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TREES & PONDS

SPRING

Observing Larger Pond Organisms

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TREES & PONDS

SPRING TREES

Activities

Written by Bernie Zubrowski

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Introduction to *Exploring Trees and Ponds*

Exploring Trees and Ponds offers a special opportunity to engage youth in exploring the natural world. The natural changes in nature over time—whether shown in plants and trees, or in pond creatures such as tadpoles and dragonfly larvae—excite middle school youth and make them curious to learn more. The activities in Exploring Trees and Ponds are designed to build on this fascination and to give youth, ages 10–14, the opportunity to become more closely connected to the natural world.

Special attention is given to promoting drawing and the use of digital cameras. Research in recent years suggests that the use of visual representations are an essential part of learning. Digital cameras provide an engaging way of recording observations and often provide a starting point for generating and answering research questions.

The activities in *Exploring Trees and Ponds* are meant to be models for carrying out investigations with youth, with the goal of ultimately motivating them to generate their own questions and design their own investigations. When the activities are carried out in an intentional manner with attention to scientific thinking, different scientific process skills can be introduced and fostered throughout the whole project. The activities can be used as the experiential base for more in-depth investigations of environmental problems or the more formal study of biological principles. For example, some "big ideas" concepts, such as form and function, can be introduced during the fall tree explorations and returned to during the exploration of pond organisms and/or spring trees. More specific science concepts, such as cells and photosynthesis, can also be introduced using these activities.

Preparation
We recommend that you read through all of the activities in this guide before you begin with the youth in your program. There are many steps that can and should be done ahead of the activities to make the experience easier on you and more valuable for the youth, ranging from making sure you have access to the needed materials, especially when those materials need to be gathered from a location outside.

Youth Journals
An integral part of any kind of nature study project should be journal keeping. In their journals, youth can record their discoveries, observations, experiments, and conclusions. This practice is essential if they are going to be systematic in their observations and experiments and allows them to make sense of their experiences in a meaningful manner. It will add depth to the overall project, giving them a sense that they are participating in activities that are significant to their own interests. It can also help them practice skills and habits of mind that will be useful in their school work.

Youth can use inexpensive spiral-bound notebooks as their journals. Paper journals allow youth to save tangible items from their explorations (for instance, flattened leaves) by securing them to the pages of the notebook. There are several methods to do this. The simplest (and least expensive) way is to put a leaf between two pieces of newspaper and press them under (or in) a book. You can add another book over time to increase the weight and make the leaves even flatter. Once the leaves or flowers are dry, youth can use a glue stick to attach them to a notebook page. You may want to research other ways to do this online to share with the youth in your program.

Alternatively, if your program site has computer or tablet access, or if your youth have personal cell phones, you may choose to have them save their journals online to free notebook apps (e.g., Evernote). Some software allow for photos to be uploaded as well.

Alternatives to Field Trips

This program suggests a number of trips to forests, fields, ponds, and even just outside of your program site. We understand that sometimes this number of outings is simply not possible for everyone in every location, so we have included a Photo Resources Gallery at the end of this activity guide and on the *Exploring Trees and Ponds* website (http://treesandponds.edc.org) that you can use with your youth should you be unable to complete the outside portions of activities.

Calendar of Activities (extended learning experiences)

The full project (using all three activity guide) can be carried out over a nine-month period, divided into fall, winter, and spring. Although the seasons have been separated into distinct guides, many of the activities contain extended learning experiences that may extend past the end of the formal season. The calendar below provides one example of how you might carry out the entire program from September through May. We hope you enjoy these explorations!

September – October (Fall)	November – March (Winter)	April – May (Spring)
Investigations		
• Field trips to forest • Local walks • Observe leaves (chromatography, composting) • Seedlings • Seeds	• Collect pond organisms • Inventory samples • Study individual organisms • View videos of macro-invertebrates • View videos and observe protozoa • Experiment with daphnia	• Observe bud changes • Local walks • Grow plants from seeds • Observe flowers • Observe leaves and substructures • Field trips to forest
Long-Term Observations		
• Adopt a tree → • Tree seedlings →	• Observe macro-invertebrates →	
Scientific Process Skills		
• Observation → • Experimentation → • Recording data → • Communication →		
Concepts		
• Form and Function →	• Cells • Energy/flow	• Photosynthesis • Transpiration
During the fall (September–October), youth take part in field trips and indoor activities focusing on trees. They can start various kinds of investigations that will carry through the whole project. These might include observing changes in outdoors trees and growing tree seedlings indoors.	During the winter (November–March), the focus is on investigating pond organism but can also include some long-term observations of experiments that were set up in the fall related to trees. During the pond activities, youth set up containers with different organisms. They can study the changes in these organisms over several months.	During the spring (April–May), youth return to the outdoors to observe the changing trees. They can also continue working with pond organisms they have collected over the winter.

Trees: Buds and Twigs

Rationale

In the parts of the United States where deciduous trees predominate, changes during the spring are dramatic. Youth are quite aware of these spring changes, but they probably have not closely observed how the leaves emerge. To prime their interest and focus their attention on the emergence of leaves, branches from trees and bushes can be collected and placed in bottles of water. Gradually, the buds will open and leaves or flowers emerge.

The goal of this activity is to have youth observe the change in the buds and the timing of their emergence, and to discuss what factors in the environment bring about the changes of the buds.

A guiding question is: **To what extent does the increasing warmth and length of daylight contribute to the emergence of leaves from buds in the spring?**

Materials

For each group of two or three youth:

- Plastic bag (gallon size) or plastic grocery bag (in which to collect branch specimens)
- Container for water (such as glass jars or soda bottles), 7–8 inches tall

For the whole group:

- Chart paper
- Permanent marker
- Digital cameras
- Tree or plant field guide
- Knife or cutting shears
- Masking tape
- Ballpoint pens
- Access to a computer/printer

Preparation

The timing of the collection of branches will depend on the part of the country where you reside. For those in northern climates, you should start collecting specimens in late February. Those in southern climates should collect specimens in January.

Youth will have a bigger interest and investment in observing changes on tree branches if they do their own collecting. Before taking youth on a field trip (whether to a park or a forest, or simply for a walk around the grounds of your program site) to look at the changes in trees, you should survey the trees and note which would be most useful to focus on and from which you could cut a small branch. Find trees that have branches low enough for easy cutting. Note the status of the buds on the branches. Do they look healthy or do they appear to be broken or damaged in some way? Are they starting to turn green?

Also, to add to the diversity of the collection, you could collect branches from other kinds of trees not found in the area where you will take the youth.

NOTE: Branches from willow trees could be particularly interesting for youth to observe. They are one of the few trees that will produce roots when their branches are placed in containers of water, so try to find some in your area.

Make a chart on chart paper to record the group's observations about bud changes on the branches. This chart should be similar to the one shown below (which includes a sample item) and should be posted close to where you keep the branches in your room. During subsequent sessions, spend a few minutes having the whole group observe and discuss any changes in the twigs. Record on the chart the changes they observed.

Record of Bud Changes

	Date							
Type of tree	3/28	4/4	4/12					
Maple	Buds tight	Bud becoming bigger	Bud is expanding into 3 leaves					

Introducing the Activity

Have youth recall their own memories of watching plants change in the spring. Ask them if they have ever looked closely at *where* the leaves emerge on the trees and how they emerge.

Start a discussion on what factors in the environment may cause these changes. The idea is to get the youth thinking about these factors but not coming to any definite conclusion.

During the Field Trip

Divide the group into smaller groups of two or three. Lead the groups to the trees you have pre-selected and have them observe the trees closely, especially the branches. Have them make drawings and take photos of one selected branch. (Remind youth when taking photos to use the macro feature on the camera to get a closer and clearer picture of parts of the branches.)

To motivate them to look closely, point out that the branch is extending itself each year. Can they find markings on the branch that would indicate each year's growth?

New spring growth showing branch extension.

Source: http://kuvanto.blogspot.com/2007/04/hiding-ladybird.html. Photo courtesy Hurina.

Encourage youth to study other branches on the tree from which they chose one branch to observe more closely. Ask:

- Do all the branches have buds?
- Where are the buds located on the branches?
- What do the buds look like?

Have the youth use a tree or plant field guide to identify their trees. In their journals, have them describe their selected trees in terms of whether they are young or old; whether they are damaged, sick, or healthy; where they are located; and whether they stand alone or are surrounded by other trees.

Have groups move from tree to tree with the same questions in mind. Have them select some branch specimens that they will bring back to the program site. Have them use a knife or cutting shears to cut off 10–12 inches *from the ends of the branches*, as shown below.

The 10–12 inches at the end of a branch will show the most growth

Photo courtesy of Bernie Zubrowski

To identify their branches later, have them fold a small piece of masking tape over each branch (sticking the tape to itself to create a secure label) at the tree site, listing the type of tree, the location, and the date.

Immediate Observations

On return to your program site, have youth place the branches in containers of water. Make sure each branch is labeled.

If possible, place these containers next to a window where they will catch some sunlight during the day.

So that the youth will be able to make comparisons from one session to the next, assist them in taking photos of each branch as well as making a drawing of each. When taking the photos, tell them to place the branch in front of a large white sheet of paper or a plain wall.

NOTE: You may want to suggest that youth carry out the following experiment: Have them place branches from the same tree in different locations, for instance, placing one next to a sunny window and another in a shady corner. Would this placement make a difference in whether and when leaves emerge?

Encourage the youth to look closely at the branches and to draw the different markings on them. Point out that the age of the branch can be determined by looking closely at its markings. Tell them that they will keep track of the changes in the buds over the next few weeks.

Long-Term Observations

During each session, direct the youth to spend a little time observing the branches they have placed in the containers. Have them make quick drawings in their journals as well as take photos of each of the branches, which they can print and place in their journals. If there are major changes with some of the branches, spend some time discussing how the branches have changed.

If time allows, have the youth go outdoors to revisit the trees from which they took their branches. Have them compare what is happening to the buds on the branches of the tree outdoors to the buds on the branches indoors.

NOTE: If meeting only once a week, try to make some arrangement with staff or youth at the program site to take photos on other days when the group is not meeting to record changes to the buds and leaves that the youth otherwise might miss.

After there has been a full emergence of leaves and flowers, have the youth check their notes and report on what changes have happened and how long it took. Ask the group:

- Did any of the leaves first emerge in colors other than green? (Some oak leaves first emerge as red in color but then change to green.)
- Did the color of the leaves change as the leaves became larger? (Some leaves start out as a pale green and gradually become a darker green.)
- Did the leaves' shape change as they became larger? (The size of the leaves increases but, in some instances, the shape also changes slightly.)

- Do some buds first produce flowers followed by leaves? (Many trees and shrubs first produce flowers before leaves, including forsythia and crabapple.)

You can also return to a question you asked previously: What environmental factors might trigger the change in the buds? (The amount of light, warmth, and rain all have an effect on flower and leaf buds.)

Point out that the emergence of the leaves is a risky undertaking for the trees. In late winter or early spring, there may be some warm days when temperatures are far above freezing but then return to winter temperatures for a few more weeks. The trees have evolved ways of protecting their buds against these possibilities. Trees also have a way of determining the length of a day. So for instance, if there is a warm period in February in the northeast United States, trees have mechanisms to stop their buds from opening up.

Observing Behavior

After youth have collected and set up the branches in the containers, it may be a challenge in subsequent sessions to direct their attention to the branches and to any changes happening between sessions. Some of the branches may not have any leaves emerge for weeks; therefore, it may be best to view this activity as intermittent and note how youth react when leaves do emerge. For example:

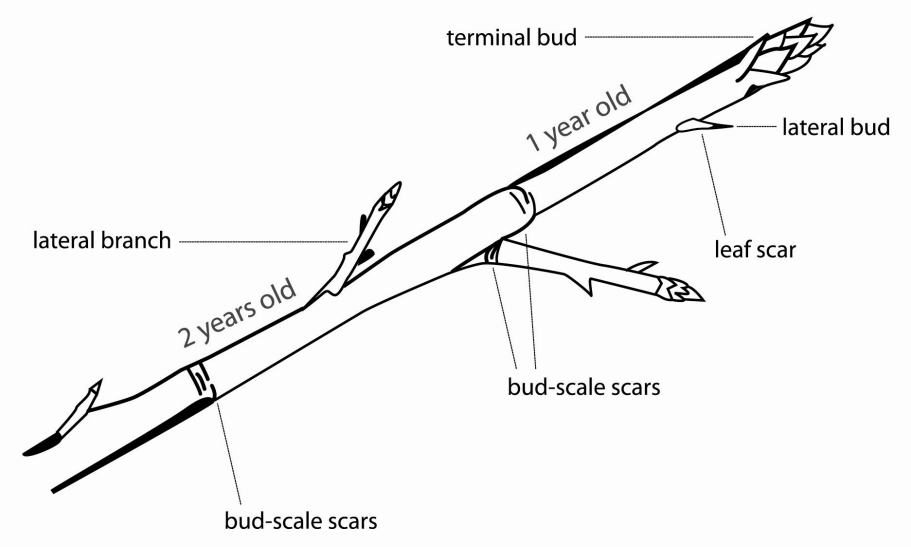
- Do they notice the emergence of leaves?
- Do they comment on the size and shape of the leaves?
- Do they make comparisons to the other leaves that have already emerged?

It is useful to keep in mind that the branches were brought inside so that youth could have a closer look at the changes and compare the timing of what happens indoors to what happens outdoors. Prompt the youth to discuss what environmental conditions appear to be major factors in bringing about the emergence of the leaves. Do they consider both the warming temperatures and, more importantly, the lengthening of the amount of daylight?

Background

If you examine a tree bud closely by pulling away the scales and cutting into it, you may discover that the bud contains miniature leaves. These preformed leaves are ready to emerge when there are warming temperatures and when the amount of daylight has increased. This strategy allows them to emerge and grow quickly. Not all trees have these preformed leaves. Among those that do are ash, beech, oak, hickory, walnut, horse chestnut, and many maples and conifers.

With other trees, only *some* of the leaves are preformed. The preformed leaves emerge but are followed by later leaves that are totally new. Among the trees having this strategy are elm, cherry, birch, poplar, willow, apple, and conifers such as larch, juniper, and western red cedar.



Bud-scale scars are an indicator of growth, forming a circle around the branch

Source: Thomas, P. (2000). *Trees: Their natural history.* Cambridge, UK: Cambridge University Press.

On the branches, you can find various markings and scars that are indicators of growth or damage, perhaps from insects. The distance between the bud-scale scars (as shown in the figure above) indicates the amount of growth each year. The thickening of the wood of the branch is recorded in annual rings.

Trees: Exploring Their Flowers

Photo courtesy of Bernie Zubrowski

Photo courtesy of Bernie Zubrowski

Rationale

One of the highlights of spring is the appearance of flowers on some trees and plants. Some trees display a bright canopy of colorful flowers. This display has an intrinsic appeal to all people and can be one way of getting youth to observe more closely the happenings of trees and plants. Some other trees also have flowers but are much less prominent. In either situation, flowering trees and plants provide a context for studying and discussing their reproductive strategies.

A guiding question for this activity can be: **What is the function of flowers in the life of a tree?**

Materials

For each youth:

- Plastic sandwich bag (for storing collected flowers)
- Paper
- Pen

For the whole group:

- Tree identification books or field guides
- A variety of flowers from a garden and/or a florist (daylilies are particularly useful because of their very visible stamens and pistils)
- Chart paper
- Marker
- Binoculars
- Knives or snips for cutting flowers from trees

- Magnifiers
- Stereoscopes
- Digital cameras
- Knives for dissecting flowers
- Access to a computer/printer
- *Optional:* Whiteboard, eraser, and erasable markers

Preparation

A day or two before the field trip with youth, survey the area you will visit and note where there are flowering trees. Use a field guide to identify the trees if you are not already familiar with them.

Collect a variety of flowers from local trees and plants. It is recommended that you also buy flowers from the florist the day before the activity. Providing a variety of different kinds of flowers will make the activity more interesting and will offer more opportunities to observe the variety of structures within a flower.

Introducing the Activity

Youth will be aware that flowers appear on trees in the spring. They probably have not looked at these flowers closely nor noted that some trees do not bear flowers. Ask youth to consider any flowering trees they have ever seen. (You can use photos from the Photo Resources Gallery titled Flowering Trees located at the end of this guide or on the *Exploring Trees and Ponds* website (http://treesandponds.edc.org). Ask the youth what they have noticed about flowering trees.

What questions do they have about the role of flowers? Record their questions on a large sheet of paper for later reference. Here are some questions to include if the youth do not mention them:

- On what part of the tree do flowers appear?
- Do all buds on trees emerge to produce flowers?
- Do all trees produce flowers in the spring?
- What follows after the flowers fall from the tree?
- What is the function of flowers?

These questions are meant to focus attention on the role of flowers; they are not meant to prompt youth to give definite answers.

After this discussion, tell the youth that they will take a short field trip to closely observe flowering trees.

During the Field Trip

Lead the youth to the flowering trees you've located. Before collecting any flowers, have them spend some time looking closely at where the flowers are emerging on the branches and at the distribution of the flowers. Have them use binoculars to look at inaccessible parts of the tree. Ask them to note whether there are any insects, such as bees, or animals, such as birds, visiting the flowers.

This is another opportunity to have youth practice their estimation skills. Challenge them to estimate the total number of flowers on an individual tree. You can point out to them that it takes a lot of the tree's energy to produce flowers. Therefore, it is significant that the tree uses this energy to produce so many flowers.

NOTE: Estimating the total number of flowers on a tree can be done in a systematic manner:

1. Count the number of the largest branches on the tree.
2. Pick one on these largest branches and use it to stand in for the other largest branches.
3. Count the number of branches coming off of this largest branch.
4. Pick a secondary branch and count the number of branches coming off this secondary branch.
5. Pick a tertiary branch off the secondary branch, and count the number of branches coming off this tertiary-branch.
6. Pick one of the smallest branches and count the number of flowers on this smallest branch.
7. Multiply all of these to come up with an estimated number of flowers on the tree.

Keep in mind that this is an estimate, so the counting of the smaller branches need not be totally accurate.

Give each youth a plastic sandwich bag, a piece of paper, and a pen, and have them collect some flowers. Remind them to record from what kind of trees they collected the flowers, the location of the trees, the date, and any other factors they think may be relevant. They can place a piece of paper with this information in the plastic bags used to keep the flowers.

Immediate Observations

When the youth return from the field trip, have them sort the flowers according to the trees from which they were collected.

Observing One Flower

Have youth focus on only one type of flower, using magnifiers and stereoscopes to examine its different parts. Have them make a drawing of the flower and take a photo of it.

NOTE: Remind the youth to use the macro feature of their camera when taking the photo. You might also provide either flashlights or portable lamps so that youth can shine them on parts of the flower to produce a clearer picture.

Have youth dissect the flower using a knife to get a look at the interior of the base of the flower.

NOTE: Knives can be sharp. Make sure that the youth use the knives in a safe manner.

After they have spent sufficient time observing and dissecting one flower, have them report what they have observed by asking the following questions:

- How many different parts of the flower did you observe?
- What did you notice about the interior parts of the flower?
- How are flower petals the same as and different from leaves of a tree?
- Did you find any small insects crawling around or inside the flower?

One way to carry out the reporting of observations is to make a group drawing, for which you will need a whiteboard. Start by drawing (or have a youth draw) a general outline of a flower.

Then ask different youth to come up to the whiteboard one at a time and add to the drawing of the flower they observed. As each youth adds a part to the drawing, ask others if they agree with the relative size and shape of the added part. If they mostly don't agree, erase the newly drawn part and have the youth try again (or give someone else a turn). Continue this procedure until all the youth agree on what they observed.

Observing Other Flowers
Having established the parts and structure of one flower, the youth can now go on to examining other flowers. Ask them to compare and contrast the other flowers they have collected as well as one of the flowers that you brought from the florist. Have them make quick drawings of the other flowers as well as take photos.

Encourage them to be patient while looking inside each flower. Depending on the length of your session and the interest of the youth, you may want to spend two sessions looking closely at the flowers.

You could also have the youth carry out some chromatography with the pigments of the flowers. See the *Leaves: Taking a Closer Look at Their Structure* activity for more specific suggestions and procedures.

Discussion
After the youth have spent some time closely examining the different flowers, have them put their materials aside and gather for a discussion.

Have them report on what they observed by asking the following questions:
- What appears to be similar among all the different flowers you have studied?
- What parts are different?
- Did all the flowers have a fine dust-like material on one part of the flower?
- If you were to draw a typical flower, how would you draw it?

As before, you can ask youth to contribute to a group drawing on a large sheet of paper or whiteboard. The goal of this activity is to have the youth arrive at the idea that most flowers have several common parts.

Move the discussion to the function of a flower. Point out that it takes a lot of a tree's energy supply to make lots of flowers, so they must serve an important function. Ask the youth to come up with explanations for the function of flowers. Share information about the function of flowers from the Background section at the end of this activity.

Long-Term Observations
Youth may not be aware that flowers are the predecessors to the emergence of fruit or seeds. To help them with this observation, in later sessions visit those trees that had flowers during previous field trips. On subsequent field trips, have the youth take pictures of low-lying branches where the flowers were in order to record what changes have happened.

Observing Behavior

There are two ways to get a sense of what youth are getting out of this activity:

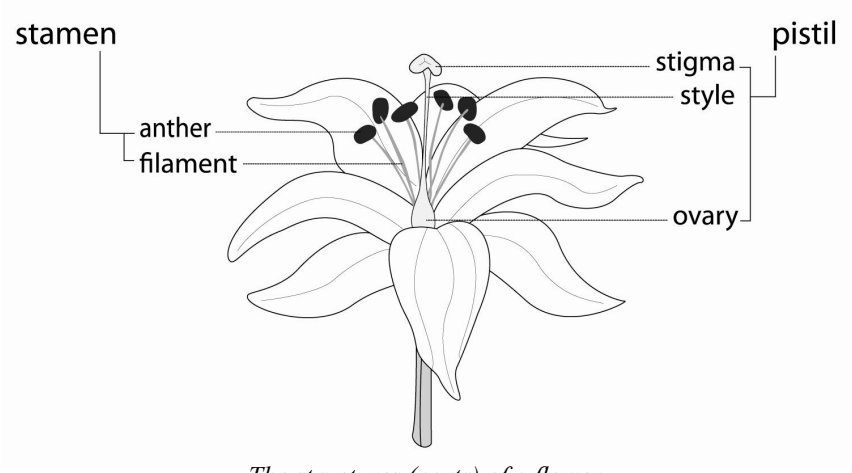
1. Observing how they examine and study the flowers:
   - Are they careful in their handling of flowers, given the flowers' delicate structure?
   - Do they use the stereoscope to look at the finer details of the flowers?
   - Do their drawings have details showing all the parts and in a relative scale?
2. Listening to how they talk about the role of flowers in the life of a tree

There are at least two understandings that the youth should come to develop:

1. The tree is using a great deal of its energy resources to produce so many flowers.
2. Flowers are the predecessors to the formation of fruit or seeds.

Background[1]

When considering all the plants of the world, the size and shape of flowers vary greatly. During the spring, one can observe very prominent colorful flowers, such as those on a crabapple tree. But other trees also have flowers that are barely visible.



The structures (parts) of a flower

Flowers contain several parts. As shown in the figure above, the stamen is composed of the anther and a supporting structure called the filament. The pistil is composed of the stigma, the style, and the ovary. Note: Not all flowers have all of these standard parts—in fact, there can be great variation.

The anther produces a very fine dust-like material called *pollen*, which has the chemical material required for the reproductive process. (The flower is the means of reproduction for trees and other plants. Some flowers are single-sex, while some trees have flowers of both sexes. These sexual organs also can vary a great deal among the plants.) The pollen must make its way to another part of the flower, the stigma, where it moves down the tube-like structure of the style to the ovary to bring about fertilization, which furthers the reproductive process. After fertilization,

[1]Some material in this section was adapted from Tudge, C. (2005). *The tree: A natural history of what tree are, how they live, and why they matter*. New York: Three Rivers Press.

the ovule (or egg) becomes the seed and, in some cases, may grow into a fruit. Most trees do not allow self-fertilization, so the pollen must be transported in some way to other trees, where it will meet the stamen of other same-type flowers to create seeds.

The flower petals attract insects, such as bees, and animals, such as birds and bats, to them because of their color and nectar. As creatures move from flower to flower, they pick up some of the pollen. When they visit another tree, some of the pollen rubs off or falls off and may find its way to the stamen of other flowers. The pollen makes it way to the inside of the stamen and travels down the pistil until it reaches the ovary, where it fuses with the ovule. Eventually, that fertilized egg grows into a seed or fruit.

You can find more detailed information about the structure and function of flowers online. One helpful resource is http://leavingbio.net/FLOWERING%20PLANTS.htm.

Seeds: Emergence and Germination

Rationale

One of the noticeable changes during the spring is the emergence of seeds. Some trees such as maples produce many seeds that hang from their branches. This event can be a concrete context for discussing several adaptive characteristics of trees and other kinds of plants. Youth can pay attention first to the manner in which the seeds emerge and then to the way the seeds are dispersed.

This is also a great time for youth to think about the germination of seeds. What are the conditions that bring about germination? It may not be as simple as youth may first imagine. Seeds from certain species of trees need more than just access to water and light in order to germinate. The timing of germination is a critical matter for the plants' survival. Some of these considerations can be investigated by the youth.

The guiding question in this activity is: **When do trees produce seeds, and what conditions bring about the germination of the seeds?**

Materials

For each youth:

- Plastic sandwich bag
- 2 or 3 plastic cups (12-ounce)
- 2 or 3 craft sticks (e.g., popsicle sticks)

For the whole group:

- Masking tape
- Field guides to trees
- Binoculars
- Digital cameras
- Potting soil for planting seeds
- Access to a computer/printer
- *Optional:* Vegetable and flower seeds

Preparation

Prior to your field trip, research with the youth—by using tree guides, contacting your local forester, or checking on the Web—which trees should be bearing seeds. Your local forester will have the most up-to-date information based on your specific location.

During this activity, you may want to provide vegetable and flower seeds to the youth because tree seeds are unpredictable in their germination. Adding these other seeds ensures that the youth will be able to see some seeds germinate and grow.

Introducing the Activity

Start off by asking youth how trees produce new generations of trees. Youth will probably mention seeds. Point out that trees use up lots of energy, which they would usually use to survive, to produce seeds. Trees have built-in mechanisms for how and when they produce seeds.

You can show photos that youth may have taken in the fall or spring showing trees bearing seeds, or you can use photos from the Photo Resource Gallery titled Seeds located at the end of this guide or on the *Exploring Trees and Ponds* website (http://treesandponds.edc.org). Zoom in to the photos of a few branches of a tree so that youth can get a sense of the large number of seeds that can be on a tree. The photo below shows a large number of maple seeds on one branch. If you didn't do an estimation in the fall (see the *Fall Trees Activity Guide* of this series) or on one of your other spring trips, challenge the youth to estimate the total number of seeds on one of the trees in the photos. The goal of this challenge is to make youth more aware of the very large number of seeds on a tree and the amount of energy that was expended by the tree to produce this large number.

Start a discussion by asking the following questions:

- Do all trees produce seeds in the spring?
- What would be the relative advantages or disadvantages of producing seeds at this time of year?
- Do conifers or evergreen trees produce seeds, and if so, when?
- Is there a relationship between flowering and the production of seeds?

During the Field Trip

Late spring (early May) is often the best time to take a field trip to look for and collect seeds. (If you are located in the southern United States, seeds may appear earlier.) If you are taking local field trips on a regular basis, take note of the changes to the trees so you can figure out when there will be plenty of seeds for youth to collect.

When the youth come upon a tree with seeds (as shown in the photograph below), have them observe the whole tree, paying close attention to the distribution of the seeds and their overall quantity.

Maple seeds

Source: http://www.flickr.com/photos/cygnus921/2393182545/. Photo courtesy of cygnus921.

Have the youth observe, photograph, and record the distribution of seeds on the tree. Ask them: Does every branch have seeds?

Ask them to think of a way to estimate the total number of seeds on an individual tree. They can first estimate the number of major branches, then the number of smaller ones branching off of the larger branches, and then the number of seeds on an individual branch. The goal of this estimation is to impress on the youth the large number of seeds that an individual tree produces.

During the field trip or on multiple field trips, try to collect as many kinds of seeds as possible. Although the general focus is on trees, encourage the youth to collect seeds from other plants that may be bearing them.

It is also useful to collect during these field trips seeds that fell from trees during the fall. These are usually browner than those that have recently fallen. They may also be slightly covered with dirt or leaves. Make sure that the youth put these in bags separate from those that have recently fallen.

NOTE: Seeds that have spent the winter on the ground may be ready to germinate immediately. In some instances, you may find some that have already sprouted. Take special care with these so that the roots and stems are not damaged when handled.

Hand out masking tape for youth to use to label the types of trees, their locations, and the date.

Long-Term Observations

There are two activities that can be done with the seeds.

Comparing and Contrasting the Seeds

In this activity, youth consider the sizes and shapes of the seeds:

- How do the seeds compare in size? Is there any correlation between the size of the tree or plant and the size of the seed?
- How do the shapes of the seeds compare? Does the shape of a seed have any relationship to the way it is dispersed?

Point out that it is useful for the tree to disperse its seeds away from itself. (For instance, maple seeds have a special shape that allows them to spin and fall slowly away from the trees. Some other seeds are fuzzy and lightweight, allowing them to be blown a distance from the tree by the wind.)

Ask the youth:

- Could any of the seeds you collected be easily carried by the wind?
- Could any of the seeds be easily carried by birds or other animals?
- What kind of outer covering is on the seed? Is it hard or soft?
- (Suggest to the youth that they take off any covering and examine the inside of the seed.) What do the insides look like?
- Why do some trees produce very many seeds? What might their strategy be?

Planting the Seeds
Provide each youth with a cup filled two-thirds full with potting soil. Have each youth plant at least one seed in a cup. (If they have many types of seeds, make sure they plant only one type of seed per cup.) Ask them to label the cups indicating the type of seed and the date of planting. Also, when they add water, make sure they do not flood the cup.

NOTE: Discuss with the youth that there is a high probability that these seeds will not germinate, and their attempt will be looked at as a kind of experiment where negative results can be informative. But if you have room, have youth try planting multiple seeds, as this will increase the possibility that some will germinate.

Seeds Collected in the Fall
If you worked with this youth group in the fall (see the *Fall Trees Activity Guide* of this series) and collected some seeds at that time, this can be a time to remind the youth that you placed some of these collected seeds in plastic bags in the freezer so as to simulate what they would experience if they were left outdoors during the winter.

Have youth plant some of these seeds. Make sure that they label the cups to indicate that these seeds were collected in the fall (along with the type of seed and the date).

Here is an opportunity to have the youth think about and design experimental conditions for germinating seeds. Get them to discuss what seeds need to germinate. For instance, can they germinate without dirt? Will they germinate in the dark?

Let the youth decide on several different conditions, using the same kinds of seeds in each condition.

NOTE: Again, it is possible that the seeds will not germinate. Given this real possibility, you can also introduce at this time commercial vegetable and flower seeds, which can be planted at the same time. Therefore, if the seeds collected from the outdoors do not germinate, the youth can still observe the germination and growth of these other seeds. Also, in the *Seeds: Roots and Shoots* activity, youth will get to observe the growth of a plant very closely.

Discussion
After the youth have closely observed the seeds and attempted to germinate them, discuss two important things with them:

1. Some trees will bear many seeds, as youth observed on their field trip(s). Point out that the production of seeds requires the tree to use lots of the food that it is producing for survival. What could be reasons for the production of so many seeds?

   Related to this question is the survival of the seeds. Point out that some animals, such as squirrels and birds, will eat the seeds. Can this be a factor in why trees produce so many seeds?

2. The timing of a seed's germination is critical. Seeds germinating during the fall are doomed because of the upcoming freezing winter. Seeds germinating too early in the spring may also

be doomed because there may be days or nights when the temperature goes below freezing. Have the youth speculate about what the seeds might detect from the environment that could determine when they might germinate.

Observing Progress

There are two times to best observe youth's growing understanding of the role of seeds.

During the Discussions

- Do youth understand that the plant produces seeds as a means of reproduction?
- Do youth have some sense that producing large numbers of seeds is a strategy for dealing with the fact that some of the seeds will be eaten by animals and many may, in fact, not survive?

During the Long-Term Observations

- Are the youth faithful in watering and caring for their plants?
- Do they put forth explanations of why a seed did not germinate?

Seeds: Roots and Shoots

Rationale

Usually, the only parts of a plant visible above ground are the stems and leaves. Sometimes, the roots of trees and other plants are partially visible above ground. However, in most cases, one can only guess how many roots there are and how deep the roots of the plant travel into the soil.

In this activity, youth set up an arrangement that will allow them to observe the growth of the shoots and the roots simultaneously. They will track the relative growth of the shoots and roots of one kind of plant and observe their relationship (do the shoots grow faster than the roots, or vice versa, or at the same rate?). They will be able to see how the roots grow, observe how they differentiate in their branching and the appearance of root hairs, and observe how deep they grow.

This arrangement can also be a context for a discussion about what a plant needs to grow. In particular, there is often a misconception about the role of dirt. (Youth may believe that dirt provides food for the plant).

Since no dirt is used in this arrangement, a guiding question can be posed: **What does the plant need to grow?**

Materials

For each group of two or three youth:

- Piece of plastic cardboard (10 inches × 20 inches); available at some craft suppliers

NOTE: In place of plastic cardboard, you can use regular corrugated cardboard. However, you will have to set up the cardboard so that it does not get wet. Directions are provided below.

- Wallpaper tray (shown at right; can be purchased from hardware or big box stores, such as Home Depot)
- Seed (a good seed to use is the scarlet runner bean)
- Dowel (1 1/8 inch in diameter, 3 feet long)
- 8 binder clips (medium size)

Wallpaper tray

Photo courtesy of Bernie Zubrowski

For the whole group:

- Roll of clear plastic wrap (e.g., Saran Wrap)
- Grow lamp (if natural light is unavailable)
- White paper towels
- 4–5 boxes of T-pins
- Masking tape (½inch wide)

- Digital cameras
- Access to a computer/printer

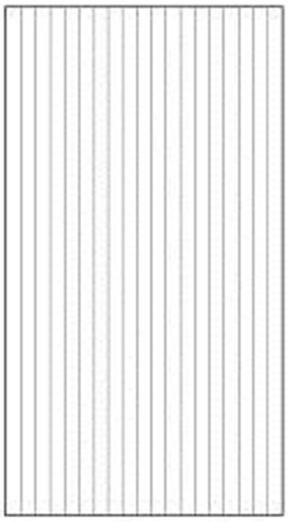
Preparation

Soak the seeds in water for several days before the session in which the youth will assemble their plant-growing structure. Presoaking will allow the youth to see changes in the seed more quickly.

To better help youth assemble their plant-growing structure, assemble one ahead of the session.

Assembling the Support Structure for the Growing Plant

1. Cut the plastic cardboard so that it is 20 inches tall and 10 inches wide. Make sure that the corrugation is traveling up and down, as shown below.

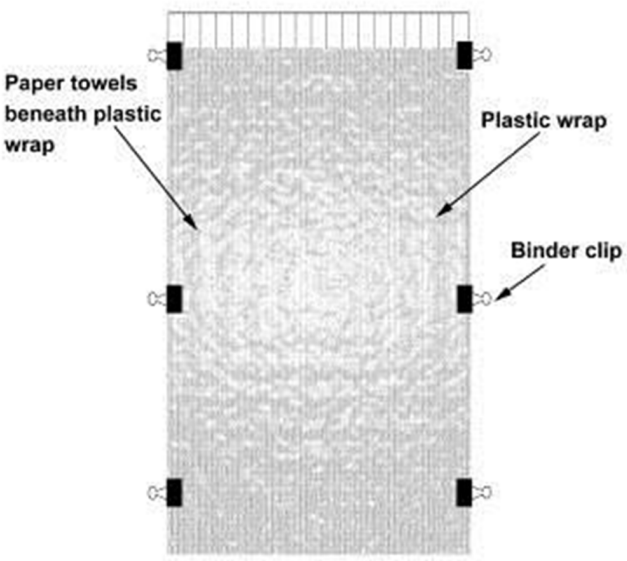


Plastic cardboard with vertical corrugation

NOTE: An alternative to the plastic cardboard is regular cardboard. Place a layer of plastic wrap on top of the cardboard before placing the paper towels on it in step 2.

2. Lay the cardboard on a table and place three layers of paper towels over the whole surface. Smooth out the paper towels so they lie flat.

3. Place pieces of plastic wrap over these paper towels so that the paper towels are covered and there is a slight overlap at both edges. Use the binder clips to hold the plastic wrap and paper towels in place. The complete setup is shown on the next page.



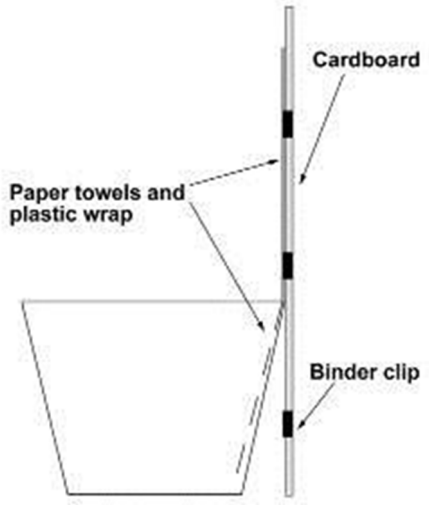
Complete setup, before seeds are added

4. Place this arrangement vertically in a wallpaper tray filled with several inches of water, as shown below. (You will have to lean the cardboard against a wall.) Pour water into the top of this arrangement so that all of the paper towels become wet.

The setup placed in the wallpaper tray

Photo courtesy of Bernie Zubrowski

NOTE: If you are using regular cardboard, don't place the bottom portion of the sandwiched arrangement in the tray with water. Instead, place the cardboard part outside the tray. Grab several inches of the sandwiched arrangement of plastic wrap and paper towels, and place this into the tray. (See the figure below.) The idea is to have the paper towels, but not the cardboard, under the water to act as a wick.



Alternative setup if using paper cardboard. Note that the cardboard is outside the wallpaper tray, but the paper towels and plastic wrap are inside the wallpaper tray.

5. Place a pre-soaked seed between the plastic wrap and paper towels near the top. Use T-pins to hold the seed in place (see figure below).

Secure the seeds with T-pins

Photo courtesy of Bernie Zubrowski

6. Place a 3/8-inch-diameter dowel into one of the corrugations (columns) of the plastic just above where the seed has been anchored. The dowel will support the stem and leaves of the plant as it grows (as shown in the figure below).

Place the dowel into the corrugation to help support the stem of the plant as it gets taller

Photo courtesy of Bernie Zubrowski

Space and Storage

You need to plan ahead in deciding where youth will keep their plant-growing structures. Find an area in the room where your sessions occur, ideally next to a sunny window and where other youth will not disturb the growing plants, and place the structures there. If you cannot place them near a window, you may need to set up a stand with a grow light, placing the groups' structures beneath the same light as best as you can.

NOTE: One field-test site was in a room without windows and without a grow light, but the plants nonetheless achieved some growth. It seems the fluorescent lights in the room provided the right part of the spectrum and a sufficient amount of light.

Introducing the Activity

Ask the youth if they have grown any kind of plant from seeds before. If they have, ask them to describe what they observed:

- What kind of plant was it?
- How big did it get?
- Did you get to see the root system?

Tell the youth that they will make a special structure for growing a plant where they can view the growth of both the top part of the plant and the bottom part—the root system. The structure will allow them to see how the root system grows in relation to the top part.

Show them the structure you constructed before the session. Have the youth form groups of two or three. Lead them through the steps for the construction as outlined in the Preparation section.

Once the structures have been assembled and the seeds added, have the youth place their trays and structures in the area you have selected for ongoing observation.

Tell the youth that they will check on the growth of their plants over the next few weeks. They will mark the growth of the shoot on the dowel with pieces of tape showing the date, and mark the growth of the roots with T-pins. The T-pins should also have a piece of tape attached with the date.

NOTES:

- To make useful comparisons of the youths' photos, explain the need to establish a set distance and height from the device from which they will take their photos. They should record this distance in their journals. For instance, they may decide to always take their photos from two feet away from their plants. Also, they might want to take two kinds of photos of the growing plant: a close-up of the roots of the plants, and a photo of the whole plant—stem and root. They can also take photos of the plant as it grows. In this recording, remind the youth to establish a distance and height from which they will take the photo. The idea is to generate a group of photos that can be compared easily.
- Care should be taken in the placement of the seeds between the plastic and the paper towels. Seeds should be placed at the very top so that they have access to air. If totally covered, mold can start to grow on them, halting their growth.

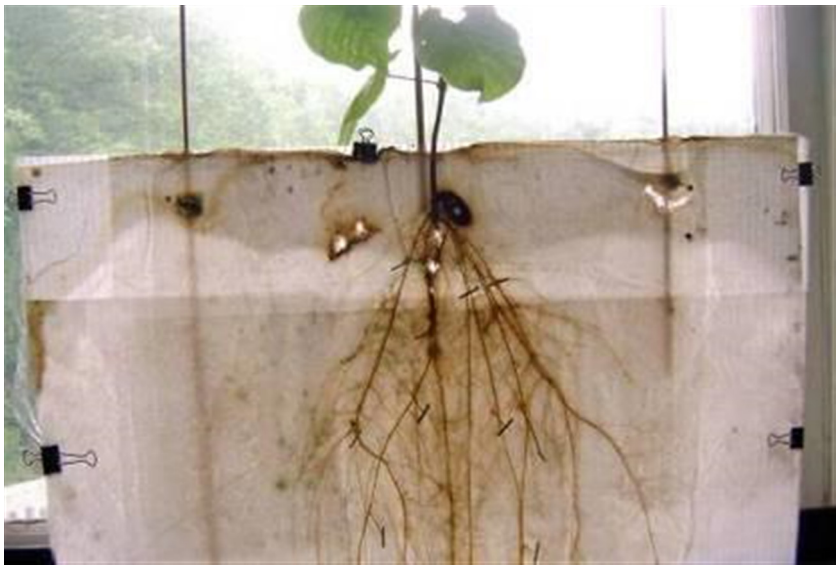
Follow-Up Observations

At each subsequent session with these youth, have them spend some time observing their plants, paying particular attention to the growth of the roots. Remind them to add a piece of tape to the dowel where the tip of the plant is and a T-pin where the tip of the roots is.

Youth also should be reminded to add some water at the top of the structure every time they meet, because the paper towel surrounding the seed can dry out quickly. This means opening the space between the plastic wrap and the seed slightly and pouring in the water. They should make sure to once again secure the plastic wrap around the seed to reduce evaporation of the water while still allowing air to circulate slightly to reduce the formation of mold.

NOTE: If you are meeting with the youth only once a week, you will need to make some arrangement so that the plants are watered in this manner every two to three days.

As the plant grows, direct the youth's attention to the way the root system is growing (as shown below).



A seedling showing the root system

Photo courtesy of Bernie Zubrowski

Point out the smaller root hairs of the roots and the way they are growing, as shown below.

A closer look at the smaller root hairs

Photo courtesy of Bernie Zubrowski

Follow-Up Discussions

The growth of the seeds may vary depending on the exposure to sunlight or a grow light. Take some time during each session to have the youth comment on what they are observing. After the plants have been growing for several weeks, have a discussion about what a plant needs to grow. Point out that every living thing needs some kind of food to survive. Since a plant is a living thing, how is it surviving? What does it need to survive?

The role of light and water may be readily apparent to the youth. However, there are some misunderstandings about the role of the water and whether or not a plant makes its own food. Have a discussion with them about the fact that no dirt is involved in this growing arrangement, so the plants are not obtaining any nutrients from soil. Point out the difference between nutrients and food. There are some essential nutrients (minerals) in the water that are needed for the plant to grow, but at the same time the plant is making its own food in the leaves of the plant. Water and a gas in the air (carbon dioxide) combine in the cells of the leaves to make a substance that is then used by the plant for its survival.

Observing Behavior

The particular plant-growing structure suggested for this activity allows youth to see the growth of roots and how they grow in relation to the shoot. Note to what extent the youth give attention to this relationship. Note also to what extent they give attention to the number of roots and the emergence of root hairs:

- Do they make drawings and take photos of the root system?
- Do they make spontaneous comments about how the roots are growing?

Background[2]

Plants take in carbon dioxide through a special arrangement in their leaves' cells and convert the carbon dioxide and water into a carbohydrate called *glucose* through a chemical reaction called *photosynthesis*. The roots supply water and nutrients, including some minerals and nitrogen, to the plant. This is a highly simplified summary of a very complicated process. The essential point is that the plant is making its own food, and the water and the nutrients assist in the production of that food.

Since the roots of the bean plant are so readily visible, this is a good opportunity to probe youth about where the roots are located with different kinds of trees. A common perception is that the largest roots extend deep into the ground. Recent research involving excavations indicates that some trees have tap roots (one long root extending vertically downward), but others do not. Lateral roots may extend far beyond the tree, and fine roots appear mainly near the surface. How the tree was started and where it grows can determine whether it will grow a tap root. For instance, oaks will more often grow tap roots, but maples will not. In highly compacted soil, roots will grow nearer the surface.

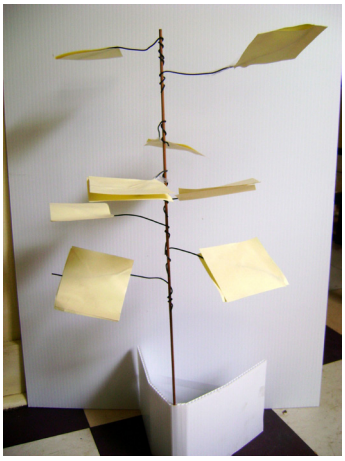
Point out to the youth that roots can serve more than the function of collecting water for the rest of the tree or plant—they can also be the site of food storage. A number of vegetables found in the supermarket—carrots, parsnips, and beets—are some examples of roots that function as food storage. Some roots, such as the beet, accumulate sugar, while others, such as orchid roots, accumulate starch. One advantage to having roots store the plant's food is that the plant is more protected from the grazing of animals and from the danger of drought.

[2]Sources: Gilman, E. (n.d.) *Where are tree roots?* University of Florida IFAS Extension, retrieved from http://edis.ifas.ufl.edu/wo017; Source: Coulter, J., Barnes, C., & Cowles, H. (1911). Ecology, Vol II. Woodstock, GA: American Book Company.

Leaves: Designing Leaf Arrangements on a Branch

Rationale

A superficial observation of trees might lead to the conclusion that the leaves on a tree are randomly arranged. Closer examination suggests that there appears to be some order to the arrangement, but it takes a careful examination to see that the arrangement has an overall design.



Youth will design their own branch and leaf arrangements.
Photo courtesy of Bernie Zubrowski

The following hands-on activity is a great way to get youth thinking about this characteristic of trees. Provide your group with some simple materials and challenge them to design an arrangement of leaves on a branch of a tree, deciding how the leaves would be placed on this branch. The goal is to have them think about how leaves are spaced on the branch so that they don't overlap and can have as much direct access to sunlight as possible.

A guiding question for this activity is: **How do leaves arrange themselves on a branch to capture the most sunlight?**

This activity is another way of focusing on the function of leaves on trees. It should precede the activity of observing the structure of leaves.

Materials

For each group of two or three youth:

- Dowel (1/8 inch in diameter, 3 feet long)—include additional dowels if you have time for groups to copy their branches
- 25–30 self-stick notes (3 × 3 inches)
- 2–3 feet electrical wire (22-, 26-, or 30-gauge)

For the whole group:

- Wire cutters, or scissors or pliers that can cut wire
- Portable electric light, as shown (as shown in the photo; make sure that the light has a receptacle and reflector that can be easily be moved)
- Access to a computer/printer

Portable electric lamp
Photo courtesy of Bernie Zubrowski

Preparation

To get a sense of what the youth will have to do, try your hand at designing a branch with leaves. See Introducing the Activity for directions.

Review photos of trees that youth have taken previously and choose ones that show the full canopy of a tree and that allow you to zoom in on some branches to see the arrangement of leaves. You can use these photos during the introduction to the activity. You can also collect some branches from different trees that have different leaf arrangements just before you carry out this activity with youth.

Introducing the Activity

Have the youth recall their observation of the trees on previous field trips by asking the following questions:

- What do you recall about the arrangement of the leaves on a tree?
- Are they random or is there some order?

Show photos taken previously by the youth and spend some time having them discuss how the leaves appear to be arranged on the trees. Call their attention to the fact that leaves are light-gatherers—they need to maximize their exposure to sunlight. Given this need, what is the best arrangement of leaves to allow the most exposure to sunlight?

Different-sized leaves on a single branch
Photo courtesy of Bernie Zubrowski

Have youth closely examine leaf arrangements on several different kinds of trees. First, have them observe the sizes of the leaves. Some trees may have leaves of different sizes, whereas other trees may have very equally sized leaves (see figure at left).

Challenge the youth to design an arrangement of leaves on a branch of a tree. This hands-on exercise can help them think about how leaves are arranged. Point out the materials youth will use: the dowel, the self-stick notes, and the wire.

Pose the challenge to the youth: **How can you design the leaf arrangement on a branch of a tree using these materials?**

Explain the use of each of the materials:

- The dowel will act as the branch.
- The wire will be the stem of the leaf.
- The self-stick notes will be the leaves.

How can they arrange the leaves so that they don't overlap very much and will be best exposed to the sun? In this situation, the portable light will act as the sun. After they have attached wire and sticky notes to the dowel, they can shine the light on their branch and see where the light

falls and whether most of the leaves are receiving some light.

Organize the youth into groups of two or three. Tell them to make some drawings before working with the materials. Encourage them to think ahead of how they will attach the wire and the sticky notes.

During the Activity

Observe the youth as they add the wire and paper to the dowel. Encourage them to stop occasionally and view the entire arrangement to see how they have aligned their paper leaves.

Testing Their Designs

Some youth may have difficulty keeping the wire from slipping on the dowel. Keep an eye out for this problem and provide some assistance. Youth can use tape to keep the wire in place.

Point out that the lengths of the wires acting as stems do not all have to be the same length.

When groups have reached a point where they think they have added enough leaves to their branch and have arranged the leaves in what they think is a good arrangement, tell them to use the portable light by holding it high as though it were the sun. Have them should place their designed branch into the light.

A completed leaf arrangement, from above

Photo courtesy of Bernie Zubrowski

A completed leaf arrangement, from the front

Photo courtesy of Bernie Zubrowski

As they shine light on their branches, have them ponder the following questions:

- Where is the branch on the tree? Is it at the top, in the middle, or on the bottom of the tree?
- When the light shines on the branch, are the leaves exposed to the light or are there some shadows on some leaves?
- Since the sun moves across the sky during the day, how does this movement change how the light hits the leaves? (They can simulate this by moving the light from one position to another while keeping it at the same height.)

After testing, youth should make some rearrangements of their leaves and test with the light again to see if they get a better result. If time permits and there is still a strong interest in the activity, have each group make copies of its branches. They can then test what happens when several of the same branches are placed close to each other as happens in a real tree. How much shadowing occurs from the presence of these other branches?

When all groups have designed and tested, reconvene the whole group and have small groups share their branches and report how well their arrangements worked.

Discussion

After the general sharing, ask the youth to reflect on what they have learned from this exercise:

- How important is it for leaves to be spaced apart and have a specific orientation to the sun?
- What arrangements seem to work best to maximize the exposure of the leaves to the sun?
- Does it make a difference where the branches are on the tree?

Point out that this exercise is an approximation of the situation with real trees. Real trees, as youth have observed on their field trips, have many branches and are oriented in multiple directions. For instance, some trees have lots of overlapping leaves, particularly at their tips. Given that the sun moves across the sky during the day, different leaves will be exposed to sunlight at different times and at different angles. Some leaves can function well in weaker

sunlight. Different trees have developed different strategies to deal with ways of gathering sunlight.

Redesign
If there is interest and time, you could have youth go back and rearrange their self-stick notes—or even add to or remove them—to see if youth can come up with a better arrangement based on what they observed from their previous designs.

Observing Behavior

This exercise allows you to get a sense of what information the youth have picked up on their field trips and how closely they have been observing trees and plants. It also can reveal how they are thinking about the function of leaves.

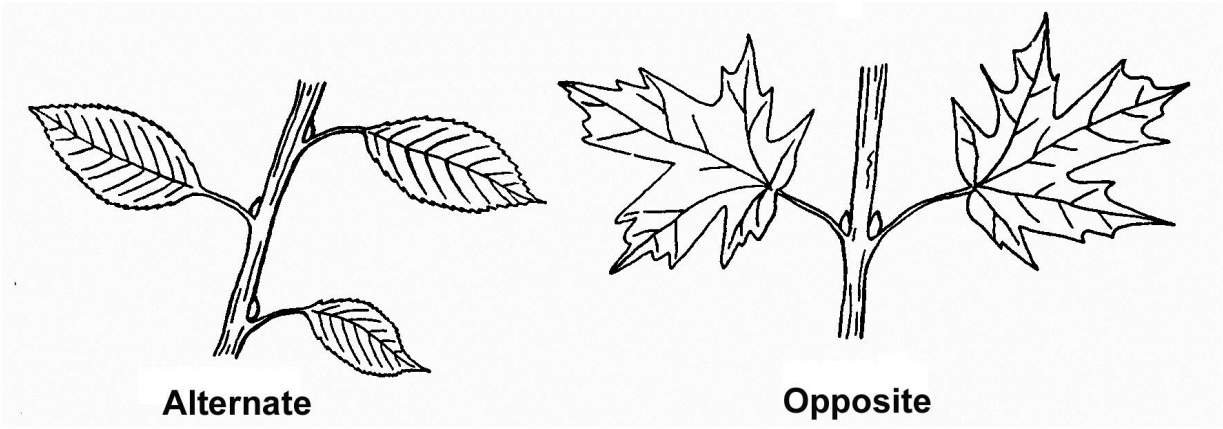
Listen to the youth talk as they go about designing and adding the materials to their branches:

- Do they approach this problem as a craft project where they are just adding the sticky notes to make it pretty, or are they talking about what is a good arrangement to catch the light?
- When they have added a number of the sticky notes to the dowel, do they stop and consider how these overlap or are spread out?
- When they use the light to see how it shines on their leaves, do they move the light around to see if it makes a difference?
- Do they make some connection between this exercise and what they have observed with real trees?

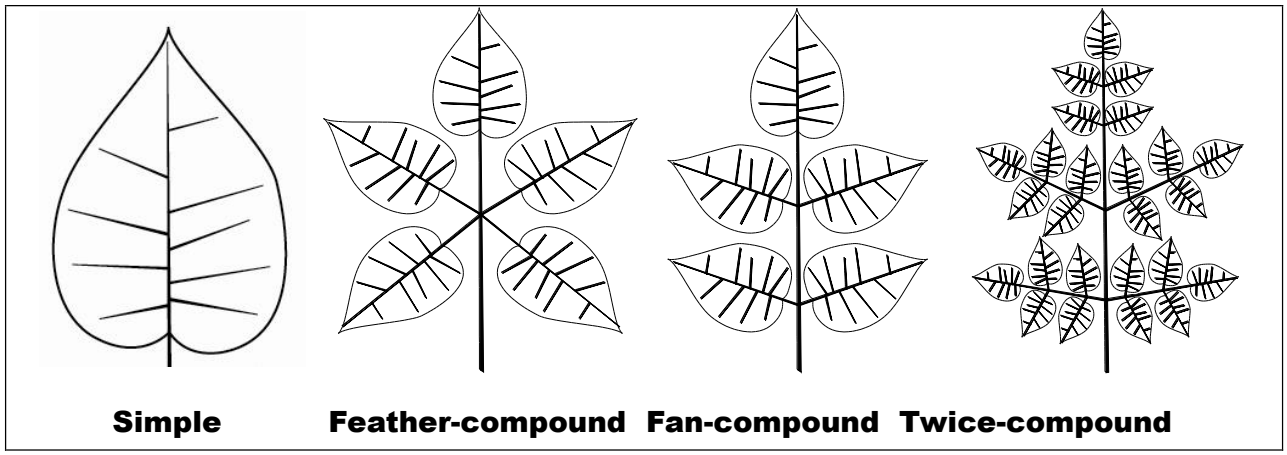
Background

Observing the arrangement of leaves on tree branches is useful in tree identification. Field guides to trees will show these arrangements and give a sense of the variation among trees.

Two broad categories of leaf arrangements are opposite/alternate leaves and simple/compound leaves (see figures below and on the next page).



Above image courtesy of Purdue's Department of Forestry and Natural Resources

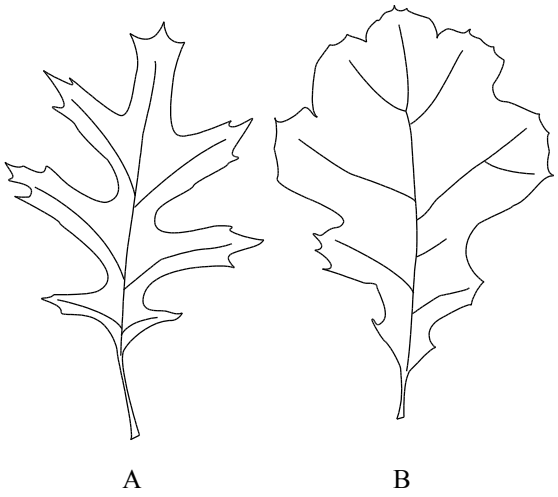


Leaves come in two types of arrangements: alternate/opposite and simple/compound (see previous page to view alternate/opposite).

Source: Coulter, J., Barnes, C., & Cowles, H. (1911). *Ecology, Vol. II*. Woodstock, GA: American Book Company.

The stalk attaching the leaf to the stem is called a *petiole*. On the same tree, the petioles may vary from short to long, particularly when the leaves are very close together. The petiole lengthens in order to help the leaf gain more sunlight.

Leaves on the same tree may also have different shapes. Lobes on leaves act as a way of reducing shading. The space between the lobes allows for light to get through to other leaves on the tree. Sometimes the shape of the leaf changes based on its location on the tree. Black oaks show this type of variation (see figure below).



Leaf variation in the black oak: (A) an upper leaf, exposed to strong sunlight; (B) a shade leaf from a lower branch of the same tree

Source: Coulter, J., Barnes, C., & Cowles, H. (1911). *Ecology, Vol. II*. Woodstock, GA: American Book Company.

For more information on the structure of trees, the shapes of leaves, and other interesting tree topics, visit the Butler University Freisner Herbarium website (http://www.butler.edu/herbarium/treeid/treeparts.html).

Leaves: Taking a Closer Look at Their Structure

Rationale

Upon closely observing a leaf, you will notice that the structure has an overall pattern and several parts and layers. You can see some of this structure without any magnification—but magnification can reveal a much finer and more organized structure.

By focusing on the leaf's structure, you can introduce youth to the system of distribution of substances in a tree and to the fundamental structure of all living things—the cell.

The guiding questions for this activity are: **What is the detailed structure of a leaf? What functions are related to this structure?**

Materials

For each youth:

- Plastic sandwich bag for collecting leaves

For the whole group:

- Masking tape (½ to 1 inch wide)
- Many different kinds of leaves
- Magnifiers
- Binoculars
- Microscopes or stereoscopes[3]
- Light meters
- Tree identification books or field guides
- Graph paper
- Crayons
- Whiteboard or chart paper
- Digital cameras
- Access to a computer/printer

Preparation

You will need a variety of leaves for this activity. You can collect these the day of the activity, or you can take the youth on a quick field trip with the specific purpose of collecting a variety of leaves to bring back to your program site for study. For purposes of comparison, collect leaves from trees as well as from flowering plants and other small plants. The greater the variety of

[3]Stereoscopes are useful for revealing the finer structure of a leaf. A microscope can reveal a little more. If you have access to either or both, include them as part of the available equipment.

leaves you can collect, the more interesting this activity will be for the youth. You can also include vegetable leaves, such as lettuce and spinach.

Make copies of the drawing on page 36 to pass out to youth later in the activity.

Introducing the Activity

Start a discussion about the structure of leaves by asking the group if all leaves have the same structure. Their size and overall shape may differ, but what about their inner structure and makeup?

Tell them that part of what scientists try to do is find what is common among a group of living things. One way of doing this is to first study one thing closely and carefully, and then to study other related things to see if there are similar patterns and structures among them. The youth's challenge for this activity is to find similarities and differences among the variety of leaves that they have collected.

Studying One Leaf

Discuss with the youth how they want to proceed. Should everyone observe a leaf from the same tree, or should each person pick any leaf? Suggest to them that for this first observation, it would be useful if everyone looked at the same kind of leaf (from the same plant or tree). They can then share their observations to find out if they have a fairly complete description. If they are going to compare their observations, they need to make a drawing and keep some notes.

Remind them that they have available magnifiers and stereoscopes (microscopes).

You can suggest two helpful techniques for seeing the internal structure of a leaf:

1. Hold up the leaf to a window or put it close to a light.
2. Put the leaf under a page of a journal and do a rubbing using the edge of a crayon. The larger veins of the leaf will show up.

As the youth make their drawings, observe whether they go beyond just including the larger veins. Make sure that the youth look very closely at the very smallest structures of the leaves where there appear to be no veins.

Discussion About One Leaf

When it appears that most of the youth have had a chance to make a complete drawing, bring the whole group together. On a whiteboard or large sheet of chart paper, make a large outline of the type of leaf the group chose to examine.

Have each youth come up and add an internal structure to the drawing. Have them start with larger veins and move to the smaller ones. They should also include the arrangement between the veins, even the very smallest ones.

Close-up views of the veins in a leaf. Note that the veins get smaller and smaller as they branch out.

Source: Flickr. The U.S. National Archives, Photographer: Charles O'Rear

At this time, you can have a preliminary discussion about the functions of these parts. Some youth may already know something about the veins. Have them share what they know with the whole group.

Tell the group that the veins are part of a distribution system of the plant. They are a way of bringing water and nutrients to the leaves from the ground, and they are a way of allowing special chemicals made in the leaves to be distributed to other parts of the plants, such as the trunk and roots.

Examining Other Leaves

Have the youth return to the selection of leaves. This time, have each youth pick his or her own leaf to study, following the same process the group used with the first leaf. Encourage them to look at several kinds of leaves and make drawings of them.

After the youth have examined several leaves, bring the whole group together. Ask them to share what they have observed. It should be apparent that there is a similar pattern to the skeletal structure of all leaves, as they all have an interconnecting system of veins surrounding various small circular-type shapes.

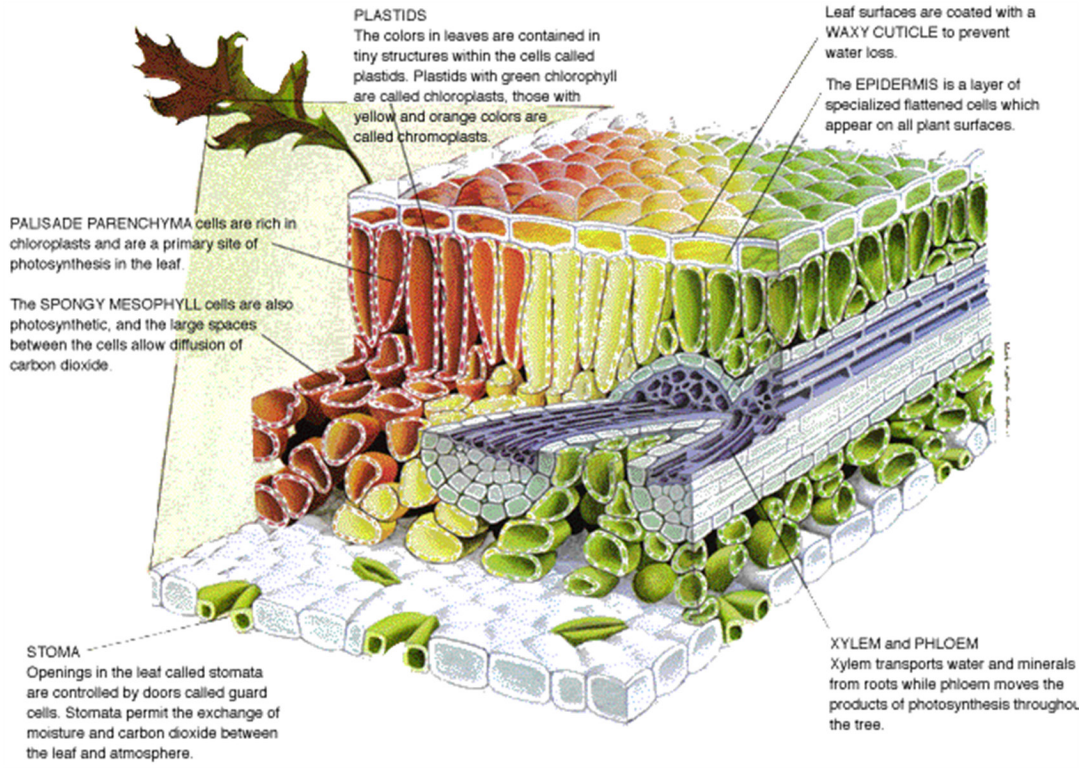
Discussion About the Structure of Leaves

Return to discussing the functions of the parts of the leaves. What do they see between the smallest sections of a leaf? Have them speculate about the cross section of a leaf. If they were able to have a way of magnifying the cross section, what would it look like?

Pass out copies of the drawing found on page 36, and give the youth time to study it. Discuss the different parts. In particular, draw their attention to the purple and white structures called the *xylem* and *phloem* and their functions.

Also point out that the leaves have openings on one side. The stoma open or close depending on the time of day and other factors, such as the amount of sunlight available. These structures allow carbon dioxide gas to enter the leaf and circulate around some cells.

Background



Close-up structure of a leaf, including the xylem and the phloem

As shown in the figure above, a leaf is a complex system of cell structures organized into several layers. Youth do not need to remember all the names of the different types of cells, but they should understand that all of these different layers exist. It is useful to point out that a leaf vein is composed of two systems: the xylem and the phloem. The phloem is the system by which the sugars produced in photosynthesis are transported to other parts of the tree. The xylem is the system by which water and nutrients are transported from the soil to the leaves. The xylem and phloem of the leaf continue through the stem of the leaf and then on to the outer bark of the tree.

For more detailed colored drawings of the structure of a leaf, see "Plants and Their Structure" from Dr. Mike Farabee's *On-Line Biology Book* (available at http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookPLANTANAT.html).

Leaves: Estimating Total Surface Area
(optional activity)

Rationale
Leaves are situated on a tree so that the tree as a whole can collect the most sunlight. Leaves' size, location, and orientation determine how much sunlight each can absorb. Youth tend to underestimate the number of leaves on a tree and the impressive surface area that these leaves provide.

Present this interesting challenge to the youth: Can you figure out the total surface area of all the leaves on a tree? How could you go about making a rough estimate of this number? The goal of this activity is to impress upon the youth the large number of leaves on a tree and that these leaves provide a large surface area for absorbing sunlight.

The guiding question for this activity is: **How many leaves are on a tree, and how much total surface area do they have to collect sunlight?**

Find a couple of trees, one small and one large—either just outside the building where you meet or out in the woods—to focus on during this estimation. Both trees should have many leaves.

During this activity, youth will carry out the following procedures:
1. While standing near the chosen trees, estimate the number of primary, secondary, and tertiary-branches on each tree.
2. Estimate the total number of leaves on the smallest branches.
3. Find a close approximation of the surface area of a large leaf and a small leaf from the selected tree.
4. Calculate the total surface area of all the leaves by multiplying the average area of a range of the large and the small leaf.

This activity can be challenging for youth who are not comfortable with mathematics. On the other hand, it is a concrete activity in which measurement and calculation can be useful in situations other than counting leaves.

During the Field Trip

Part 1: Estimating the Number of Leaves on a Tree
Take youth outside to the small tree you preselected. Have the youth make a quick rough estimate of how many leaves they think are on the tree. Let them share their estimates with the whole group and write their estimates in their journals.

Next, ask them how they might arrive at a closer approximation by figuring out a way to estimate the number of leaves on the various branches. Remind them that the idea is not to come up with a very close calculation but to get a "better than rough" estimate.

Have them break up into groups of two or three to discuss their strategy and the steps they would take. Have them share these with the whole group.

Here is one way they can go about this estimation (as described in previous activities):
1. Count the number of the largest branches on the tree.
2. Pick one of these largest branches, and use it to represent all the largest branches.
3. Count the number of branches coming off of this largest branch.
4. Pick a secondary branch and count the number of branches coming off this secondary branch.
5. Pick a tertiary branch off the secondary branch, and count the number of branches coming off this tertiary branch.
6. Pick one of these smallest branches and count the number of leaves on this smallest branch.
7. Multiply all of these to come up with an estimated number of leaves on the tree.

The idea is to narrow down the number of branches in a structured manner instead of counting all of the biggest and smallest branches on the tree.

Have the small groups share their new estimates and record them in their journals. Once the youth have done this for the small tree, move on to the larger preselected tree and have the youth make their second estimates.

When the youth are done, have them collect some different-sized leaves from these trees for later use.

Part 2: Finding the Surface Area of One Leaf

Remind the youth of their field trip challenge: to estimate the total number of leaves on a large and a small tree. To put the next challenge in context, carry out a discussion of the function of leaves as light-collectors and the role that light plays in promoting photosynthesis.

The amount of food the leaves make is a function of the amount of light they collect, which depends on the surface area of the leaf. Getting a sense of the total surface area of all the leaves on a tree provides some understanding of how trees survive through their production of their own food. Tell the youth that they can extend their original estimation and estimate the total surface area of all the leaves on a tree is. To do this, they must first find the surface area of a typical leaf.

How would they go about finding the total surface area of a typical leaf? Tell them that they can use the leaves they have collected from the trees and graph paper to carry out these calculations.

Give them a few minutes to discuss among themselves how they would go about doing this, listing all the steps that would be involved. You will probably need to help them think through the whole process, as some youth will have difficulty imagining it.

Have individuals share with the whole group the steps they think are involved. Compare their process to the steps listed below.

One way to approach the task of finding the average surface area of the leaves on a tree is to find the surface area of a large leaf and a small leaf from one tree, then take the average of the two.

To carry this out, they need to do the following:

1. Draw an outline of a selected leaf on the graph paper.
2. Count the number of full squares within the leaf outline and estimate the number of incomplete squares (for example, if the outline goes over five squares but does not cover them completely, you may estimate the area actually covered by the leaf to be approximately equal to two and a half full squares). Calculate the total area for this leaf by multiplying the area of one square by the number of full and incomplete squares. So if the graph paper has cells (squares) a quarter-inch in size, then 16 cells equal one square inch. To find the total area in square inches, divide the total number of cells (complete and incomplete) by 16.
3. Since all the leaves on a tree are not the same size, the youth need to determine some kind of average surface area. They can do this by finding out from other youth what the range of areas was from one of the largest leaves to one of the smallest. They can then choose a number that lies about halfway between these two extremes, or, to be more accurate, they can add the different areas and divide by the number of leaves used for the calculations to find the average. This number represents the average size of a leaf on one of the selected trees.

Part 3: Finding the Total Surface Area of All the Leaves on One Tree

Having arrived at a number representing the surface area of a typical leaf, tell the youth that they can now try to make an approximation of the surface area of all the leaves on a tree.

To make this calculation more concrete, ask the youth how this total surface area of leaves would compare to the surface area of the room they are currently in. Would all the leaves placed next to each other cover the whole floor, or would there be more leaves or fewer leaves? Have them discuss how they would go about answering this question.

Here is one way:

1. Find the total area of all the leaves on one of the trees by multiplying the area of the average-size leaf by the estimated total number of leaves (which they calculated during the field trip).
2. Measure the length and width of the room they are in, and calculate its total area.
3. Compare the total area of the leaves of the tree to that of the floor of the room.

Depending on the math ability of the youth, you may have to take them step by step through this process of calculations as a group.

Once they have completed all the steps, have the youth discuss whether they were surprised at the results. Point out to them again that the size of the leaves varies on a tree and that the amount of direct sunlight will vary on each leaf during the day. Nevertheless, leaves function as a very large food factory for the tree. You can also share with them the tree facts in the note below.

NOTE: We tend to hugely underestimate the total number of leaves on a tree. In his book *Trees: Their Natural History*, Peter Thomas gives some estimates for different trees:

- A large apple tree holds 50,000 to 100,000 leaves.
- A normal birch may average somewhere around 200,000 leaves.
- An old oak tree can have 700,000 leaves.
- A mature American elm tree may have somewhere around 5 million leaves!

Tell youth that there is more to consider about the distribution of leaves on a tree. In another activity, they will be challenged to design a branch or several branches on a tree, deciding how the leaves on the tree can be distributed.

Observing Behavior

For some youth this activity may be very engaging, while for others it may be frustrating and intimidating; doing it as a group process in an informal manner can make it less intimidating.

The first challenge is to figure how to break down the process of counting leaves into steps.

- Are most youth able to do this, or do they need a great deal of guidance?

They must then move through the steps, keeping in mind their goal and what they are trying to calculate.

- Are most youth able to move through the steps with little help?

Once they've completed the steps, they must multiply the numbers.

- Are most youth able to do these calculations?

You can point out that they can use this process in other situations. For instance, suppose they were in a sold-out stadium for a baseball or football game. How could they estimate the number of people who were attending the event? Do they suggest a process where they break down the stadium into smaller sections and then estimate the number of people in the smaller sections? Asking them to apply the process to a new situation can give you a sense of what they learned from this activity.

Trees: Designing a Tree

Rationale

Making a model of a tree is a great way to help youth consolidate their observations about trees and plants. You can give youth some simple materials and challenge them to design a tree that fulfills certain conditions. In the process of carrying out the design, they should recall all of their previous observations and discussions. The final product and their description of it can be a way of accessing what they have learned and understood.

This activity can be used as a culminating activity for a year-long project studying trees and plants.

Materials

There are various materials that can be used by youth in their construction of a model tree. The following are suggestions.

For each group of two or three youth:

- Aluminum pan (10 x 12 inches)

For the whole group:

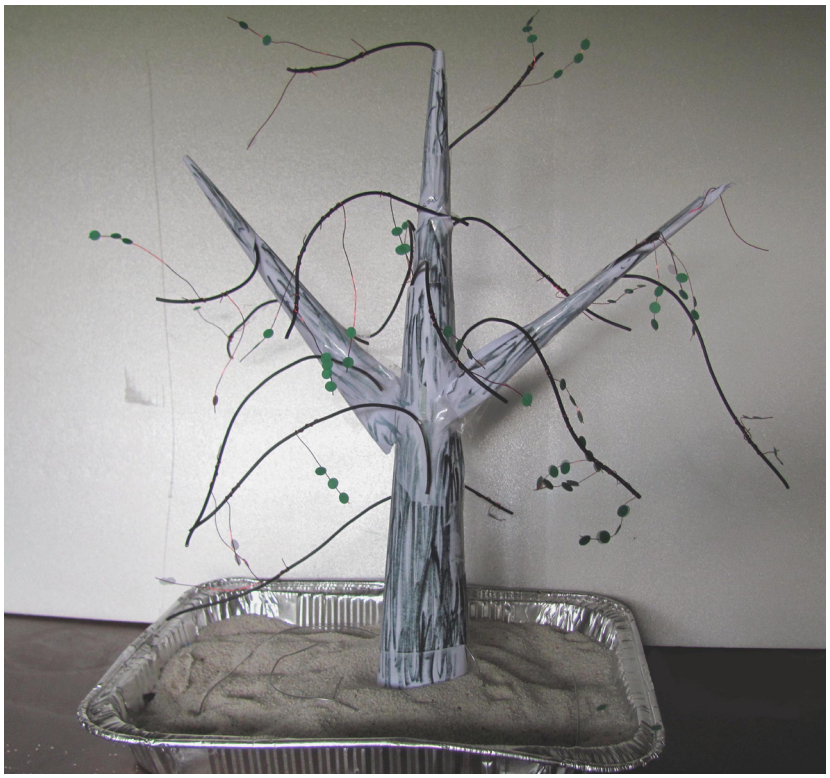
- 3 rolls electrical wire (22, 26, and 30 gauge; can be purchased at hardware stores or electronics stores, e.g., RadioShack)*
- 3 rolls hookup wire (20 gauge)*
- Paper (8½ x 11 inches; used/recycled paper is recommended)
- Dot stickers
- Rulers
- Piece of cardboard (12 x 12 inches)
- Digital cameras
- Access to a computer printer
- *Optional*: Bag of sand (to anchor the tree)

*A different-gauge wire is suggested to represent different thicknesses of branches.

NOTE: Sand is a messy material to work with, but it will add an interesting dimension to the activity. It challenges the youth to design a root system that will firmly anchor their model tree. It also helps them appreciate the important function of the root system. Roots are not only the means for gathering water, they also keep the tree standing upright—as does the sand.

Preparation

To get a sense of the project and anticipate any problems the youth may encounter, it is recommended that you make a model tree ahead of time (see the figure below), following the directions in the activity. In the process of building your model, determine if the wire you have chosen is relatively easy to bend and wrap around the other wires.



An example of a finished tree model

Photo courtesy of Bernie Zubrowski

Introducing the Activity

Tell the youth that they will make a model of a tree, using what they have learned from all their observations and discussions throughout this long-term project. To help them narrow down the type of construction they will make, ask them to refer to their journals and their photos to help them recall some of their observations.

Overall Structure

Ask the youth:

- What do you recall about the different arrangements of the branching of the trees?
- What do you recall about how the leaves were distributed on the trees?

You can also use photos from the photo resource section of the *Exploring Trees and Ponds* website (http://treesandponds.edc.org). There are a group of photos showing the overall shape of trees and a group of photos showing the branching arrangement of trees.

Having reviewed these two general characteristics, show the youth the materials they will use. Tell them they can roll up the paper to form the main trunk of the tree; use the wires to form the different branches of the trees; use the small stickers as leaves on the trees; and use the sand to anchor their models (which means that they should include some kind of root system).

Ask the youth what constraints they think they might encounter. Youth may worry that their trees will fall over without a suitable root system. Have them discuss how they might address this constraint.

Have the youth form groups of two or three and begin discussing in their groups how they will design their tree.

Remind the youth that they should think in terms of proportionality or scale for the trunk and crown of their tree. For example, one inch in height on their models for the trunk and main branches could represent one foot in the real world. A 12-inch model using this scale would represent a tree that is 12 feet high.

They should also think about and design a model tree for a particular type of environment. Ask them to consider the following questions:

- Where does the tree live? In a relatively wet or dry environment?
- Does it get lots of sun or only a little each day?
- Does it grow quickly or slowly?
- Is it an evergreen or a deciduous tree?

Encourage groups to make drawings before they start working with the materials.

During the Activity

Observe how each group is proceeding. Do the youth complete the main trunk with a root system before adding branches? Check with each group and make sure their root system is solid enough that their model won't tip over easily.

It would take a lot of time to add "leaf" stickers to all the branches of their trees. Tell the youth to pick one branch to show how the leaves would be arranged. Remind them of the activity *Leaves: Designing Leaf Arrangements on a Branch*. On the other branches, they can add just a few leaves or none at all.

Depending on the abilities and age of your youth, the construction may take one or more sessions.

Follow-Up Discussions

When all the groups have completed their constructions, have each group present its model to the whole group. Ask groups to share the following:

- What kind of tree did you intend to produce?
- Did you have any problems making parts of the tree?
- How did your group discuss and design the overall structure of the tree, the distribution of the branches, and the distribution of the leaves?
- What kind of environment does the model tree inhabit?
- How does their design take advantage of that kind of environment?

Observing Behavior

As mentioned in the rationale, this design project can be a culminating activity that challenges youth to utilize their observations and discoveries from all the previous activities.

Listen to their comments as they start their design and as they construct their model:

- To what extent are they approaching the project with a sense of the structure of a tree and how it functions?
- Are they approaching it as a craft project or a science project? For instance, do they give special attention to the root system? Is their tree able to stand on its own without being taped down?
- If you have them place it in a shallow container of sand, does the tree remain standing?
- Does their branching system include primary, secondary, and tertiary branches (in other words, are there smaller branches coming off the larger branches)?
- Does their use of the small stickers indicate that they have thought about leaf arrangement?

PHOTO RESOURCES GALLERY: Tree Shapes

How to Use Tree Shapes Photos

A typical simple drawing of a tree in cartoons and in children's literature usually shows a rounded shape for the tree's canopy. This shape tends to be what we picture in our minds when we think of a tree. However, trees come in a variety of shapes, which becomes apparent when one starts to look more closely and make comparisons. This photo gallery presents a few of these different shapes, ranging from spherical to conical or columnar. Some photos of the same species of tree, some single and some in groups, show slight variations of shape within that species.

You can share this set of photos with youth after they have been on a few field trips and have recorded their own collection of shapes. They can compare and contrast the types of trees they have observed and recorded with the ones shown in this set.

One engaging way of showing these photos is to present to youth photos of two trees at a time. (Some software will allow you to do this.) These two photos can be of similar or very different tree shapes, and their juxtaposition will accentuate the similarities or differences.

There are two ways to ask youth to react to these photos.

1. Have them take on the viewpoint of an artist. What trees would they prefer to draw or paint? What is appealing about some trees compared with others? What kind of feelings do they have about the tree?
2. Have them take on the viewpoint of a scientist. What can the shapes of the trees tell them about how a specific type of tree grows? Does it appear to grow slowly or quickly? Is it a type of tree that will stand strong under very strong winds?

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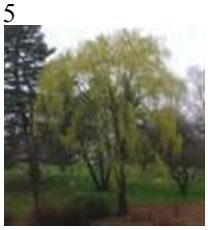
5 

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For full size images, visit the Photo Resources section of the http://treesandponds.edc.org site.

PHOTO RESOURCES GALLERY: Branching

How to Use Branching Photos

Winter is a good time to observe the "skeletal" structure of the overall branching of trees. Take youth out during this time and have them adopt a tree (see the fall activity *Field Trip: Adopt a Tree*) and photograph this tree to compare with other trees with different branching arrangements. After they have assembled their own collection of photos, you can share this set with them, which shows some of the different branching patterns of broadleaf trees.

Here are two ways that you can introduce these photos and engage youth in a discussion about them.

1. Some of the trees can be thought of as a type of sculpture. The arrangements of branches can suggest states of emotion. Weeping willows can suggest fatigue or sadness. Lots of crooked branches can suggest a mysterious presence while all the branches of a tree pointing upward can suggest happiness or high energy. Challenge the youth to describe their own feelings through the photos they are viewing.
2. Look at the trees scientifically. Which type of tree appears to be the one that has grown quickly or slowly? Which type of tree appears to be most vulnerable to strong winds? You can also use this time to focus on the hierarchical pattern of the branches. How many primary (large) branches are there? How many secondary branches come off of this primary branch? What is the arrangement of the tertiary branches?

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For full size images, visit the Photo Resources section of the http://treesandponds.edc.org site.

PHOTO RESOURCES GALLERY: Curiosities

How to Use Curiosities Photos

Sometimes on field trips, youth may come across unusual happenings with trees. As shown in the photos within this set, one can sometimes observe the trunk of a tree pushing through or even enclosing a fence. Occasionally, one can also observe very large bumps on trees while the trees apparently still remain healthy. Given that these situations are unusual, it can be an opportunity to discuss with youth how trees adapt and survive.

Included in this set of photos are ones showing trees growing upside down. These trees were placed in this situation by an artist and are located at the entrance to the Massachusetts Museum of Modern Art in North Adams, Massachusetts. When originally hung in this arrangement, the branches were facing down vertically, but as one can see, the branches are starting to grow sideways and upwards. These photos were taken several years after they were hung in this way. This is an example of what is known as geotropism: plants have developed hereditary tendencies that make them sensitive to gravity. They recognize which way is up and know to grow in that direction.

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For full size images, visit the Photo Resources section of the http://treesandponds.edc.org site.

PHOTO RESOURCES GALLERY: Group Portraits

How to Use Group Portraits Photos

Landscaped parking lots (at shopping areas, surrounding parks, etc.) will often have trees planted in a row along the edges and sometimes within the lots themselves. Many times, these trees are all of the same species, and they were probably of the same age when planted. If these trees are positioned far enough away from each other such that their canopies do not merge, then each tree can be compared to the others in the group. This situation can provide an instance where youth can study variation within one species of tree. The overall shape may vary slightly and some branches may stick out, or one or two trees may have already died indicating that these trees were not as healthy as the others nearby.

When showing these to your youth, give them time to study one photo at a time. Challenge them to describe what differences they can observe among the groups of trees. Use the zoom function in your viewing software to get a closer look at the trees, which will help youth notice differences in the branching arrangements among the groups.

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For full size images, visit the Photo Resources section of the http://treesandponds.edc.org site.

PHOTO RESOURCES GALLERY: Roots

How to Use Roots Photos

In the city, roots are often hidden under concrete or asphalt, but in the forests, you can often find exposed roots. Using this photo gallery, youth can view roots that are exposed due to erosion. In several of the photos, a tree is shown where much of its roots are exposed, showing very large roots near the surface.

Youth tend to have a conception that tree roots go very deep into the soil. These photos can show them that just below the floor of the forest is a tangle of very shallow roots.

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For full size images, visit the Photo Resources section of the http://treesandponds.edc.org site.

PHOTO RESOURCES GALLERY: Seeds

How to Use Seeds Photos

Some trees put out seeds in late spring and during the summer. More noticeable are trees such as oak and beech that produce there seeds in the fall. This photo gallery shows several kinds of trees bearing seeds. As can be seen in the photos, some trees have seeds on all the branches while others have seeds (cones) only on the top branches.

Using these photos, have youth make estimates on the number of seeds produced by a tree:

1. Use the zoom feature in your photo software to enlarge the photos to view one or several branches of a tree.
2. Estimate the number of seeds on this section of the tree.
3. Estimate how many branches are on the tree.
4. Multiply these two numbers to arrive at a rough estimate of the number of seeds on the tree. Youth will find that there are many hundreds. Given that producing seeds takes energy away from the growth of a tree, have youth think about what the value is for the tree of producing so many seeds.

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For full size images, visit the Photo Resources section of the http://treesandponds.edc.org site.

PHOTO RESOURCES GALLERY: Flowering Trees

How to Use Flowering Trees Photos

In the spring, some broadleaf trees put on colorful displays of flowers. In urban and suburban locations, people have planted many ornamental trees, such as crabapples. These trees are not usually local (native) species but, rather, they were selected because of their colorful displays in the spring. When viewing the photos in this gallery, use the zoom feature in your viewing software to get a closer view of the different flowers.

Challenge youth to estimate the number of flowers produced by the tree:

1. Estimate the number of flowers on one branch of the tree.
2. Estimate the number of branches on the tree.
3. Multiply these two numbers to get a rough estimate of the total number of flowers.

After youth estimate the number of flowers, have a discussion of why the tree produced so many flowers given that much of its food supply was used up to carry this out.

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For full size images, visit the Photo Resources section of the http://treesandponds.edc.org site.

PHOTO RESOURCES GALLERY: Fall Changes

How to Use Fall Changes Photos

In some parts of the country, fall is a time of very colorful displays. This is particularly true in the northern United States. This set of photos shows the range of colors (variations of red, orange, and yellow) that appear on the leaves of trees in the fall.

One group of photos shows change within a group of trees over 10 days in October. Another group of photos shows a change in one tree over eight days.

These photos can be used to discuss the pigments that are in the leaves of broadleaf (or deciduous) trees. They can also be used to discuss how broadleaf trees prepare for the coming winter. Youth can speculate what changes in the environment bring about this change.

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For full size images, visit the Photo Resources section of the http://treesandponds.edc.org site.

PHOTO RESOURCES GALLERY: Bark

How to Use Bark Photos

During your field trips to a forest or local neighborhood, youth will probably take photos of the bark of some trees. Unless you are located in an area with a particularly large variety of tree species (perhaps you are near an arboretum), the variety of bark that youth find will probably be limited. This set of photos shows a range of colors, textures, and shapes. After youth have put together their own collection of photos of bark, you can share with them these photos.

When showing these photos, have youth speculate on the adaptive characteristics of the different kinds of bark. Does it make a difference to a tree if the bark is one color or another, or if the bark easily peels? What function does the bark perform for the tree?

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For full size images, visit the Photo Resources section of the http://treesandponds.edc.org site.

PHOTO RESOURCES GALLERY: Vines

How to Use Vines Photos

You can use this photo gallery to discuss the fact that there are other plants that grow on trees, including vines, and in some situations, these plants can cause the trees to die.

On your trips to a forest, you may encounter some of these interesting vines growing up trees. Youth are often fascinated by these curious plants.

You can use this set of photos of vines to discuss possible enemies of trees. What survival strategies do trees adopt to deal with the overgrowth of vines? What happens if vines grow abundantly on a tree, covering the entire trunk and making their way into the leaves at the top? Will they eventually strangle the tree?

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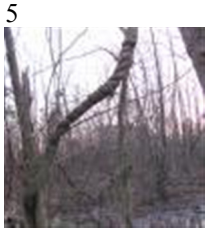

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For full size images, visit the Photo Resources section of the http://treesandponds.edc.org site.

PHOTO RESOURCES GALLERY: Ice

How to Use Ice Photos

Trees have evolved over millions of years to have developed arrangements of leaves and branches that can function well in particular kinds of environments. It can be said that they have developed forms that anticipate weather conditions. For instance, some evergreens in snowy climates have branching arrangements that allow snow to fall off easily. However, there are sometimes rare weather events that can wreak havoc with trees. Sometimes during the winter, when the temperature is hovering at the freezing mark, precipitation falling as rain freezes on contact with everything, including the branches of trees. If the precipitation lasts long enough, enough ice can form to cause even the largest tree branches to break, and in some cases, an entire tree can be destroyed.

This set of photos shows the aftermath of a December ice storm in the area northwest of Boston, Massachusetts. Branches from many trees were broken. As one photo shows, branches on birch trees were completely bent over. And, in another photo, a tree having two very large branches was split in half.

These photos present a situation for discussing with youth the types of strategies that trees have evolved in order to survive. For instance, some trees growing in a clearing in the forest can grow very quickly since they do not have competition. However, if they grow very quickly, they might put out thin branches and have a thin trunk. This allows them to keep reaching for the sun beating out other trees, but it also makes them more vulnerable to extreme weather, like this ice storm.

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For full size images, visit the Photo Resources section of the http://treesandponds.edc.org site. All photos in the photo resource gallery are courtesy of Bernie Zubrowski.

The *Exploring Trees and Ponds* Series: Activity Descriptions

FALL TREES

Field Trip: Exploring a Forest
An excellent way of starting off the whole project is to take a trip to a local forest. Youth make on-site observations to help gain an overall picture of trees and plants, their habitats, growing conditions, etc. Careful planning for this trip will make it productive and motivating for the youth.

Field Trip: Exploring Your Neighborhood
Youth become acquainted with the trees and plants in their local neighborhood. Since these are readily accessible, they can be the subjects for long-term observations. Youth observe changes during the seasons and thereby gain a sense of how trees survive and grow.

Field Trip: Adopting a Tree
Youth adopt one or several trees in order to narrow their focus. Having been stimulated by several trips to their local neighborhood, they generate questions and then follow through by carrying out systematic observations through the seasons.

Trees: Observation Indoors
Youth compare and contrast changes that happen during the course of the project to small tree seedlings brought indoors. They also compare the environmental conditions that may affect when trees lose their leaves.

Leaves: Extracting Pigments
Youth crush leaves and other natural materials and soak them in different liquids. They then carry out the technique of chromatography to separate out the pigments for observation**.**

Seeds: Observing and Experimenting
Youth collect and plant seeds to investigate the experimental question of whether seeds will germinate right away or if they need a span of time to germinate.

WINTER PONDS

Observing Pond Creatures
Youth observe creatures as large as fish and tadpoles and as small as beetles and dragonfly larvae. Using an existing curriculum (developed for the traditional school context but easily adapted for out-of school and for different age groups), we provide suggestions for activities for long-term explorations of larger (fish, tadpoles, snails) and smaller (dragonfly larvae, daphnia) organisms.

Surveying Pond Water for Different Microorganisms
Youth observe samples of pond water using microscopes to see how many different kinds of very small organisms may be present.

Observing the Movement of Microorganisms
Youth use microscopies to isolate a few of the microorganisms and study how they move.

Visiting and Exploring a Pond
Using simple equipment, youth discover where different organisms are found in ponds and collect multiple samples to bring back to the center for a long-term exploration studying organisms in depth. The goal of this activity is to have youth witness the diversity that can be found in one kind of ecosystem.

Finding Out What Is in Pond Water Youth have collected specimens from a pond and have brought them back to their science center. Now they look at them more closely with magnifiers, examining how many different items they've collected and comparing and contrasting them.

Close Observations of Pond Organisms Youth observe their collected organisms very closely by placing one organism on a tray or plastic plate and then studying its body structure and other features using magnifiers. Youth keep notes of what they see and make drawings or take photos that they can share with the whole group during discussions.

SPRING TREES

Trees: Buds and Twigs
Branches from trees and bushes can be collected in the early spring, brought indoors, and placed in water. Youth can then closely observe the emergence of leaves and flowers. They can consider such questions as, Do the leaves on the trees all emerge at the same time or do some trees sprout leaves sooner than others? Do all trees produce spring flowers? What environmental factors may bring about these changes?

Trees: Exploring Their Flowers
On field trips, youth observe the emergence and timing of flowers on different kinds of trees. They also examine different flowers and get a sense of their structure. This provides a context for discussing the reproductive strategies of trees.

Seeds: Emergence and Germination
Youth collect seeds and attempt to germinate them. Youth may not be aware of the dormancy of seeds. Spring is a good time for youth to consider and study this property.

Seeds: Roots and Shoots
The roots of plants are not easily observed. In this activity, youth build a specially designed arrangement that allows them to observe the growth of roots and the correlation between root growth and stem extension.

Leaves: Designing Leaf Arrangements on a Branch
Youth are challenged to design the arrangement of leaves on a branch of a tree using simple materials. This exercise can help them see that there is order to the way leaves grow on trees.

Leaves: Taking a Closer Look at Their Structure
Youth's close examination of the structures of different kind of leaves, especially their cellular arrangements, can be the context for examining the micro-structure of trees and the distribution of water and food in trees.

Leaves: Exploring Estimating Total Surface Area (Optional)
Youth estimate the total number of leaves on a tree and then find the surface area of one leaf. Then they calculate the total surface area of all the leaves on a tree.

Trees: Designing a Tree
Using simple materials, youth are challenged to design their own trees.