoma or pore in a leaf. During the day, increased heat energy will cause water to evaporate. Evaporation occurs when the energy of movement (caused by heat energy) is stronger than the forces holding the molecule to other water molecules.
4. To show evaporation, pull on the top circle to draw the next circle near the top, then tear off the top circle. Explain that this represents a water molecule being evaporated from the leaf (transpiration). When the top molecule leaves the plant, it must break away from surrounding water molecules. This creates a pull on those water molecules, drawing them further up the xylem.
5. Have students write descriptions of transpiration based on the demonstration, identifying areas where clarification is needed.

Procedure...The Activity...Part II:

Note: This activity will work best on a sunny day after a rain storm or after an area has been watered.

1. Divide the class into small groups; give each group an empty plastic bag and have them record its weight. If the scale is not sensitive enough to weight one bag, the class can weigh all their bags together, or they can simply describe the appearance of the bag.
2. Identify trees, shrubs, or small plants located on the school grounds. Assign each group to a plant. (More than one group to a plant also works)
3. Have each group carefully place its bag over part of a limb of its tree or shrub. (Facing the sun works best) Tie the bag with a twist tie or string. Each group should count and record the number of leaves in its bag)
4. Challenge the students to develop a method to estimate the number of leaves on the tree. After the groups have recorded their estimates; ask each group to carefully examine its bag for changes.
5. After 30 minutes (it can be longer, but all bags should be removed at the same time), carefully remove the gag from the limb; take it to the class and weigh it. If leaves or debris are in the bag, remove them with forceps or tweezers before weighing it, trying not to remove any of the moisture. Again, if a scale is not available, students can observe the bags, looking for condensation.
6. Have each group measure the amount of moisture accumulated in the bag by using the following formula: weight gain = total weight – start weight.
7. Pool the class data and have each group answer the following questions based on the data collected by the class:
   a. Which plant transpired the most water?
   b. Which plant transpired the least water?
   c. Estimate the mass of water each plant would transpire during seven hours of sunlight. Assume a constant rate of transpiration.

Have students summarize the process of transpiration. How did the water get into the plastic bags? Discuss the amount of water transpired by plants in the

Plant Name or Description	Transpiration Rate (Ounces or Grams per 30 Minutes)	Transpiration Rate per 7-Hour Day
Plant 1		
Plant 2		
Plant 3		
Plant 4		
Plant 5		
Plant 6		
Plant 7		
Plant 8		
Plant 9		

Wrap Up and Action: schoolyard and where water goes after it leaves the plant. Have students relate their answers to the role these plants play in the water cycle.

Return students' attention to the arrows they drew on the Water Cycle Diagram student activity sheet in the Warm Up. Do they think the placement of their arrows are correct? Are revisions needed? Show students copies of the Water Cycle that includes arrows and labels and have students compare the two.

Assesement: Have students:

- describe the process of transpiration (Part 1, step 5 and Wrap Up).
- estimate and/or calculate the mass of water transpired from plants in the schoolyard (Part II, step 7)
- indicate the role of plants in the water cycle (Wrap Up)

Bayscaping: Upon completing the activity, for further assessment have students:

- write a paragraph envisioning what the water cycle would look like without plants; they might want to consider Earth's poles and the pre-Cambrian period.

Resources:

Biological Science Curriculum Study.1987. *Biological Science: An Ecological Approach*. Dubuque, Iowa: Kendall/Hunt Publishing Company.

Walker, Sally M. 1992. *Water Up, Water Down; The Hydrologic Cycle*. Minneapolis, Minn.: Carolrhoda Books.