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# Chapter 6. Trees

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## Introduction

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One of the authors remembers being quite confused the first time an adult told him, “You can’t see the forest for the trees!” In the study of natural history, ideally one would try to “see” both the forest *and* the individual trees, because there is much to learn from both. A given

schoolyard, of course, might not have a forest or even a small woodcut nearby, but most schoolyards will have at least some trees. So for the purposes of schoolyard investigations, we consider a wooded lot, a stand of trees, or even a single tree a “tree habitat.” Just one large tree

in your schoolyard can provide many opportunities for investigation and exploration.

Tree *parts* also provide many subjects for study. Trees vary widely in the features of their trunks, bark, leaves, flowers, fruits, and other parts. Some tree parts—such as flowers and fruits—are only visible at particular times of the year, but at *any* time of year *some* part of a tree will be available for study. A later section in this chapter presents more detail on tree parts.

The Appalachians nurture the most diverse forest vegetation in the eastern United States and are home to well over 100 native species of trees. In addition, many more non-native trees have been introduced. So there is enormous

variety in what you and your students may discover around your schools!

## A Seasonal Note

Like most of the plants and animals mentioned in this book, trees provide many warm-weather opportunities for inquiry. But teachers are sometimes at a loss for winter science lessons or activities. Trees are good for study and inquiry anytime! The suggested inquiries in this chapter should give you several ideas to keep your students practicing science skills in winter. (Please see the Seasonal Guide near the end of this book for other suggestions on winter topics.)

## Introductory Tree Inquiry

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### The Importance of Trees

*Start a study of trees by beginning with students thinking about how important trees are to us.*

Why are trees important?

What do you like about trees?

How is a tree important to you on a summer day?

What economic value do trees have? How are trees used by people?

How are trees important to the air we breathe?

What animals use trees? How?

What other plants use trees? How?

Can you think of any living things that are *neither* plant nor animal? If so, how do they use trees?

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## Trees and Their Surroundings

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Trees affect their physical surroundings and other nearby organisms. The following paragraphs describe a number of ways that trees do so.

- **Effect on sunlight and temperature.** A tree provides shade in a location that would otherwise be exposed to full sun. With less light penetration, temperatures are lower than the surroundings, and organisms living underneath the tree are shielded from heat and water loss.
- **Effect on soil moisture.** Evaporation from the soil surface underneath a tree is reduced, so this soil *may* be moister than surrounding soil. On the other hand, trees require a lot of water. Huge quantities of water are lost through openings in tree leaves in the process called **transpiration**. A large tree has a vast root system that may be roughly equated to the size of the crown (the spread of the branches) above the ground. These roots can absorb so much water that, during extended periods without rain, you may find that the soil under a large tree is actually dryer than the soil in surrounding areas.
- **Effect on wind.** A tree may serve as a windbreak, reducing the force of the wind and sheltering organisms from the dangerous effects of winter wind. Humans also benefit from trees serving as windbreaks. Various factors determine the value of a tree as a windbreak, including how fast it grows, its shape, its strength, and whether or not it is a deciduous tree.
- **Competition with other plants.** Plants that are growing under a tree compete with the tree for light, water, and nutrients. For example, you may notice that grasses grow less densely underneath some trees than in surrounding areas. In many cases the cause of this will be some combination of reduced light penetration and the use by the tree of available water and nutrients.
- **Benefits to other plants and fungi.** Some kinds of plants may be found in *greater* numbers underneath a tree, because they can tolerate the conditions (lower light, for example) under the tree more effectively than other plants (such as the grasses). Trees can provide places and support for other plants to grow. Some plants, rather than putting energy into making hard or woody tissue, rely on other plants or

structures to support their weight, diverting their energy into rapid growth, and elongating their stems. Japanese Honeysuckle, Poison Ivy, and grape vines are common examples of plants that will climb, wrap around, or drape themselves on trees. (See the section on Vines in the Fencerows chapter.)

Trees also provide special habitats for other small plants. In southwestern Virginia, mosses and **lichens** growing on the bark are readily found on the shady sides of trees. Fungi can be found growing on or under trees. Certain mushrooms, the above-ground reproductive structures of some types of fungi, may be found only under certain types of trees. Below ground, a type of fungi called mycorrhizae often live intertwined with tree roots in an interdependent relationship; neither fungus nor tree is able to grow well without the other.

- **Habitat for animals.** Trees provide perches, hollows, and nest sites for many different kinds of animals. Use of trees by birds is most familiar, but trees are also used by amphibians, reptiles, and mammals. Among amphibians, some salamanders, such as the **Redbacked Salamander**, use the underground tunnels left by decaying tree roots as retreat sites when conditions on the forest floor become too harsh (in hot, dry summers, for example). Some salamanders also climb trees at night to feed on insects or other **invertebrates** on the trees' bark, and some frogs spend much of their lives in trees. Among the reptiles, some snakes primarily live in trees. The **Rough Green Snake**, for example, hunts from tree branches and occasionally lays eggs in tree cavities. Mammals may dig burrows underneath the roots of trees, make nests in the branches, or find hollows inside the tree to occupy.

Trees also provide many nooks, crannies, and crevices for many smaller animals. The deeply furrowed bark of many older trees provides places for insects to hide, lay eggs, or form pupae—and consequently, for birds to forage. Underneath the bark, **bark beetles** excavate tunnels and chambers, while other beetle larvae burrow deeper into the wood of the

tree. Branches and leaves provide habitats for many other organisms.

Trees also provide building material (twigs and strips of bark) for bird and mammal nests, while insects such as paper wasps use wood from trees to make paper for their nests.

- **Food for animals.** Tree leaves provide food for an enormous array of insects. Some feed directly on the leaves while others are predators that eat the leaf-feeders. The leaf-feeders may mine the inner layers of the leaf, pierce the leaf and feed on fluids, or physically chew up the entire leaf. Some of these insects will hide underneath the leaves, fold them or roll them into homes, or camouflage themselves by looking exactly like a leaf or twig.

Many trees are flowering plants, so a variety of flowers are produced by trees. Some tree flowers provide nectar that attracts pollinating insects. (Other tree flowers are wind-pollinated and may produce a large amount of pollen, much to the distress of allergy sufferers.)

Trees produce huge quantities of different fruits—nuts, berries, and acorns—and seeds, which are nutritious and important food sources for many birds and mammals. In large forests, the number of acorns produced from year to year has a major influence on the health and population growth of many game animals, such as deer, turkey, and squirrel. Many insects also utilize tree fruits for food, and particular insects' life cycles are synchronized with the development of the fruit.

- **Role in soil nutrient cycling.** As with soil moisture, soil nutrients are affected greatly by trees. Trees absorb large amounts of nutrients such as nitrogen, potassium, calcium, phosphorus, and magnesium. Much of this material ends up in the tree leaves. Leaf fall and subsequent decomposition return these essential materials to the soil for use not only by trees but by other plants as well. The leaf litter accumulating under a stand of trees creates a habitat for various organisms; many of these, including bacteria, fungi, and many

animals, are involved in decomposing the litter, while others feed on the decomposers.

While leaf fall is most often associated with deciduous trees, conifer needles also fall off eventually and produce leaf litter. Coniferous leaf litter has different effects on soil and soil organisms, especially because it can affect the soil acidity, as indicated by soil **pH**. Coniferous leaves tend to be more acidic than deciduous leaves. Higher acid levels tend to slow decomposition, so the needles of conifers tend to take longer to break down.

## Changes as a Tree Ages

As a tree ages and dies, the ways that it provides or affects habitat change but do not become less important. The growth of trees may slow or cease due to changes in its environment. Possible changes include shading from other trees, drought, physical damage to the trunk or roots by natural or human causes, or attacks by bacteria, fungi, or invertebrate pests. Under such conditions, we say the tree is “stressed.” Stressed trees are often targeted by insects, many kinds of which seem to thrive on trees in a weakened state. It is not unusual to find insect pests in far greater numbers on trees experiencing environmental stress than on nearby healthy trees. As insects invade a weakened tree, the activity of woodpeckers and other predators attempting to reach these insects creates even more new habitats and points of entry.

Fungi also attack a tree as it ages. Thread-like fungal fibers penetrate the tree, releasing enzymes that help break down the wood and change it into a form the fungi can use. It is only when the fungi form conspicuous reproductive structures, like those of the plate-like shelf fungi, that we realize the fungi are there.

When a tree falls, it becomes a rotting log and home to even more organisms of decay and decomposition. New kinds of habitats for other organisms become available as the wood continues to break down. Worms, slugs, pill bugs, centipedes, millipedes, salamanders, and snakes all might be found in or under a log. As the wood continues to decay, it will eventually become indistinguishable from the soil around it.

## Trees and Their Surroundings Inquiries

**!** *When investigating trees, be on the lookout for Poison Ivy vines attached to the tree or growing nearby. See also the information on Poison Ivy in the Vines section of the Fencerows chapter. Also, remember that certain trees, such as Black Locust (discussed in the Fencerows chapter), have thorns. These lines of inquiries investigate different ways that trees influence certain aspects of their surroundings. Keep in mind, however, that, although the inquiries look at individual aspects of a tree's surroundings, in reality a tree is affecting all these aspects simultaneously.*

*The concept of a transect can be useful in measurements of trees' effects. A transect is simply a line along which you make observations or measurements or take samples. A transect line can be set up by tying a string to a tree trunk and stretching it away from the trunk. Measurements, such as temperature, can then be made at measured points along the string to help quantify the effects of shade, etc.*

*Useful materials: rulers or meter sticks, string, thermometers, soil thermometers (or roasting thermometers), trowel or shovel, anemometers (commercial or homemade—see Trees and Wind below), shoe boxes, Berlese funnel, pH paper.*

### Investigating Habitats and Food Provided by a Tree

*Have your students go out to a large tree growing in your schoolyard.*

Imagine this schoolyard without this tree.

How would this location be different if the tree were not here?

How would places to hide or eat be affected?

Examine the tree and describe how it provides *habitats* for animals, such as insects, amphibians, reptiles, birds, and mammals.

How do trees provide *food* for animals?

What parts of this tree could be eaten by different kinds of animals? Can you find any animals eating parts of the tree?

Can you find evidence that parts of this tree have actually been eaten?

What are some organisms that you can think of, or that you can identify through library research, that are associated with trees? Make a chart or poster to arrange this information.

What organisms can you *actually find* on the tree?

How does the habitat provided by trees change during the year? How does the food provided by trees change during the year? How do the habitat and food provided by a tree change as the tree ages?

### Trees and Sunlight

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

How does the tree affect the amount of light that reaches the ground underneath it?

Measure the area covered by the tree's shadow at different times of the day. Make a chart or graph to record and summarize the data.

How does the area affected by the shadow change during the course of the day?

How might plants living under the tree respond to these daily changes? How might animals respond?

How will this tree's shadow change with changing seasons? How could you measure this?

### Trees and Ground Surface Temperature

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

Make a graph showing the temperature changes, and describe the patterns you observed.

How might the temperature variation you observed affect where plants and animals are likely to be found?

How would you expect the temperatures you observed to change during the *day*?

How would you expect the temperatures to change during the *year*?

Try this same experiment, but measure air temperature one meter off the ground. Keep all thermometers shaded. How do your results compare?

*As a closing or follow-up activity, set up a temperature scavenger hunt. Designate boundaries, then turn your students loose with thermometers, pencils, and paper to find the hottest and coolest places in the schoolyard.*

## Trees and Soil Temperature

*Soil thermometers can be purchased at a reasonable cost from a science supply company or from (probably) your local farm or garden supply store. A soil thermometer looks just like a kitchen thermometer used for taking the temperature inside a roast or turkey. Alternatively, you can measure soil temperatures by using a trowel to cut a crease in the soil wide enough to insert a thermometer into the ground. Be sure to measure the temperature at the same depth every time.*

How do soil temperatures vary as you move away from the tree?

How will this variation affect plants growing here? Animals? Soil organisms, such as earthworms?

Where are soil temperatures the highest in your schoolyard? Lowest? How can you explain these observations?

## Trees and Soil Moisture

How do trees affect soil moisture?

How do sunlight and temperature affect moisture in the soil?

Where would you expect the soil to be moistest? Least moist? Why?

How could you measure soil moisture to test the hypotheses or guesses you just made? How will recent rains affect your measurements? How will time of day affect your measurements?

Do trees compete with surrounding plants for moisture? What might be the effect of such competition?

Even though a tree provides a lot of shade, how could it actually cause the soil to be drier underneath it compared with farther away? Can you find any evidence that this actually is happening?

How much water do you think a large tree needs daily to survive? See how your prediction compares to values given in reference books.

*(For more on water use by trees, see the line of inquiry entitled "Leaves and Water Loss" in the Tree Parts section of this chapter.)*

## Trees and Wind

*Inexpensive anemometers (wind-speed measuring devices) can be made from index cards, paper clips, and coat hangers. The Delta Education company of Hudson, New Hampshire, publishes a booklet on how to make them (this source is listed in the Additional Materials chapter of this book), or you may find instructions in other references. If you are able to find or make anemometers, have your students use them to investigate how wind and wind speed are affected by trees on your school grounds.*

Where are the windiest locations on your school grounds? The least windy locations?

What factors affect the wind speed on your school grounds?

What impact do trees have on the wind?

How important is wind to plants and animals?

What is "wind chill"? How dangerous can wind chill be to animals?

Do you have any sites on your school grounds where the wind is significantly affected by a stand of trees?

Do you have locations where planting a stand of trees could serve as a "windbreak"? What factors would be important for you to consider to answer this question?

How could these windbreaks save money for your school?

What kind of trees would you choose to plant in a windbreak?

What qualities of the tree type would be important to you in making this decision?

## Competition Between a Tree and Other Plants

How does the shade produced by a tree affect the plants that grow underneath it?

Do all plants require the same amount of sunlight in order to grow?

Can you find any plants that are growing under the tree but are not growing elsewhere?

Can you find plants that are growing in full sun but not under the tree?

How could we quantify these observations?

How do we know that the plants we find under a tree are there because of the *shade* created by the tree? What evidence do we have?

What other *tree influences* might affect the plants found around the tree?

What other *non-tree influences* might affect these other plants?

## Leaf Litter and Decomposition

**!** *When collecting leaf litter, caution students to be on the look-out for spiders, centipedes, or other stinging or biting organisms that might be hidden in the leaf litter (see also the section on Millipedes and Centipedes in the Roofs, Walls, and Eaves chapter). If you have a stand of trees in your schoolyard, you will have a source of leaf litter with which to investigate decomposition and recycling of the materials needed for plants. Using a shovel or trowel, carefully place cross-sections of leaves and soil in shoe boxes so that groups of three or four students can examine the leaves, either outdoors or back in the classroom. Be sure not to disturb the integrity of the layers.*

Describe the material in your box.

How does the material change as you go downward through the layers?

When do you think the leaves on the top fell to the ground?

What will happen to these leaves on the top over time? How do you think they will change?

Find some partially decomposed leaves in the litter layer. How are they different from the leaves on the top? How have they changed? Which parts of the leaves decompose first?

What factors do you think affect leaf decomposition?

What kinds of animals can you find in the leaf litter? What are these organisms doing here?

What does this habitat provide for animals?

Why is the decomposition of leaves so important in a forest ecosystem? What would the forest look like ten years from now if decomposition suddenly halted?

How is decomposition of leaves important in recycling nutrients (materials needed by plants and animals)?

What materials are returned to the soil through decomposition of leaves?

How can you find out more about nutrient cycling?

## Comparing Deciduous Leaf Litter to Coniferous Leaf Litter

*If you have both a stand of deciduous trees and a stand of coniferous trees, you will have an excellent opportunity to compare different types of leaf litter. Take your students to both sites and have them walk on both types of litter and make their own observations.*

How are the two types of leaf litter similar? How are they different?

Walk across each. How do they feel under your feet? Which is spongiest? Why?

*Have your students measure out equal amounts of leaf litter from the two sites and mix these into equal quantities of water. Use pH paper to measure the pH of the solutions.*

How does the pH compare at first?

How does the pH in the water change over several days? How can you explain this?

What is the effect of acidity on plants and animals? How could we find out?

How do the plants growing beneath conifers differ from those growing beneath deciduous trees?

How do the animals living in conifer leaf litter differ from those in deciduous leaf litter? *(You can use a Berlese funnel to separate organ-isms from the litter. See the description of a Berlese funnel in the Collecting Insects section of the Fencerows chapter.)*

How can you explain these differences?

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## Tree Parts

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! As mentioned in the preceding section, “Trees and Their Surroundings,” watch for *Poison Ivy* growing on or around trees.

The different and distinct parts of trees offer a rich resource for learning about plant structures and functions in general, as well as about how trees specifically interact with their ecosystems. Tree parts are also a handy resource for learning about natural *diversity*, for two reasons. First, there is great variation among trees in leaves, reproductive structures, roots, trunks, branches, buds, and bark. Second, each kind of tree typically has many organisms associated with it, from fungi to insects to birds and mammals. Some of these organisms are unique to a particular kind or family of trees, while others may be less discerning. Investigations into tree parts lead easily into learning about the organisms that inhabit or make use of those parts.

This section is divided into seven topic areas: **tree shapes, trunks, bark, leaves, twigs, flowers, and fruits**. Collectively, these topics offer dozens of inquiry possibilities over all seasons of the year. We have compiled a number of possible lines of inquiry on these topics. Most of these inquiries require only minimal specific content information, because the questions ask about the particular characteristics of the trees and tree parts that students find and observe in their schoolyard. Before presenting the lines of inquiry, however, we have included some basic content points on each of the topic areas.

### Tree Shapes

- Tree species often have characteristic shapes, which in many cases can be used to identify the kind of tree.
- But growth conditions will affect shape. Trees growing out in the open, with of available light, tend to branch more laterally than trees of the same species growing within a forest.

### Trunks

- The trunk is the main stem of the tree.
- As the stem, the trunk provides an attachment point for branches and leaves, and it contains a system of tubes used for moving materials back and forth from the leaves and branches to the roots.
- The trunk grows laterally as well as vertically. In temperate climates, the lateral growth

results in the annual rings that can be used to estimate a tree’s age. In the tropics and subtropics, however, trees grow multiple rings each year.

- Different kinds of trees have different arrangements of branches on the trunk.

### Bark

- Bark is a protective covering over the trunk and branches. Removal of bark or holes in the bark makes a tree vulnerable to diseases and to insects.
- Different kinds of trees often have bark with characteristic color, patterns, or odor.
- The bark tends to be thicker on lower portions of the trunk and branches.
- Many animals—mostly insects—live in or under bark, sometimes on a specific kind of tree.
- Algae, mosses, and lichens are kind of plants that can be found growing on tree bark. In addition, some kinds of fungi—which are not plants—grow on tree bark.

### Leaves

- Leaves are the main site where the tree makes food in the process of photosynthesis.
- Most flowering trees are “broad-leaved,” meaning they have flat or broad deciduous leaves. In southwestern Virginia, most of the broad-leaved trees are deciduous, meaning they shed their leaves in the fall. Some other broad-leaved trees, however, such as hollies, are evergreen. Most conifers have needle-like or scale-like evergreen leaves. These leaves are shed periodically, although not all at one time.
- Needles may be in bundles or arranged along a twig in a characteristic way, such as spirals or circles (known as “whorls”) around the twig.
- In broad-leaved trees, leaf shape, arrangement, type of edge, and other features all vary depending on species, but the features follow recognizable patterns. These are important characteristics in identifying trees.
- Broad-leaved trees may have **simple** or **compound** leaves. Simple leaves are made up of only one blade; compound leaves have many blades, called **leaflets**, making up a single leaf. The distinction between

leaves and leaflets is important in distinguishing many types of trees.

- Two key features indicate a leaf instead of a leaflet: 1) If you break off a leaf, the twig has a “leaf scar” where the leaf was attached, showing a cross-section of the tubes that carry water and nutrients to and from the leaf; and 2) leaves have buds at the base of their attachment stalk, whereas leaflets do not.
- Leaf veins are extensions of the material transport tubes in the stem (which are seen in cross-section in the leaf scar). They carry water and nutrients to the leaf, and carry food produced in photosynthesis away from the leaf to the other parts of the tree.
- Broad leaves have openings through which gases (such as carbon dioxide) can be absorbed. In addition, however, water can be lost from the tree through these same openings. This water loss, known as transpiration, has important consequences for water use by the tree.
- Deciduous leaves change color in the fall when green-appearing pigments—the ones most involved in photosynthesis break down and reveal pigments of other colors (such as yellow, red, or orange).

## Twigs

- Twigs are extensions of the trunk and branches, and so they are part of the stem of the tree.
- Twigs are where new growth and development of tree parts occurs. Buds on the twig develop into new shoots (young stems), leaves, or flowers. Before the new growth or development occurs, the buds protect the immature structures.
- Buds and leaf scars on twigs are important characteristics used to identify deciduous tree types in winter or early spring, when leaves are not present.

## Flowers

- As in all flowering plants, a tree’s flowers are where sexual reproduction takes place.

- A given tree may have only one type of flower, with male and female parts, or may have separate male and female flowers. In some kinds of trees, male and female flowers are found on the same tree, while in other kinds of trees the two types of flowers are found on separate trees.
- Regardless of the type or location of flowers, pollination is necessary to get pollen from the male flower (or flower part) to the female flower (or flower part). Wind and animals, especially insects, are the two main means of pollination.
- Flowers’ showy colors, fragrances, and energy-rich nectar are ways that plants attract pollinators.
- Most schoolyard evergreen trees, such as pines and cedars, are conifers and do not flower. (For more on this topic, see the section on Eastern Redcedar in the Fencerows chapter.)

## Fruits

- Fruits are the structures that contain a flowering tree’s seeds.
- We usually think of “fleshy” fruits like an apple, but there are many kinds of tree fruits, including acorns, walnuts, and the “keys” of maple trees.
- If the tree does not flower, it will not produce a fruit. Conifers, such as pines and spruces, do not have flowers, so they do not produce fruits. Conifers’ seeds are contained in seed cones, rather than in true fruits.
- Fruits play a role in the spreading, or dispersal, of a tree’s seeds. As with pollination, seed dispersal in many trees relies on animals and wind (depending on the kind of tree). The winged fruit of maple trees is a good example of how to spread seeds by wind; those of cherry trees are a good example of how to spread seeds by animals, especially birds. (For more on this topic, see the section on Black Cherry in the Fencerows chapter.)

## Tree Shapes Inquiries

*Useful materials: Field guide to trees (see the Additional Materials chapter of this book for suggested references).*

### Characteristic Shapes of Trees

From a distance, look at the shapes of several different types of trees (e.g., a cedar, a spruce, an oak).

How do their shapes differ? How are they similar?

How are the branches arranged on the tree?

Do trees of the same type have a characteristic arrangement of branches? Explain.

Can you look at trees and find patterns that distinguish one tree from another? Try sketching the general pattern of these trees.

See if other students can use your pattern to identify the tree type. What features did they use to help them identify the tree by shape alone?

### Factors that Affect Tree Shape

What factors affect the shape of the tree?

How does growing against the side of the building affect the shape of the tree?

Compare the shape of a tree growing in the forest with the same kind of tree growing in an open field (choose a type of tree you can easily identify). How do the shapes differ? What could cause the difference?

Walk around your school grounds. Can you identify trees whose typical shape seems to have been affected by something? How have they been affected? What factors influenced their shape?

## Tree Trunks Inquiries

**!** *Watch for Poison Ivey growing on tree trunks. Useful materials: string, rulers or meter sticks, flexible tape measures.*

### Measuring Tree Trunks

*Diameter and circumference are two easy measurements for comparing trunk size. As a standard for comparing the mass of trees, professional foresters and ecologists measure the "diameter at breast height," or DBH*

How "thick" is the trunk?

What are different things we could measure to compare the thickness of the trunk?

How could you measure the diameter/circumference?

If you only had a piece of string and a ruler, how would you measure the circumference?

Where is the trunk widest or where is the circumference greatest? How does the circumference change as you move up the trunk? Why is this so?

If you want to compare the diameter/circumference of different trees, where on the trees would you measure?

How do the trunks of different trees compare?

What is the function of a tree trunk?

### Tree Age

*If there are any cut or fallen trees in or near your schoolyard, you can estimate their age by the well-known method of counting the annual growth rings. Alternately, ask a parent who cuts wood for burning in a wood stove to cut some 4 to 8 centimeter slices (cross-sections) of wood from the un-split trunk of a fallen tree. Request at least 10 slices so that students can work in groups of 2 or 3.*

How many years old was this tree when it was cut?

How do you know?

Did the tree grow the same amount each year?

In which year did it grow the most? The least?

What might cause a tree to grow a lot in one year and very little in another year?

List all the factors that you can think of that might affect how well a tree grows.

What else can the tree rings tell you about the life of this tree?

Where in the world would you find trees that do **not** show annual growth rings? In these places, what climate factors make the difference?

## Age of Conifers

*The age of many conifers can be determined by counting the number of whorls (levels) of branches radiating out from the trunk of the tree. A new whorl of branches is added each year; the distance between whorls indicates a year's growth of the trunk. White Pines show this most conspicuously (see also the section on White Pines, later in this chapter).*

How old is this tree?

How tall was the tree 3 years ago?

How tall was the tree when it was 5 years old?

Has it grown the same amount in height each year?

Choose two years in the life of the tree, one when it grew a lot and one when it grew less. Look for weather records and compare the rainfall, snowfall, and average temperatures of those two years.

## Tree Bark Inquiries

*Useful materials: field guide to trees showing photos of bark (see the Additional Materials chapter for suggested references), drawing paper, crayons (with wrappers removed).*

### Features and Functions of Bark

*Take your class outside to examine the bark of a tree.*

Describe or sketch the bark.

What color is it?

How does it feel?

Peel or break a *small* piece of bark off the tree. Smell it. Does it have a distinct odor? Try snipping off a small piece of twig and peel back the bark and smell it, too. Does it have a distinct odor?

How thick is the bark? Is it the same thickness everywhere? How does the bark thickness change going up the tree?

How does the bark of the tree you are looking at compare to the bark of surrounding trees?

What is the function of bark? What if the tree did not have any bark? Can you find any places on the tree where the bark was disturbed? What do you think caused this?

What effect does bark damage or loss have on the tree?

Does bark grow back over a damaged place? Can a tree heal itself?

What are some natural ways that trees are damaged? What are some human-influenced causes? How could human-caused damage be reduced?

### Bark Inhabitants

*Have your students examine the bark of a tree for organisms or signs of organisms living there. Be sure to look for eggs, egg cases, pupae, cocoons, and cast skins. In addition, you may find wastes from wood-burrowing insects or the remains of tunnels cut in the wood. You may also find plant inhabitants on the bark: lichens, moss, or algae (a green tint indicates algae).*

What organisms can you find on the bark of the tree you are observing?

If the tree is dead and you can peel back loose pieces of bark, look for organisms or clues to the presence of organisms that may have been there.

Sketch the organisms that you find.

Where did you find organisms or signs of them?

Describe or sketch the habitats that bark provides for various small organisms.

## Bark Rubbings

*Have students make bark rubbings by placing a piece of paper against the tree and rubbing it with the side of a crayon (with the paper wrapper re-moved). If possible, have a field guide to trees available for students to compare photos of different trees' bark.*

Describe the pattern produced by your bark rubbing.

Compare and contrast bark rubbings from different trees.

Exchange bark rubbings with another student. Can you find the tree or type of tree from which the rubbing was made? What were the key features that allowed you to identify it?

Could you identify a tree by observing the bark?

Do some kinds of trees have more distinctive bark than others?

As a project, make a collection of bark rubbings from different trees and display them beside the leaves of those trees.

## Tree Leaves Inquiries

*The possibilities for inquiry lessons based on leaves are not quite as numerous as the leaves on a tree, but almost! Deciduous trees will probably offer more options, but don't neglect the evergreens, especially in the winter. Useful materials: field guide to trees with good photos of leaves (see the Additional Materials chapter for suggested references), hand lenses, marking tape to tag twigs, weighing balances, graph paper, pH paper, water, Cobalt Blue Paper (see "Leaves and Water Loss" below for information on Cobalt Blue Paper), plastic bags, graduated cylinders (or narrow clear containers), rulers.*

### Investigating the Needle-like Leaves of an Evergreen

Are the needles arranged in bundles?

If so, how many needles are there per bundle?

Compare the number of needles in 10 randomly selected bundles.

Does the number of needles in a bundle vary on the same tree?

If the needles are not arranged in bundles, how are they arranged on the tree?

What is the shape of an individual needle? Can you roll it in your fingers?

Break a needle in the middle and look at its cross-section. How many sides does it have?

Do the needles from different kinds of evergreens have different cross-sectional shapes?

### Investigating the Broad, Flat Leaves of a Deciduous Tree

How are the leaves attached to the tree: opposite each other, in an alternating pattern, or circling the twig?

Is the leaf made up of a single leaf blade or of many leaflets?

Examine the leaf carefully. What is its overall shape?

Look at the edges of the leaf. Are they smooth or "toothed" (jagged)?

Compare several leaves from the same tree. Are they all alike? How do they differ? What features do they all have in common?

Sketch or describe the pattern of veins.

What is the function of a leaf?

What do leaves need to do their job? Where do they get the materials to do this job? How do these materials get to the leaf?

Compare the top and bottom of a leaf. How do they feel? How do they differ?

Use a hand lens to look at the leaf surfaces and edges closely. What does the hand lens reveal that you had not noticed before?

### Comparing Leaves from Different Trees

*Students will need to know the difference between a leaf and a leaflet (see the background information on leaves above, or the "leaf" entry in the Glossary). A systematic way to compare leaves is a **dichotomous key**, found in many field guides. A dichotomous key poses a series of*

questions about progressively more specific characteristics. For example: Are the leaves deciduous or evergreen? If deciduous, are the leaves simple or compound? And so on. See if your students can develop their own.

Compare leaves from different trees. How are they similar? How do they differ?

Take leaves from many different trees. How could you group them?

What features allow you to distinguish the leaves of one tree from those of another?

Can you come up with a system of questions and answers to distinguish leaves from different trees?

Try it!

## Observing Leaf Growth and Development

*Have your students tag a branch of a tree and watch the buds daily to see how they change and how leaves develop.*

How do the buds change over time?

What eventually appears from the buds?

How do the leaves change over time?

How fast do the leaves grow? Measure one each day and record its change in width and length.

## Tree Leaf Math 1: How Many Leaves?

*Lead your students through this procedure for estimating the number of leaves on a tree. The estimate can then be used in the other "tree leaf math" inquiries that follow.*

Look at a tree and make a guess of how many leaves are on the tree.

Estimate of the number of leaves: Count the number of leaves on one or more branches; determine the average number of leaves per branch; then count or estimate the number of branches.

Record your estimates on a class list. How much do the estimates vary among the class?

Can you think of a better way to make an estimate?

## Tree Leaf Math 2: Weight of Leaves

*If your students have made an estimate of the number of leaves on a tree ("Tree Leaf Math 1: How Many Leaves?" above), they can then estimate the weight of leaves on the tree. You can encourage students to work out their own plan to do this, but here is the basic procedure: 1) Use a balance to weigh enough leaves to get a reliable reading; 2) divide by the total number of leaves you weighed to get an average weight per leaf; 3) multiply this value by an estimate of the number of leaves on the tree to get an estimate of the total weight of leaves.*

How many grams/kilograms/pounds do you think the leaves in a tree weigh?

Design a method to estimate the weight of leaves in the tree. Does the total weight of the leaves surprise you?

What does the weight of these leaves tell you about the nature of the branches and trunk?

What might happen to a deciduous tree if the leaves did not fall off before winter snow (or ice) falls?

## Tree Leaf Math 3: Leaf Area

*If your students have made an estimate of the number of leaves on a tree, they can then estimate the total area covered by the leaves. The area of a single leaf can be estimated as follows: Place the leaf on graph paper; trace the outline of the leaf; count the number of squares inside the outline (use fractions for partially enclosed squares); then multiply the number of enclosed squares by the area of a single square. Graph paper with 1-centimeter squares works well. The area of one leaf can be multiplied by the estimate of the total number of leaves on a tree to estimate total surface area. Note: Plant scientists measure only one side of hardwood leaves in estimating the functional area, because the top surface accounts for most of the photosynthesis carried out by a leaf*

What do you think is the area of a single leaf (the top side only)?

Using graph paper, devise a way to measure the area of a leaf.

Do several leaves and determine the average surface area.

Now, what do you think is the *total* area of the leaves on a tree? How could you estimate this?

If you stretched this area out on a playground, how much area do you think it would cover? Express

your answer in square meters, then mark off this many square meters in the play ground. Are you surprised?

How does it help a tree to have a large total leaf area?

## Leaves and Water Loss (Transpiration)

*Method 1: Your students can measure water loss through leaf openings (transpiration) by the following method. Place a plastic bag around a group of leaves at the end of a branch and tie the bag off tightly with a piece of string or a "twisty-tie." Leave the bags on for one day or longer, then return to measure the water in the bags. If you have access to graduated cylinders, use them for this measurement, as the amounts of water will be small. If you don't have graduated cylinders, you can compare relative amounts of water in each bag by pouring the water into any narrow, clear container and measuring the height of the water column with a ruler. Try putting bags on the branches of different trees in similar locations.*

What do you see in the bags?

How did water get in the bags?

Is there enough water in the bags to measure?

Which trees released the most water?

What effect did location of the trees have on the amount of water lost? What effect does the sun have on the amount of water that is lost from the leaves?

Do you think placing the bag around the leaves affects how much water is lost by the leaves compared to having no bag on the leaves? Do you change the environment of the leaves by putting a bag on them?

If you did this experiment again, what weather conditions might you want to record?

*Method 2: Another way to measure transpiration is to use Cobalt Blue Paper. Cobalt Blue Paper turns pink when exposed to moisture. If you time how long it takes for a piece of Cobalt Blue Paper that is clipped to a leaf to turn pink, you will have a rough measure of the rate of water from the leaf. Use paper clips to fasten strips of Cobalt Blue Paper to living leaves (make sure the surfaces of the leaves are dry). You may wish to sandwich the Cobalt Blue Paper between the leaf and a piece of clear plastic wrap. Cobalt Blue paper can be purchased from a science supply company. A local high school biology teacher can probably help you find a source of Cobalt Blue paper.*

Does paper attached to the top of a leaf change as fast as the one clipped to the bottom of a leaf? Why?

Does the location of the leaf on the tree affect the rate of transpiration? If so, how?

How does the rate of transpiration change under different weather: sunny vs. cloudy, dry vs. humid, or windy vs. calm?

Do you think different plants have different rates of transpiration? How could you find out?

## Are Leaves Waterproof?

Can water soak into a leaf?

What happens if you drop some water onto a leaf?

What happens if you drop some water onto a paper towel? Onto a piece of wood? Onto your skin?

Make a chart to compare the results of dropping water on various materials.

Try leaves from different trees (or other plants) and see if the results are the same.

## Leaf Colors

*In the fall, have your students collect a representative leaf from a tree every couple of days as the colors change from green to various colors to brown. Have the students save the leaves and make a chart showing the changes. For ways to save leaves, see the section entitled Ways to Record Leaf Features for Further Study, at the end of this chapter.*

How many different colors can be found?

Do certain trees display certain colors in the fall?

How many different colors appear in the leaves of a single tree?

Do all the leaves on a tree change color at the same time?

Describe the pattern of colors shown by the leaves on a tree. How can you explain this pattern?  
Compare leaf-color patterns for several trees. What factors seem to affect the color change?

## Tree Twigs Inquiries

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*Twigs can be studied all year, but they make an especially good subject in winter. A tree field guide will give you information on the important features of twigs. Useful materials: tree field guide, pruning shears, marking tape or tags for labeling twigs, hand lenses.*

### The Features of Twigs and Buds

*Have your students examine the twigs of a tree. If it is likely that the tree you are looking at will be pruned back soon, you may wish to remove a few twigs to allow students to view them more closely in small groups. To minimize damage to the tree, always use pruning shears (not scissors) to leave a clean cut when collecting twigs.*

What features can be observed on the twig?

Are buds present?

What are the parts of a bud? Take one apart and look at the parts with a hand lens. Describe what you found inside.

What did you learn about buds by taking one apart?

How are the outer layers of the bud different from what is inside? What is the function of these outer layers?

What other features can you observe on the twig? Can you find a structure that shows where leaves were previously attached?

### Comparing Twigs from Different Trees

*Collect short sections of twigs from different trees in your schoolyard after leaves have fallen from the trees. Label the twigs, keeping track of the type of tree from which the twigs were collected. Give these twigs to students to see if they can find the tree(s) from which the twigs were taken. You could also set up a matching game indoors.*

How are the twigs you see similar? How are they different?

What features can you use to help you match twig to tree?

Describe these features for the different twigs or trees.

Is it hard or easy to tell trees apart by their twigs alone?

Try grouping different tree types based on their twigs.

Check a tree identification book to see how scientists group trees and tell them apart according to twigs. Try coming up with your own system!

### Twig Growth Rates: Comparing Trees

*On several different types of trees, have students mark a twig, measure the length of the twig in the spring before the buds have opened, then measure the length of the same twig before the end of school in June. Record how much the twigs of the different tree types grew in that time period.*

Which trees grew fastest in this time period?

Why do some trees grow faster than others?

Which type of tree would you plant in your yard if you want to have some shade as soon as possible?

What other features of the tree would you consider when deciding what tree to plant in your yard?