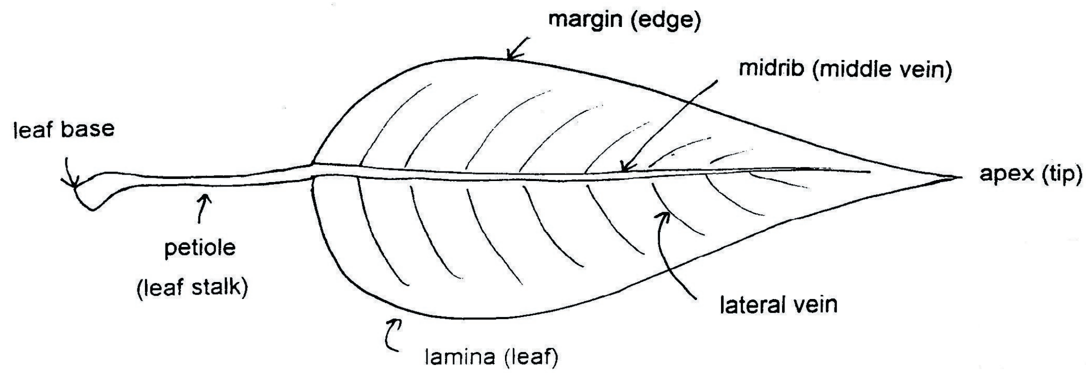
LESSON 5: LEAVES and TREES

LEVEL ONE

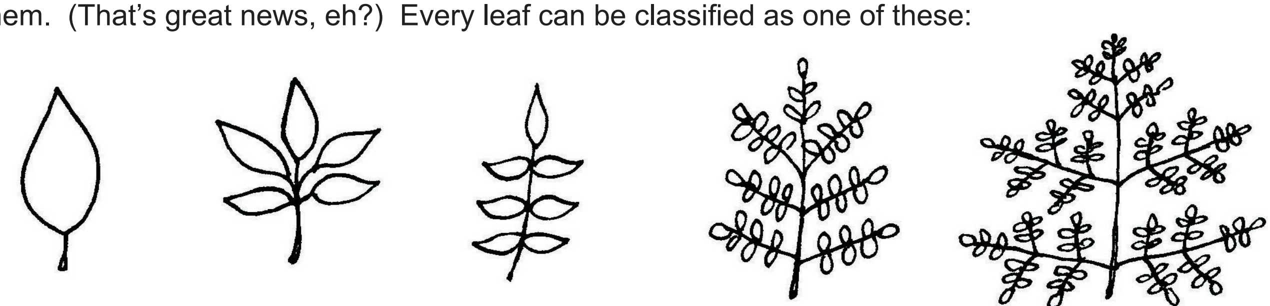
This lesson might also be called "more about the vascular system." We are going to study leaves, which are part of the vascular system, and trees, whose notable trunks and bark are also a part of the vascular system. Let's look at leaves first.

There are names for the parts of a leaf:



Now some of you may be thinking to yourself, "Why do scientists always have to make things more difficult by using hard words?" But you must remember that part of science is learning to be precise not just with your experiments, but with your words, as well. Communicating ideas clearly is an important aspect of science. Some of the words on the leaf diagram appear in other branches of science, not just botany. For instance, the word "lateral" pops up in many branches of science, and no matter where you see it, it always means "side" (or something having to do with sides).

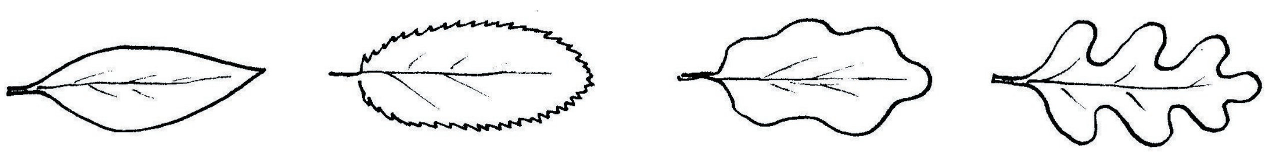
Leaves come in a great variety of shapes, and botanists have come up with names for all of them. (That's great news, eh?) Every leaf can be classified as one of these:



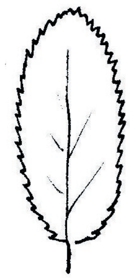
simple palmate pinnate double pinnate triple pinnate

Look carefully at the patterns of the double and triple pinnate leaves. Can you see how the same pattern is repeated? In the triple pinnate leaf, the tiny branches and the intermediate branches have the same pattern as the whole leaf

There are a great variety of simple leaves and some of these shapes are not so simple (the lobed type doesn't look so simple, but it's not palmate or pinnate).

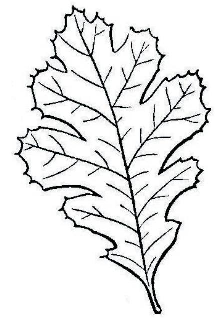


smooth serrated undulating (wavy) lobed

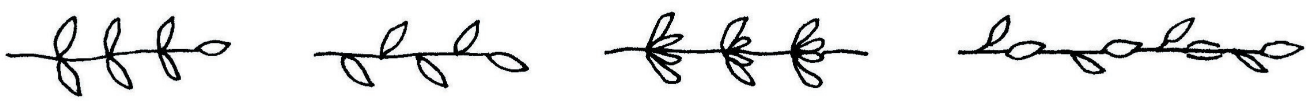


Serrated things have very sharp little bumps along the edges. You might have a serrated knife in your kitchen. Serrated knives are good for cutting breads or meats. Why do leaves have serrated edges? We can only guess-- we don't know for sure!

Warning: the natural world doesn't always make classification easy. Plants don't know they are supposed to conform to these categories. For example, what type of leaf is this leaf on the right? It looks both lobed AND serrated.

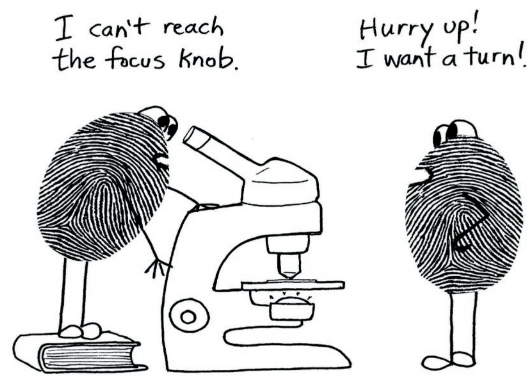


Botanists also like to look at the way the leaves are attached to the stem. Pairs of leaves that come off the stem at the same place are called ***opposite***. When the leaves alternate sides, they are called ***alternate***. There are also ***whorled*** patterns where the leaves come out in bunches at certain points. When the leaves wind up around the stem, it's called a ***spiral*** pattern.

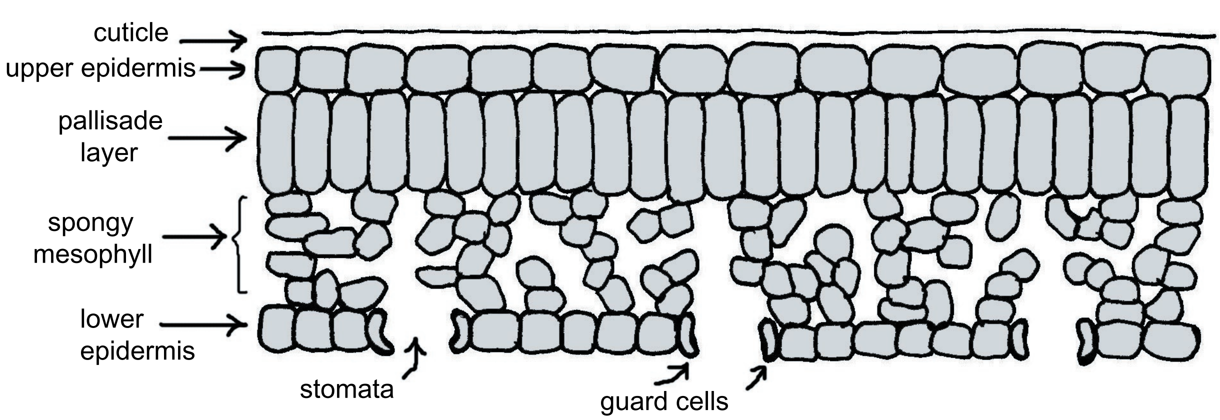


opposite alternate whorled spiral

Now it's time to do some microscope work. We'll be looking at a super-close up view of a leaf that has been cut in half. Leaves are so thin you might think they only have one layer of cells, but they actually have four distinct layers. This will take a little imagination because we are going to show you a two-dimensional slice of a three-dimensional object. Some of the cell layers might look a little strange because of flattening it to two dimensions.

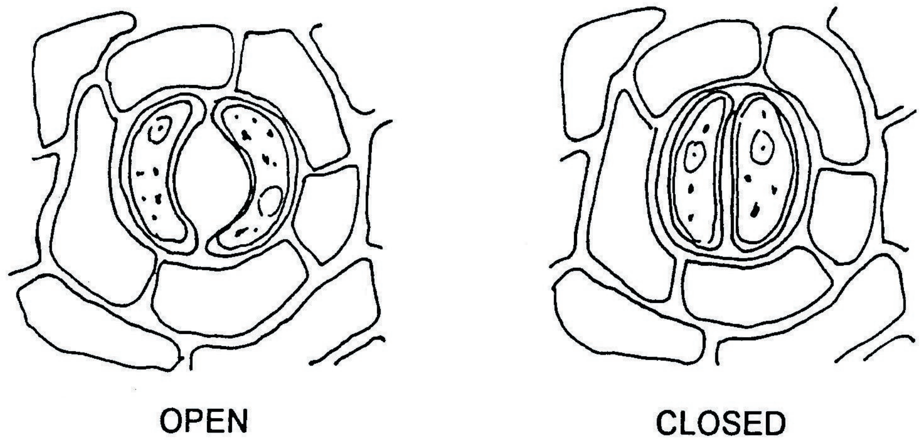


The top of the leaf is covered with a waxy protective layer called the ***cuticle***. (This doesn't count as one of the four layers.) The first real layer is the ***upper epidermis***. Under that there's the ***pallisade*** layer. A pallisade is an old-fashioned military fort made of logs stuck into the ground vertically (up and down). The person who first looked at these leaf layers decided that this second layer resembled a pallisade fort because all the cells are long and tall and thin with no spaces in between. The cells of the pallisade layer have lots of chloroplasts and do a lot of the leaf's photosynthesis. Under the pallisade layer is the ***spongy mesophyll*** (*mez-o-fill*). There are lots of empty spaces in this layer. This is the layer that looks the strangest in two dimensions. There are cells that look like



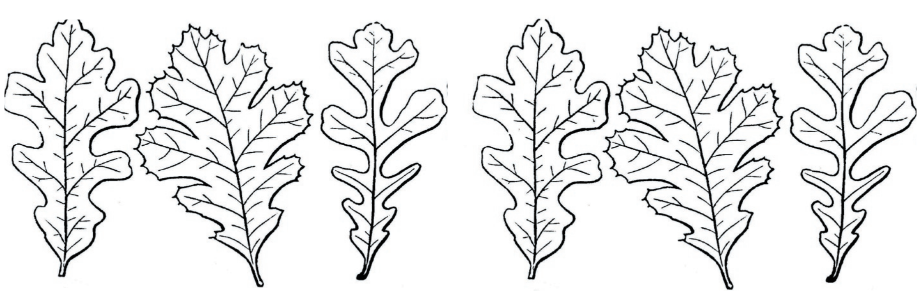
they are hanging in mid-air. But remember that there are cells in front and behind that are attached to these cells. The empty air spaces in this layer are where the carbon dioxide and water vapor get in and get to the cells that need them for photosynthesis. Then there's the bottom layer, the ***lower epidermis***. In this bottom layer are holes called ***stomata***. Around the edges of the holes are special cells called ***guard cells***. The guard cells can make the holes larger or smaller depending on whether the cells in the spongy mesophyll layer are wet or dry. If the leaf starts to dry out, the holes can close, keeping water vapor trapped inside the leaf. (It's sort of like keeping the bathroom door closed so your nice warm steam doesn't get out. When you open the door, the bathroom dries out quickly.) The guard cells look very strange in this cross-section view. They look like little C's. Let's look at a regular view, looking straight down on them (or straight up, since they are on the bottom side of the leaf!).

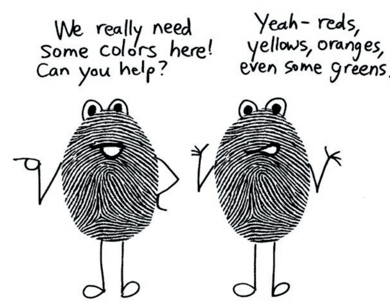
This picture shows how the guard cells change their shape to open or close the hole. This system works automatically because it is the moisture level of the leaf that makes them work. If the leaf is moist, so are the guard cells. When the guard cells are full of water they curve outward, keeping the hole open. When the leaf dries out, the guard cells lose moisture and shrivel shut, closing the hole.



As we learned in lesson one, it's the chlorophyll in their cells that makes a plant green. So what happens in the fall when leaves turn red and yellow? In the autumn, the northern climates get less sunlight. Not only does the sun go down earlier, but it also comes up later. The plants start getting less than 12 hours per day of sunlight. This means there is less light for photosynthesis. Plants can't produce as much chlorophyll. As the amount of chlorophyll goes down, you start to be able to see other chemicals that were there in the leaves all along but you couldn't see because of the green chlorophyll. Two of these chemicals are ***xanthophyll*** (*zan-tho-fill*) and ***carotene***. (In Greek, "xantho" means "yellow," and "phyll" means "leaf.") The xanthophylls create the brilliant yellows in fall leaves. The carotenes provide the bright oranges and reds. These chemicals are in the leaves all year; we just can't see them. They help catch energy from light, just like chlorophyll, but they catch different wavelengths than chlorophyll does. They also seem to help protect the chlorophyll. Chlorphyll does most of the work, but xanthophyll and carotene are important helpers.

These chemicals are found in other places, too, not just leaves. The orange color of carrots comes from a high level of carotene. In fact, as a general rule, anywhere you find orange in the natural world, it's probably carotene. Egg yolks are yellow because of the carotene the hens ate. The hens' bodies processed the carotene from their food and used it to color the yolks. Humans have a spot at the back of their eye that is yellow because it contains carotene. This spot helps to protect the eye by absorbing harmful light waves. (Eat your carrots!!)



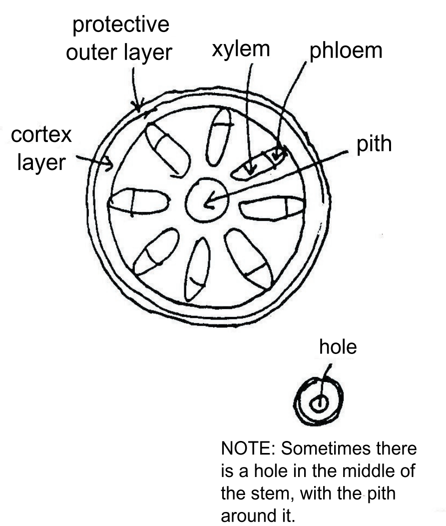


Now let's switch over to a different part of the vascular system and talk about stems again. Stems that are relatively small and soft are called ***herbaceous*** (*er-bay'-shuss*) stems. Plants such as flowers and garden vegetables have herbaceous stems. Larger, sturdier plants, such as bushes and trees, need stems that can support their weight, so their stems must grow wider and become tougher. Stems that are hard and thick are called ***woody.*** Tree trunks are actually very large "woody" stems.

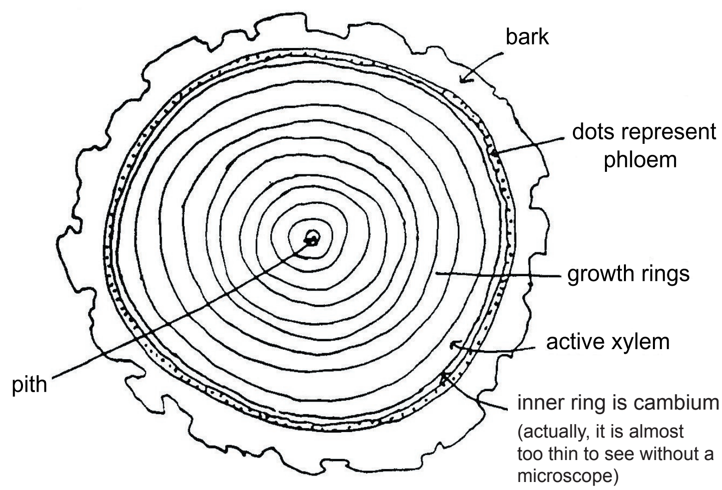
Let's take a look at the anatomy of a tree trunk. Everyone knows about bark. It's the part of the trunk we see. Bark is actually dead phloem cells that are getting pushed out and away from the tree (sort of like shedding or molting in animals). The tree is constantly growing new phloem cells under the bark so the old bark needs to fall off to allow the trunk to expand and grow. Each species of tree has its own type of bark. Experts can look at a piece of bark and tell you what kind of tree it came from.

Right underneath the bark is a layer of phloem. (Remember the phloem? It carries fluids both up and down.) Inside the phloem is a layer called the ***cambium***. This is an extremely important layer. This is the area that grows all the new xylem and phloem cells. The part of the tree trunk that we think of as "wood" is actually layers of dead xylem cells that have accumulated over the years. The inner side of the cambium is constantly growing new xylem cells. The older xylem cells eventually become clogged and stop transporting water very well. Each year the cambium grows a new ring of xylem. The xylem rings can be used to tell the age of a tree. The smallest ring at the center was originally the pith when the tree was a baby plant. Start with that tiny pith ring, then count outward until you reach the bark (well, actually the cambium layer just inside the bark) and you'll know the age of the tree.

HERBACEOUS STEM



LARGE WOODY STEM (TRUNK)



The Renaissance artist and scientist Leonardo da Vinci was the first person (in recorded Western history) to figure out that you can tell the age of a tree by counting its rings. He also figured out that the relative sizes of the rings correspond to the weather conditions of each year. A very wet, rainy spring produces very large rings. A dry spring produces thinner rings. In this way, a tree leaves a record of weather conditions during its lifetime.

In 1904 it was discovered that you can match tree ring patterns in lumber and figure out the age of wooden archaeological artifacts. This branch of science is called ***dendrochronolgy*** ("dendro" is "tree," "chrono" is "time.").

ACTIVITY 1: "THE ALIEN PLANT" DRAWING ACTIVITY

Just for fun, let's imagine that a space expedition has just returned from an alien planet. They tried to bring back a really bizarre plant specimen they found there, but unfortunately the specimen got crushed so badly in the baggage compartment that it was almost unrecognizable by the time they got back to Earth. Fortunately, one of the astronauts had taken a botany course recently and could accurately describe the plant in its prime condition. Use the astronaut's description to draw what the plant would have looked like.

"The plant consisted of one main stalk with three compound palmate leaves. One of the compound palmate leaves was at the top of the stalk and the other two were opposite each other at the middle of the stalk. Each compound palmate leaf was made up of three laminas. The top lamina was perfectly round, had undulating edges and was blue. The second lamina was diamond-shaped with serrated edges and it was green. The third lamina was oval with lobed edges and was purple. All three petioles were red and so was the stalk. All the midribs and veins were black. The roots of this strange plant were fibrous, like monocots here on Earth."

ACTIVITY 2: THE PLANT INFO SONG

Listen to "The Plant Info Song" on the audio CD, then try singing it yourself with the accompaniment-only (karaoke) track.

Oats, peas, beans and barley grow,
My botany teacher told me so,
She made me learn some plant info,
Some day I may need it, you never know!

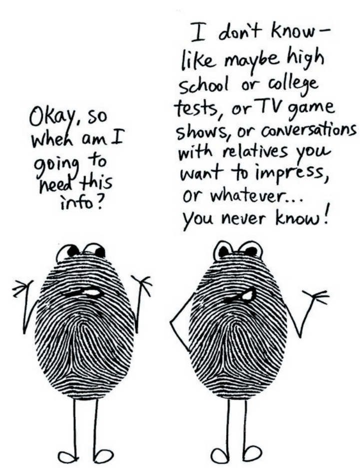
Photosynthesis is how
Plants make sugar, remember now:
Light and water and CO_2
Make energy, water and O_2.

It's chlorophyll that makes them green,
But some turn colors by Halloween;
The days get short, then can be seen
Xanthophyll and carotene.

Water goes up through xylem cells;
They also carry minerals.
Through the phloem the sugar goes down
And up and down and up and down.

Oats and barley are monocots,
Just one seen leaf is all they gots
Parallel veins and fibrous roots
Are their outstanding attributes.

Dicots all have two seed leaves;
Our dicots here are beans and peas.
With long tap roots and palmate veins
They take in water when it rains.



ACTIVITY 3: LOOK AT A REAL LEAF CROSS SECTION

Use an Internet image search with key words "leaf cross section" (possibly also with the word "micrograph") to find some images of real leaves that have been cut and cross-sectioned. (If there is any pink or red or blue in the picture, the botanist has used a stain on the leaf to stain certain parts such as the nuclei or chloroplasts. How closely does the real leaf resemble the diagram? Can you identify the layers? Are any chloroplasts visible? If you see any large circles, they are probably where a vein is running through the leaf.

ACTIVITY 4: TREE RING ACTIVITY

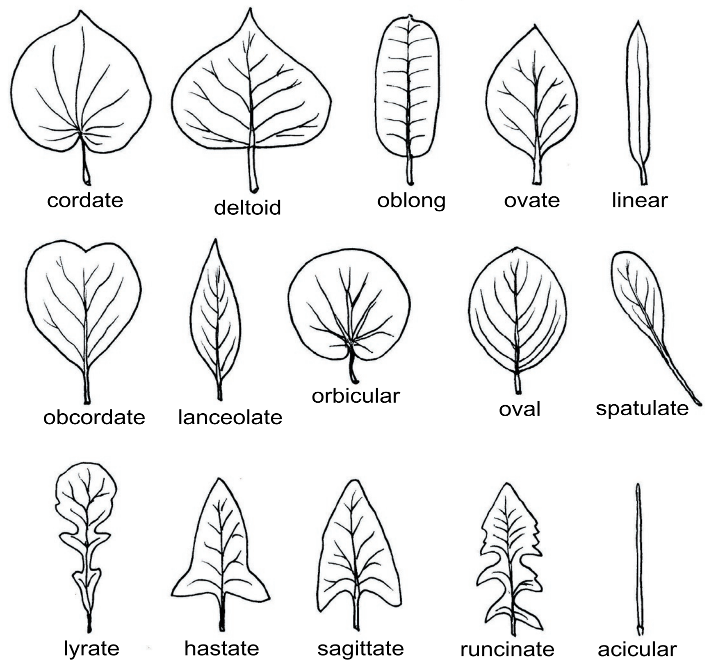
Here's an interactive online activity where you match tree ring patterns back to 1820. (You will need an up-to-date version of "Shockwave" flash player in order to make it work. They have a link to the Shockwave download if you need it.)

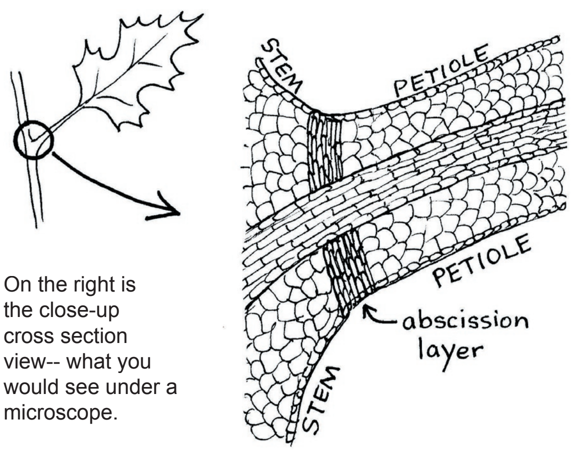
http://www.pbs.org/wgbh/nova/vikings/treering2.html

LEVEL TWO

So you've digested all the information in level one and are ready for more? Okay, great! Let's learn a little bit more about leaves and trees.

There are many more names for leaf shapes. Have you ever seen any leaves that look like the ones in this picture? You've probably seen quite a few of these shapes but didn't know they had names. Do we expect you to remember all these names? Of course not. But it's interesting to know they exist and if you ever need them, you can always look them up on the Internet by entering the key words "leaf shapes." There are several weapon-related words here. You probably recognized the word "lance" in the word "lanceolate." Hastate comes from the Latin "hasta" meaning "spear," and "sagittate" comes from the Latin "sagittatus" meaning "arrowhead." Cordate comes from the Latin word "cord" meaning "heart" (related to our English word "cardiac"). Obcordate means "opposite of cordate." See how it's the same shape only upside down? The deltoid is named after the Greek letter delta ("D"), which looks like a triangle. The lyrate leaf is supposed to look like a lyre (harp). Runcinate leaves have their lobes turned backwards like an old-fashioned working tool called a "plane," which in Latin is "runcina." Acicular is from the Latin "acus" meaning "needle."

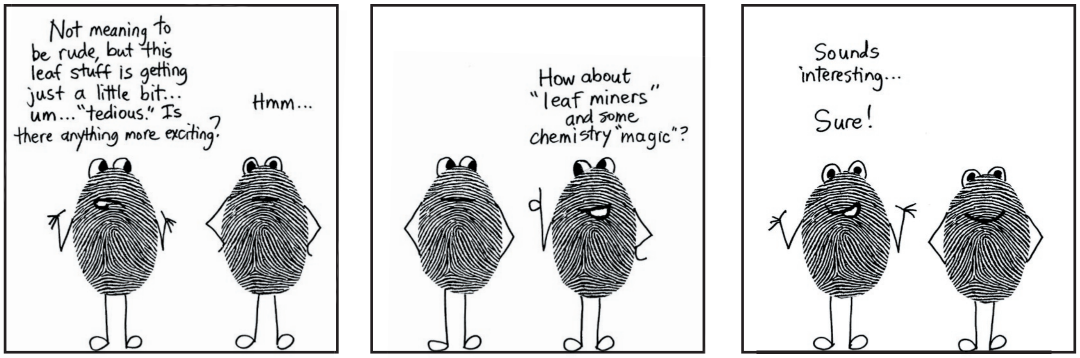


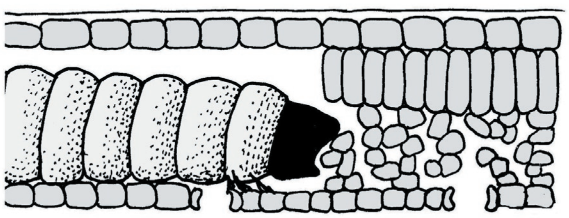


On the right is the close-up cross section view-- what you would see under a microscope.

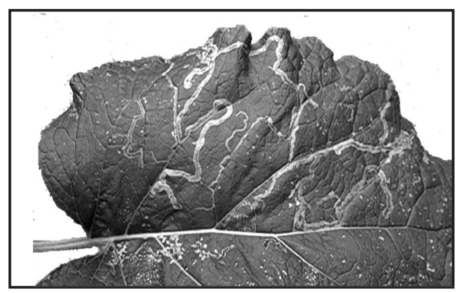
You already know that in northern climates the leaves of ***deciduous*** (*de-sid-ju-us*) trees fall off before winter sets in. ("Deciduous" is the fancy Latin way to say "falling off.") The "why" of this phenomenon is that winter is not only cold but also dry. The leaves are the primary source of water evaporation. If the tree kept its leaves during the winter, it would dry out. (Pine trees can keep their leaves (needles are really leaves!) because the needles are so small and thin that they don't let much water evaporate.) Severe cold would be a problem, too. The water in the leaves would freeze and the tree would be stuck with dead leaves hanging all over it. Better to just get rid of the leaves and grow new ones in the spring!

The "how" is accomplished by a special layer of cells at the base of the petiole. When the leaf first grew, this layer of cells was also grown, in preparation for the eventual fate of the leaf-- falling off. This layer of cells is called the ***abscission layer***. This word is related to the words "incision" and "scissors," and it means "cutting off." When the number of daylight hours decreases to a certain point, the tree starts producing a hormone that tells the abscission cells to start swelling. As they swell, they not only push the leaf away from the twig, but they also form a protective layer that will seal the twig after the leaf falls off, to protect it from disease or insect damage.





Here's something really interesting to look for next time you are on a nature hike. See if you can find a ***leaf miner.*** You know what miners are-- people who tunnel into the earth to find coal or diamonds or metal ores. A leaf miner is a very small insect that spends the larval stage of its life cycle between the upper and lower epidermis layers of a leaf. Remember, you can only see these layers with a microscope, so we're talking really small bugs! The adult insect pricks the leaf and lays its eggs inside, under one of the epidermis layers. When they hatch, the larvae start eating and don't stop until they are ready to break out of the leaf and begin their adult life as moths or beetles or flies. (Even as adults, these guys are pretty small. A leaf miner moth has a wing span smaller than the width of a pencil. A leaf miner fly could fit inside this letter "o.") The larva chomps away at spongy mesophyll and pallisade cells, leaving an empty tunnel behind it. As the larva grows, so does the size of the tunnel. (Want to know something funny? If you hold the leaf up to the light, you can see a trail of poop that the larva left behind in the tunnel!) If you are lucky you might even find the larva still in the tunnel. The larva spends less than a week in the leaf, so you'll have to be lucky enough to find it during that time. When the larva is ready to turn into an adult, it eats through the epidermis layer and escapes. Next time you go on a hike in the woods (or help to weed your garden), be on the look out for leaf miners!

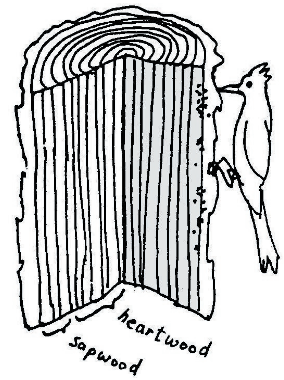


Leaf miners make squiggly patterns that are fascinating to look at.

Now for the chemistry. Another natural pigment that plants make (in addition to chlorophyll, xanthophyll and carotene) is ***anthocyanin***. That one sound poisonous, doesn't it?! If someone told you there was anthocyanin in your food you might not eat it! But anthocyanin is just a harmless natural pigment that makes the reds, blues, and purples in the plant kingdom. ("Antho" means "flower" and "cyan" means "blue.") Anthocyanin has a special quality that the other pigments don't have. It can change color. For a one-plant demonstration of what anthocyanin can do, check out the hydrangea. This bush produces large flowers that are sometimes red, sometimes white, and sometimes blue. This totally mystified ancient peoples. It was almost magical to them because they didn't have a clue about soil chemistry. They never did find out what was going on. Now we know that acidic soil causes the hydrangea to make blue flowers, neutral soil produces cream-colored flowers, and alkaline soil (the opposite of acidic) produces pink or purple flowers.

Anthocyanin isn't just in flowers; it can be found in any part of a plant-- roots, stems, leaves, flowers and fruits. It's the red in beets and apples, the blue in blueberries, and the purple in purple cabbages. In leaves, it acts as sort of a sunscreen, absorbing the sun's harmful rays (the rays that give you sunburn).

Now for just a little bit more info about wood...



The dead inner layers of xylem are sometimes called the ***heartwood***. It is this part of a tree that is most usable by lumber companies. The outer part is called the ***sapwood***. It tends to be very soft and wet. Lumber companies strip off this sapwood when they process the trees. It doesn't make good two-by-fours. The sapwood is wonderful if you are an insect, though. Sapwood is host to many insects and their larvae. Woodpeckers know this, and they drill in to find and eat them.

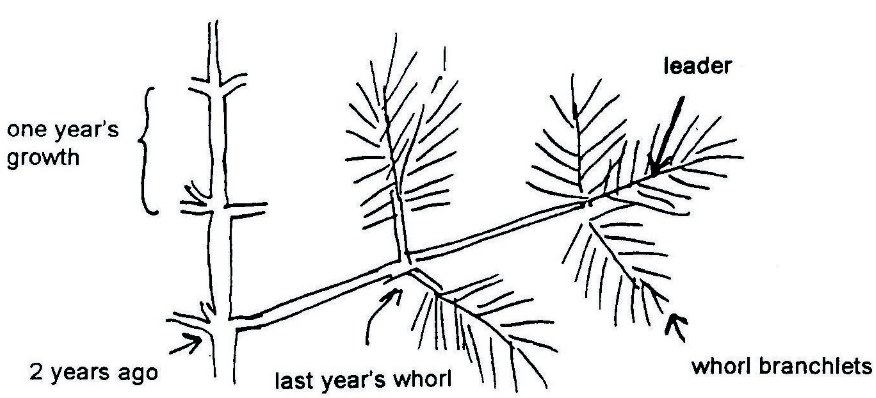
The quality of the heartwood is slightly different in each species of tree. Woodworkers know this well, and have discovered which types of wood are best for certain things.

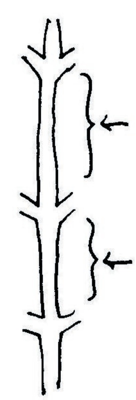
- Oak is extremely hard and is great for things like floors and tables. If you try to pound a nail into an oak board, the nail is likely to bend before it's halfway in.
- Pine is very soft and nails go in easily. This makes it a good choice for building houses. The carpenters don't have to spend all day trying to get the nails in.
- Ash is used to make baseball bats.
- Persimmon is sometimes used for golf clubs.
- Maple and birch are great for kitchen cutting boards.
- Native Americans discovered how handy birch is for making canoes.

Over the centuries, people have found uses not only for the xylem, but also for the fluids that flow through the phloem.

- Maple syrup is made from the rising spring sap of sugar maple trees. You can put a pipe into the phloem tubes and catch the sap as it tries to go up into the leaves. Good tree tappers know how many pipes they can stick into a tree without affecting its health.
- Certain pine trees make a substance that can be used to make turpentine, a solvent used with oil paints. Turpentine can also be used to make a hard chunk of rosin (*roz-in*). Rosin is rubbed onto the bows of stringed instruments such as the violin. The rosin is dry but just a little bit sticky, so it creates a lot of friction, which helps generate a loud sound.
- The sumac tree produces tannin, a chemical used to tan animal hides and make leather.
- The juice of willow tree roots and bark have been used as a natural source of aspirin.

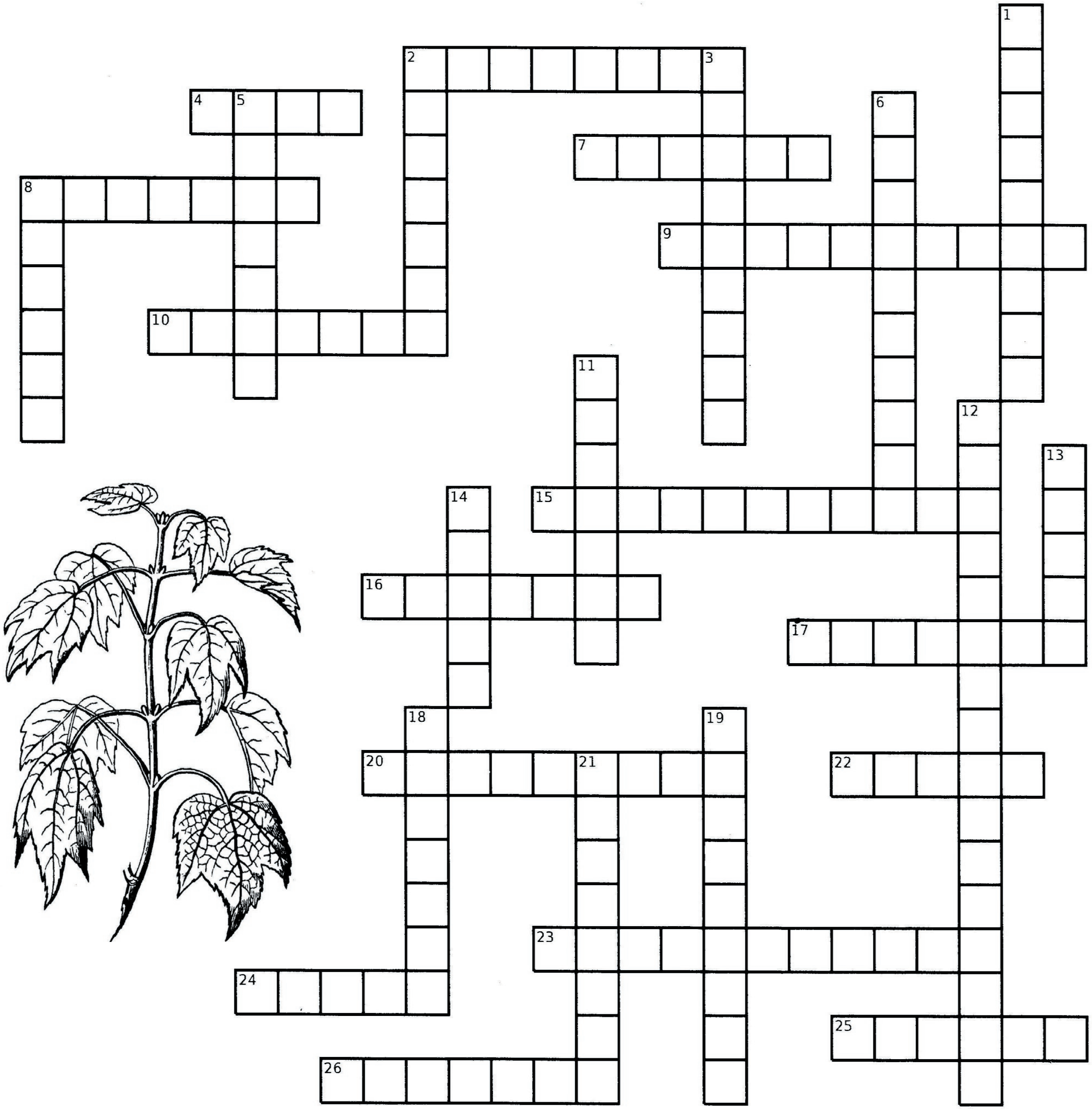
We learned how to tell the age of a tree by counting its xylem rings. Here's a method for determining the age of a pine tree: count "whorls" on the trunk and branches. A whorl is a place where several twigs or branches are attached. Many kinds of pine trees grow one "leader" and a set of whorls each year. Begin counting back along the branch, one year for each whorl. After you have counted the whorls, add four years to that number because a pine tree is usually four years old before it puts out its first whorl.





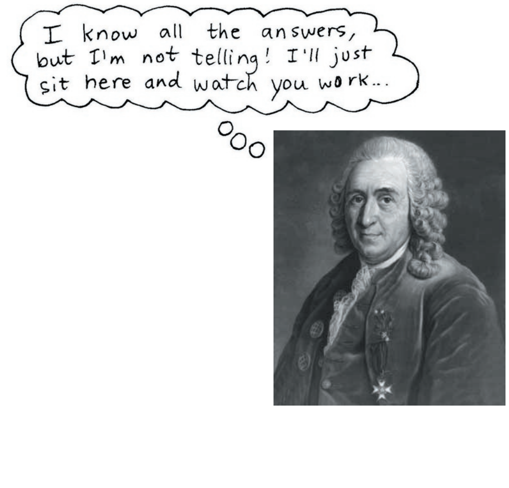
IThe spaces between the whorls tell how much the tree grew that year. Big spaces indicate a good year with lots of rainfall.

<u>ACTIVITY 1</u>: REVIEW CROSSWORD PUZZLE



ACROSS:

2) This pigment responsible for the orange color in carrots.
4) This word means “tip.”
7) This is the correct name for “leaf.”
8) This is the correct name for the leaf stalk.
9) This kind of stem is soft and flexible.
10) The waxy layer on top of a leaf
15) The pigment that can make a plant either red or blue
16) The holes on the underside of a leaf
17) This leaf shape is named after the Greek letter “delta.”
20) This layer resembles an old-fashioned fort.
22) These cells surround the stomata.



23) This pigment is yellow.
24) These tubes transport water up from the roots to the leaves.
25) This is a fancy word for “edge.”
26) This means a bunch of leaves going out from the same point on a stem.

DOWN
1) This type of tree drops its leaves before winter.
2) This means heart-shaped.
3) This layer’s name means “outer skin.”
5) This type of leaf resembles the shape of your palm.
6) The layer at the base of the petiole that detaches the leaf from the twig when autumn comes
8) These tubes carry water and sugars (sap) up and down, up and down.
11) This type of leaf can be single, double, or triple.
12) The science of using tree rings to date an old wooden artifact
13) This type of leaf has edges that go in and out even more than an undulating leaf.
14) This kind of stem is hard and stiff.
18) This layer in a tree trunk grows new xylem and phloem cells.
19) This layer is spongy.
21) This means the leaf has sharp points along the edges.

ACTIVITY 2: PHOTOS AND VIDEOS OF LEAF MINERS

Use an Internet search engine set on “images” to search for “leaf miners.” Then use the key words “leaf miner larva” to see close-up pictures of these tunneling little bugs. Don’t forget how small they are. Most can fit inside this O. However, some are larger-- there are thousands of species of leaf miners. If you want to see a really gigantic leaf miner, check out this species that feasts on boxwood trees.

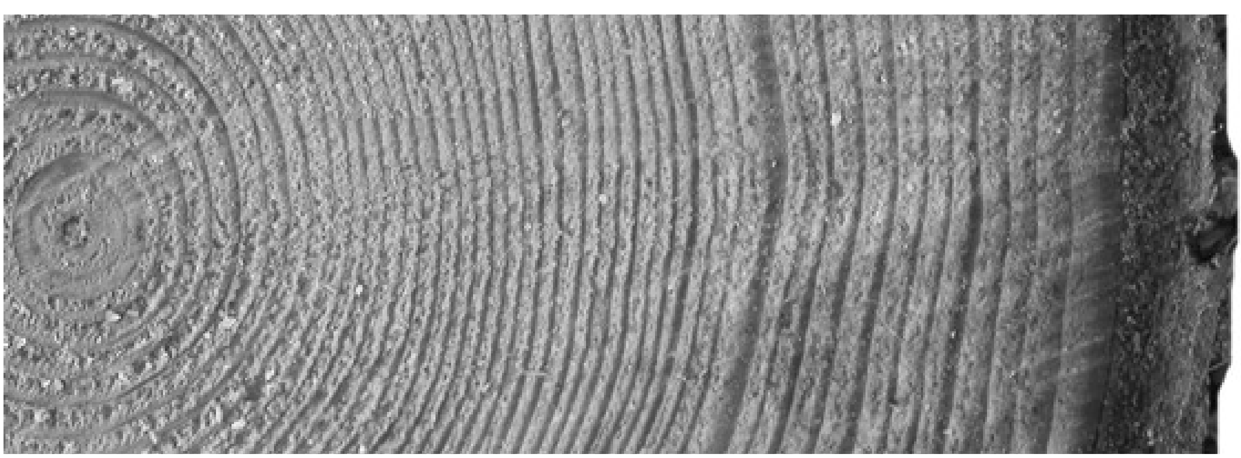
http://www.youtube.com/watch?v=e5ndystdZi4&feature=related

If you want to see a video of a leaf miner munching away inside a leaf, here you go:

http://www.youtube.com/watch?v=PP8L-T39n3E&feature=related

ACTIVITY 3: DETERMINE THE AGE OF A DECIDUOUS TREE

Count the rings on this cross section to determine how old the tree was when it was cut down.



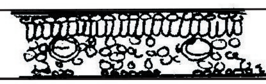
LESSON 5

1) Group project: make a leaf cross-section mural

You will need:

- pieces of paper cut into 3-inch (8 cm) strips
- clear tape (or glue stick)
- colored pencils
- picture of leaf cross section from this chapter (as a reminder of what to draw)

Give each participant one strip of paper. The goal is to make this strip look like a piece of leaf cross section. (Use picture in text as guide.) You might want to demonstrate this first, to make sure they understand the scale of how big the cells should be. They'll have to fit in all the layers within the 3 inches. You might want to have them pencil in light guidelines so they don't run out of room for one of the layers. When the cross sections are finished, tape them together end to end to form one long cross section.

etc. ←  → etc.

How long do you think this leaf mural would have to be to represent one actual inch of a real leaf? Plant cells are approximately 1/750 inch wide, so you will have to draw a section that is 750 cells wide. If you can draw 100 cells per foot of paper, the mural would have to be 7 feet long!

TIP: A group photo of everyone standing behind the leaf mural makes a nice keepsake for portfolios.

2) Preserving (pressing) leaves

You will need:

- a variety of leaves
- either a leaf press or some sheets of newsprint and some heavy books
- sheets of newspaper or white construction paper (or other fairly absorbent paper)

Some leaves preserve better than others. Clovers, for example, seem to work better than dandelions. Leaves with high water content will be difficult to preserve in good condition. (A simple leaf/flower press can be made with two pieces of fairly thick plywood, four bolts, and four wing nuts. Stack the two pieces of wood together and drill holes in the corners just large enough for the bolts to slip through. Stack all your leaves and papers, put them between the pieces of wood, then insert the bolts and tighten.)

To preserve leaves without a press, place your leaves in between sheets of paper. Paper that is a bit rough (such as newsprint or white construction paper) will absorb more water. You can use ordinary paper if your leaves are fairly dry (like clover leaves). Stack the papers carefully (don't put too many leaves on a page) and put them under a stack of heavy books (or other heavy objects you won't needing to use in the near future). Let them sit under the books for several weeks (the longer the better). Take them out carefully, as they could be brittle. They can then be used for craft projects or as part of a lap book about plants.

If you would like more specific directions and extra tips, there are numerous web sites that give information on this subject. Just do a search and choose a site that gives you the information you want.

3) Tree Leaf Bingo

You will need:

- a copy of the two tree leaf sheets for each player
- one copy of the KEY sheet
- scissors
- tokens of some kind for the players to place on their squares (pennies work well)

Set up:

1) Each player cuts out their leaf squares. There are a total of 24 leaves.
2) Each player receives a supply of pennies (or other small tokens).
3) The “caller” cuts out the squares of the KEY and puts them in a box or bag so they can be drawn out one at a time.
4) Decide whether you will play a 3x3 square or a 4x4 square. Each player takes either 9 or 16 cards and arranges them into a square. The rest of the cards remain as a personal draw pile. You will need them during the game.

How to play:

The caller randomly pulls out leaf cards and calls out the names. If the player has that card in his square, he puts a penny/token on it.

If the caller draws out a WIND card, the players must remove all of that type of card from their squares unless those squares are weighted down with a penny/marker. The player then fills these empty spaces with cards from his draw pile. This happens every time a WIND card is drawn. Yes, the game board keeps changing! But whatever has a penny/token on it cannot be blown away by the wind.

SPECIAL NOTE: You will need to decide whether you want your players to study the leaves before you start to play. Ideally, this game would be a fun way to review after the students have done some other leaf identification activities. However, previous study is not necessary and the players can just learn as they go. You might want to have the caller show the KEY cards to the players during the first round, with the caller showing each leaf as it is called. Then as rounds progress, see if the players can remember them without the cards being shown. Either way, the players will learn (or review) and have fun!

Here are the terms the players will need to know in order to play.

PINNATE: Leaves that have many small leaflets branching off the main stem. In this game the pinnates are the locust, the black walnut, the mesquite, and the “tree of heaven.”
SIMPLE PALMATE: Leaves whose shape resembles the palm of your hand and whose major veins all radiate from the same point at the bottom. In this game the simple palmates are the maples, the sassafras, and the sweetgum. (You might want to compare the tulip tree and the sugar maple to see the difference between palmate and lobed.)
COMPOUND PALMATE: Leaves that have a palm shape, but also are composed of more than one leaflet. The compound palmates in this game are the shagbark hickory and the Ohio buckeye.
LOBED LEAVES: Simple leaves that have definite lobes. In this game the lobed leaves are the oaks, the tulip tree, the ginko, and the sassafras.
DELTOID: Triangular shaped leaves. In this game, the deltoids are poplar, cottonwood, and quaking aspen.
SERRATED EDGES: Edges that are spiky or jagged, like a serrated knife. In this game the serrated leaves are the poplar, beech, quaking aspen, cherry, cottonwood, willow, shagbark hickory, Ohio buckeye, sweetgum, red maple, and black walnut.

NOTE:
If you happen to live in a part of the world where these trees are uncommon, you could substiute your own homemade cards showing leaves from trees you have in your area. You could draw your own pictures or print some using Google image search. (You might even be able to use actual leaves, pressed and glued to cards.)

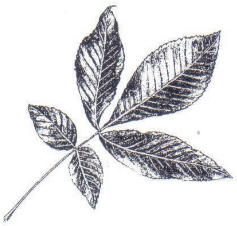

Quaking Aspen


Red Maple


Sassafras

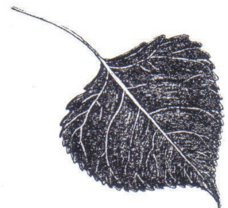

Cherry


Black Walnut

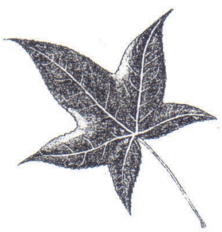

Shagbark Hickory


Southern Magnolia


Sugar Maple


Cottonwood


Dogwood


Sweet Gum


Tree of Heaven


Tulip Tree


Holly

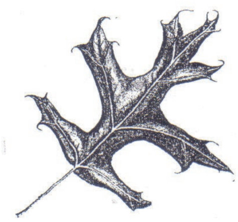

Locust


White Oak


Willow

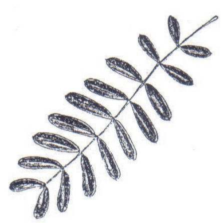

Red Oak


Ohio Buckeye


Pin Oak


Beech


Ginko


Mesquite


Poplar

WIND
Takes away all serrated edges unless weighted

WIND
Takes away all monocots unless weighted
(ginko is only monocot)

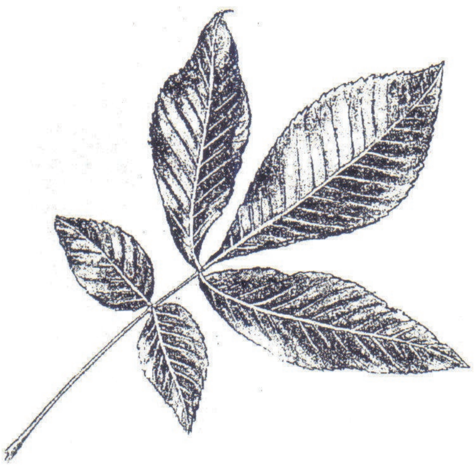
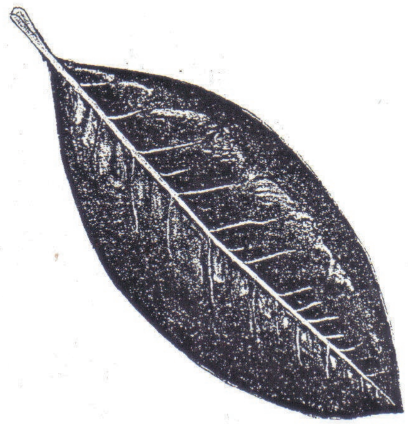
WIND
Takes away all pinnate leaves unless weighted

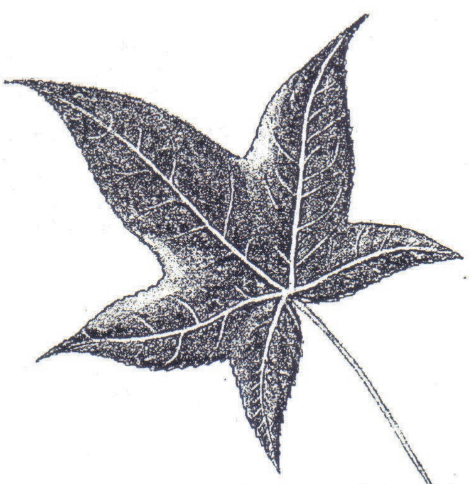
WIND
Takes away all compound leaves unless weighted

WIND
Takes away all palmate leaves unless weighted

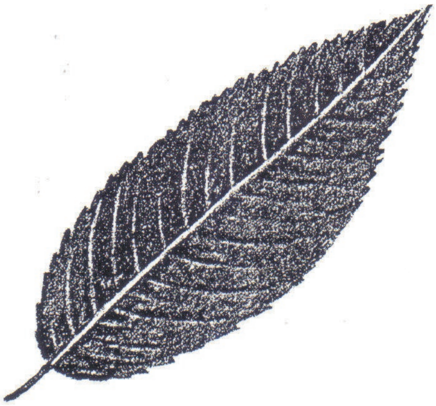
WIND
Takes away all deltoid edges unless weighted

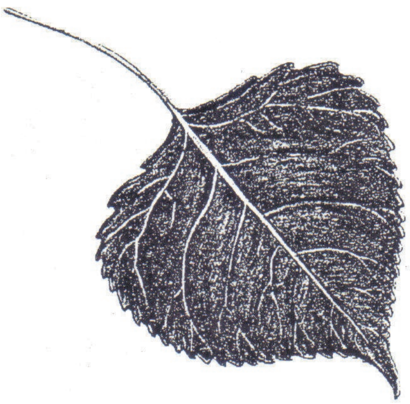




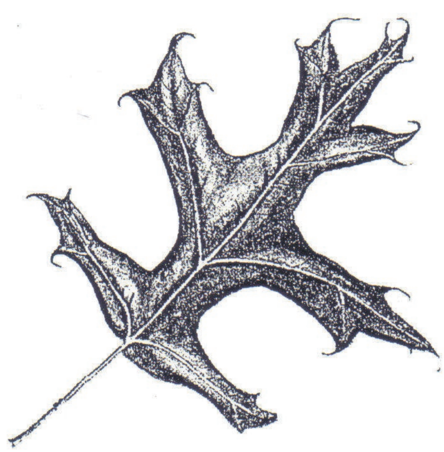







4) Lab experiment: use anthocyanine to test soil pH

NOTE: This is more of a chemistry experiment than a botany project. Feel free to skip it if you want to.

You will need:
- a purple cabbage
- a pot of boiling water
- some clear glass jars (can substitute with bowls if you don't have clear jars)
- a few spoons
- some soil samples (just a few spoonfuls of each, gathered from very different environments)
- optional: baking soda, vinegar, orange or lemon juice, soap, wood ash

We read about how the hydrangea plant will develop different colored flowers depending upon the acidity of the soil. Scientists measure acidity using a scale called the pH scale. The "p" stands for the word "potential" and the "H" stands for "hydrogen." When an acid is put into water, it releases hydrogen ions. (An ion is an atom that has an electrical charge.) The pH scale goes from 1 to 14, with 1 being strongly acidic, 7 being neutral, and 14 being extremely alkaline (which is the opposite of acidic). And just to confuse you, alkaline substances can also be called "bases." You often see the words "acid" and "base" used as opposites.

Things that are acidic have a sour taste and a strong smell. Examples of acids include vinegar, lemons, unripe fruit, tea leaves, and carbonated beverages. Bases (alkaline substances) have a soapy texture and a bitter taste. Soap is a base-- that's why it feels soapy and tastes so bad. Other bases in a typical house include baking soda, oven cleaner, medicine used for indigestion, and laundry detergents.

Different types of soil have different pH levels. Some soils are acidic. The soil under a pine tree is likely to be more acidic than soil found in a grassy field. Some plants love acidic soil. Other will die in it. Farmers test the soil in their fields often to keep track of the acidity or alkalinity. If the soil gets out of balance, they can add substance like potash or peat to bring the pH back to the level that is best for the crops they are growing.

In this experiment you will use anthocyanine to test the pH of soil samples.

To obtain anthocyanine, boil some purple cabbage leaves (perhaps three or four leaves-- the exact number is not important) in about a quart of water (don't bother measuring the water; it doesn't have to be exact). Let the water cool and dispose of the leaves. You should then have about a quart of bluish-purple water.

To test the soil samples, put a spoonful of soil into a clear glass jar, then add enough anthocyanine water to cover the soil. The water will remain purple, or it will turn red if the soil is acidic. The water will turn blue if the soil is neutral, and it will turn green if the soil is alkaline. If your soil samples do not produce a wide variety of colors, try the anthocyanine on lemon juice, a carbonated beverage, baking soda and soap. (A small sample will produce the same result as a large one. Plan your experiment so that you don't run out of anthocyanine water too soon. (Or you can just boil more cabbage leaves!)

5) Extra coloring page (optional)

You will need:
- copies of the following pattern page
- colored pencils, crayons or watercolor paints

If you've got students who love to color, here's an exra page you might find helpful. You can use bright colors and make each color represent a type of cell, or you can make it more realistic and use various shades of green or yellow. If you want to use bright colors, here's a suggestion for a color scheme (but you can make up your own, too). Write a color key in the blank space at the bottom left (so the viewer knows what the colors represent).

White: air spaces
Yellow: epidermis (top and bottom)
Red: phloem (inside vascular bundle)
Brown: sheath (covering of vascular bundle)
Orange: cuticle
Green: palisade layer and spongy mesophyll
Blue: xylem (inside vascular bundle)
Purple: guard cells

LEAF CROSS SECTION