

LESSON 7: PLANT ADAPTATIONS

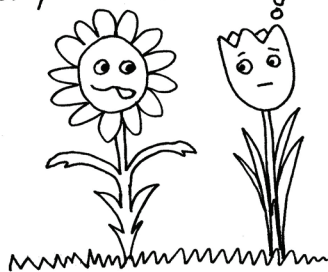
LEVEL ONE

Life is seldom ideal. We all live with situations that are difficult for us in some way. Some people face severe problems such as not being able to find enough food or clean water, living in extremely hot or cold climates, or having to deal with a chronic illness. Others of us live with milder limitations having to do with our age, our size, our family situation, the neighborhood where we live, the work our parents do, the personalities of our siblings, and so on.

We don't think of plants as having the same problems that we do, but to a large extent, they really do. They can experience malnutrition, extreme temperatures, unfriendly neighbors, competition for territory, "parents" who overshadow them, "siblings" who are more or less successful than they are, chronic and acute illnesses, and problems due to aging. Obviously, they can't think about their problems like we can. All of their responses come not from their brains (which they don't have) but from their pre-programmed DNA that allows them to adapt and survive.



Would you rather lose your chloroplasts or your mitochondria?



Let's take a look at two of the most basic problems a plant might face. We could introduce these problems as a silly "Would You Rather...?" question. In the "Would You Rather...?" game, players are forced to choose between two bad options. For example, "Would you rather be trapped in outer space or at the bottom of the ocean?" No matter which you choose, the outcome will not be good. You must choose what you feel to be "the lesser of two evils," and then explain your choice. The game is intended to encourage interesting discussions and hopefully bring some laughter along the way. If plants were playing this game, one of them could ask this question: "Would you rather have almost no water at all, or so much water that you are drowning in it?"

Assuming that a plant had a brain and could think about this question, it would ponder the consequences of each option. Not having enough water would mean that as transpiration occurred, there would be no way to replace the water lost through the leaves. The plant would dry out and probably die. Being immersed in water would mean that the stomata (holes) in the leaves would be filled with liquid water, preventing the plant from "breathing," causing the plant to die. Too much water might also encourage the growth of harmful bacteria. So which option is worse? It's like choosing between dying of thirst and drowning. Two bad options!

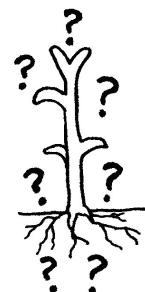
Some plants would definitely choose the "too little water" option. In fact, they live out that scenario every day and manage to survive. Desert plants have special adaptations that allow them to live in places that get less than 10 inches (25 cm) of rain a year. In deserts, rain is often seasonal, and months can go by with no rain at all. How is it possible for a plant to survive that long without water? Garden plants start wilting if they don't get rain every week.

A normal plant growing in a place with adequate rainfall has a constant flow of water going in through its roots, up through its stems, and out through its leaves. (Remember, the beginning of this process is actually the "out through the leaves" part. The loss of water in the leaves causes water to flow up through the stems, and finally come in through the roots.) If there is not a constant source of water available, this mode of living doesn't work. What changes would have to be made to a plant's anatomy in order to prepare it for life in a desert?

LEAVES: This is where the water loss problem starts. That pesky transpiration process is constantly allowing water molecules to go flying off into the atmosphere. Can this be prevented? Could we just get rid of the leaves? Maybe, but leaves are where photosynthesis occurs, so the plants would starve without photosynthesis. If a plant did not have leaves, it would have to have photosynthesis occurring somewhere else. Or maybe we could just reduce the size of the leaves instead of getting rid of them altogether. Smaller leaves would mean less water loss.

STEMS: What changes could be made to the stems? Could photosynthesis occur here? Could the stems be adapted for water storage instead of simply holding tubes for water transport? If so, the stems might have to become very large at times.

ROOTS: Is there any way to make roots more efficient at gathering water? Should the roots go deeper? Or would it be better to keep them shallow and near the surface so that they can quickly soak up rain when it comes? Would having more tiny root hairs help?



The most famous of all desert plants is the cactus, of course. Cactus plants look like they have no leaves. Technically, their sharp spines are actually leaves, but these leaves are so thin that they lose almost no water at all. We saw a similar adaptation in pine trees. Pine needles are actually very thin leaves. However, since pine needles are green, it is easier to think of them as leaves. Cactus spines just don't seem like leaves, but botanists assure us that spines are indeed highly adapted leaves.

What could possibly be the purpose of a leaf that can hardly do photosynthesis and doesn't initiate transpiration? What are cactus spines good for? The main thing they do is hurt like crazy if you get them in your skin. Sharp spines help to protect cacti from thirsty desert animals who might want to quench their thirst with a big bite of juicy cactus

stem. Some botanists think the spines might also help to collect water at night. Little droplets of dew form on the spines. These droplets run down the spines toward the stems, then they flow down the stems, ending up at the base of the plant where the roots near the surface can absorb the moisture quickly before the sun comes up.

The body of a cactus is technically a stem. Most cacti are green (or at least green-ish), which tells you that these bulky stems contain chlorophyll. Wherever there is chlorophyll, photosynthesis is occurring. Cacti must use adapted forms of photosynthesis, however. Regular photosynthesis requires a constant supply of water and carbon dioxide from the air. The "downside" of not having regular leaves is that you can't use regular photosynthesis. The types of photosynthesis desert plants use are called "C4" and "CAM." (Regular photosynthesis is known as "C3" since it produces 3-carbon sugars. C4 produces 4-carbon sugars. "CAM" is an abbreviation for a gruesomely complicated word that even scientists don't like to use because it's too long. They just say "CAM.")

Cactus stems have the ability to store a lot of water—enough water to keep the cactus alive during dry seasons that last for many months. The body of a cactus usually looks like it is made of "pleats" that go in and out. This shape allows for easy expansion and contraction without any disruption of the roots at the base of the plant. The root system of a cactus is often very shallow and

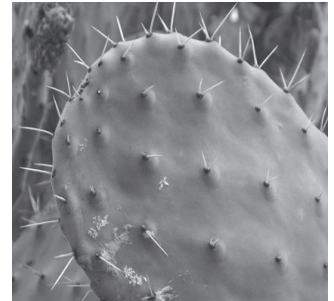


extends outward from the plant quite a distance. When rain comes, the cactus has thousands of root hairs waiting and ready right near the surface. Large cacti can take in over 100 gallons (400 liters) during a single rain storm.

A few types of cacti have very long tap roots in addition to lots of surface roots. The long central tap root can be twice as long as the body (stem) of the cactus. This deep root can store a lot of water.

Cactus stems have a structure that other plants do not have: bumps called **areoles**. Botanists guess that areoles are most closely related to the branches of regular plants. It is from the areoles that both spines and flowers grow.

One last important cactus survival strategy is to grow slowly. Cacti don't need to be in any hurry. Growth takes energy. A plant's energy comes from sugars made during photosynthesis. Desert plants are already at a disadvantage when it comes to photosynthesis because they have to keep their stomata shut all day to prevent loss of moisture. Growing slowly reduces the need for sugar.



The bumps are areoles.

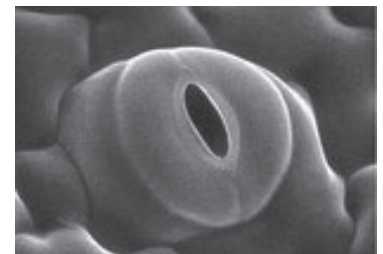


This beautiful succulent is called aeonium.

Cacti are not the only type of plants that can survive in dry climates. Plants called **succulents** are similar to cacti in many ways, though they have actual leaves, not spines. The leaves of succulent plants feel thick and “juicy.” The stems are often very thick and can store water. Some succulents have stems and leaves that are filled with a gooey substance called **mucilage** (*MEW-sell-ahj*). The mucilage acts like a sponge and holds water. A common succulent plant that many people recognize is the aloe vera plant. Some people call it the “burn plant” because you can break open the leaves and use the mucilage to soothe burned skin. The mucilage may feel slimy and weird, but it does make your skin feel better.

Succulent leaves feel like they are covered in a waxy substance. This is because they *are* covered in a waxy substance. We met this waxy substance back in lesson five when we saw the cross section of a leaf. The thin top layer was called the cuticle. All leaves have at least a tiny bit of cuticle, but succulent leaves have a lot of it. Cuticle is fairly waterproof, so it keeps moisture from getting out of (or going into) the leaf.

Another characteristic of succulent leaves is a reduced number of stomata. Those little stomata holes are where air and moisture get in and out of a leaf, so if you have fewer holes you have less of a problem with water molecules escaping. Succulents have fewer stomata than regular plants. Also, succulents tend to close their stomata during the day when the sun is hot and evaporation (and therefore dehydration) will occur quickly. They open their stomata at night, when the air is cooler and evaporation is less of a problem.



This is a photo of a real stoma.

I decided to upgrade to stomata.

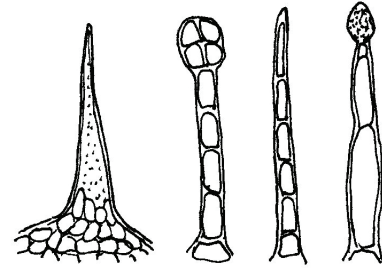


These stomata tricks are pretty slick, but there's a downside to them. The reduced number of stomata and the daytime closings also mean that a succulent leaf can't take in as much carbon dioxide as a normal leaf can. Like cacti, succulents need to use those alternative forms of photosynthesis: “C4” and “CAM.” In these forms of photosynthesis, carbon dioxide is brought in at night and the carbons are snipped off and stored in the form of an acid. (You could think of it like canning food, perhaps?) The succulent cells have to be very efficient with their carbon atoms because there is a limited supply of carbon dioxide.

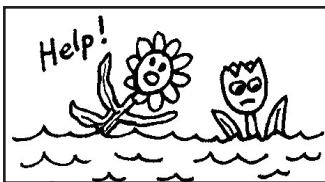
One last succulent survival trick worth mentioning is hair. Some plants grow hairs on their leaves or stems in order to provide some extra protection from the wind and sun. The hairs act like a layer of insulation, slowing down the rate of evaporation. On cold desert nights, dew can condense on the hairs and perhaps a small trickle of water will reach the roots by morning.

A really thick layer of hairs probably also functions as a way to deter insects from biting into the plant. The insect can't get its mouthparts close enough to the stem because the hairs get in the way. This feature can be seen on plants in temperate (not so hot) areas of the world, not just in super dry climates. You might have some plants with hairy stems and leaves growing right near you. Sunflowers, for instance, have very hairy stems. The plant called "Lamb's Ear" has leaves so fuzzy they feel like animal ears, not plant leaves.

Plant hairs are not made from the same stuff that animal hairs are. Animal hair is made of "dead" protein molecules. Plant hairs are made of living plant cells. Plant hairs are properly called **trichomes**, and they are extensions of epidermis cells. (Remember the upper and lower epidermis cells from the leaf cross section?) These specialized epidermis cells can grow to be very long and thin. Some have specialized cells at the tip that can secrete strong-smelling substances. The strong smell of most herbs (such as mint) come from smelly oils produced by gland cells on the tips of trichomes.



Some trichome cells are long and skinny. The round tips make smelly oils.



Let's turn now to the other terrible option for plants: drowning in water. Too much water will kill most plants, but there are some plants that are adapted for living in water all the time. What adaptations would a plant need to have in order to survive being in water all the time? Would the stomata be a problem? Would water still flow up the xylem tubes? Would the roots need to be in dirt?

There are many types of aquatic plants and their adaptations are just what they need for their specific environment. Some plants have their roots submerged in water all the time while their leaves stay out of the water. Other plants have roots and stems under the water and leaves that float on the surface. The most extreme water plants live completely submerged all the time.

What adaptations would a plant need to have in order to be able to live submerged in water all the time? Would it need stomata or cuticle? What about roots? Would it be able to make flowers?



A manatee eating seagrass. (USGS photo)

Seagrasses spend their entire life under the water. They look and act very much like regular grass. They even have those pesky rhizomes that let them use vegetative reproduction to spread very quickly. This is annoying in your garden when the grass starts taking over your strawberry patch, but along seashores this ability to spread quickly is a very good thing. Seagrasses are a very important part of shoreline ecosystems. Seagrasses reproduce using flowers and seeds, too. The pollen is carried by water instead of wind.

Seagrass leaves have neither cuticle nor stomata. It's pointless to try to keep water in or out when you are surrounded by it all the time! The cells in the leaves are okay with being saturated with water all the time and the cells have micro-adaptations that let them take carbon dioxide right from the water. Like all leaves, seagrass leaves need sunlight for photosynthesis. This means that seagrasses can only grow in relatively shallow water. If the water becomes cloudy because of pollution, the deeper seagrasses will start to die out. Dying grass might not sound like a big deal, but seagrasses occupy a very important place in many aquatic ecosystems. Seagrass beds are filled with all kinds of animal life. If the grasses disappear, so do the animals.

Seagrasses have another adaptation that helps them to survive in the water. They have

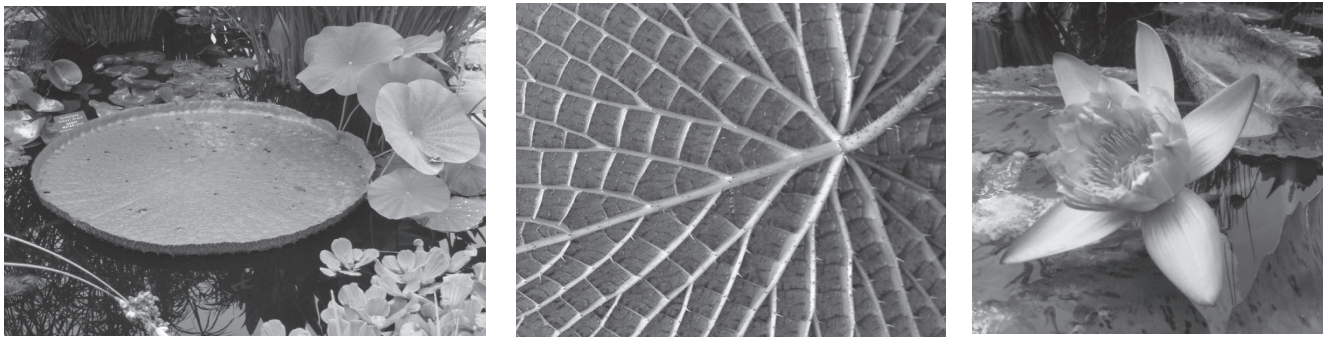


These three different types of seagrasses all have leaves that flex and bend with the water currents.

microscopic air sacs in their leaves and stems that act like little floaties, keeping the leaves upright in the water. (If you take seagrass out of the water, it droops over your hand like a wet noodle. The leaves don't have stiff central veins like regular grass blades do. Seagrasses need to be able to bend and flex and "go with the flow" in the water. If their leaves were stiff, they'd get torn apart by the motion of the water.) The tiny air sacs in the leaves and stems provide just the right amount of buoyancy so that the leaves stay upright in the water, reaching toward the sunlight.

Water plants are surrounded by water, so transpiration is not necessary. Cells can get whatever they need by osmosis. (Remember, osmosis is when molecules go right through the cell's membrane.) The carbon dioxide, water, and nutrients are abundant all around the cells, so xylem tubes aren't really necessary. In most water plants, the vascular bundles are very much reduced, and in some cases they are almost absent.

A slightly less drastic situation is when a plant is only partly submerged in water. The bottom half of the plant stays in the water while the top part is allowed to touch the air. A great example of a plant adapted to this situation is the water lily. Let's take a close-up look at a lily that holds the world record for the largest leaf in the plant kingdom: the Amazon lily.



Found in the Amazon River in South America, this lily can grow leaves that are up to 8 feet (2.5 meters) across. These giant leaves are almost perfectly round and look like floating plates. They are quite stable and can support the weight of small birds and animals. Their strength is due to a network of strong veins on the underside of the leaf. Their ability to float is due to small air pockets inside the veins. In addition to being strong, these veins can also be deadly—they are covered in sharp spines. Fish learn very quickly that nibbling lily veins is a bad idea!

The bottom sides of the lily leaves have two other features that are worth mentioning. Like seagrasses, they have no stomata and no cuticle. Unlike seagrasses, these undersides have lots of red pigment in them. The red pigment molecules help to catch wavelengths of light that are missed by the green chlorophyll pigments on top.

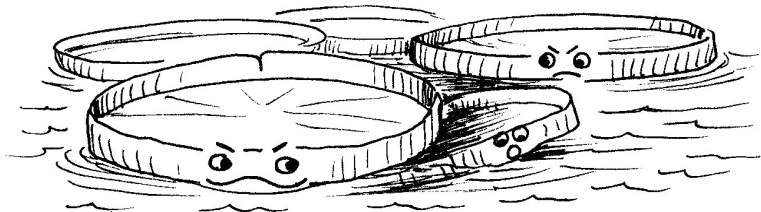
The top side of a lily leaf is nothing like the bottom side. It's green, is covered with waxy cuticle, and contains stomata. The top side is adapted to living in air, the bottom side to water.

The life cycle of the Amazon water lily sounds like something from a fantasy story. Its flowers bloom for only two days. The first night it blooms, the flower is female. It's white and smells like fragrant perfume, an odor that scarab beetles find irresistible. Once the flower has attracted beetles, it closes up, trapping the beetles inside. During the night, the flower changes its gender from female to male, and its color from white to pink. It also stops making perfume. When the flower opens up at the end of the second day, the beetles are freed from their flowery prison but are covered with pollen grains. The flower no longer smells good, so they fly off to find another white lily flower, carrying the pink pollen grains with them.



Once fertilized, the flower closes and falls to the bottom of the river where it forms a seed. The seed does not begin to grow until the next year. Lily seeds usually germinate right as the Amazon River is reaching its annual flood stage, with the water rising several inches a day. The newly sprouted water lily stem must grow at an unbelievably fast rate in order to keep its "head" above the rising water. The stem is capable of growing up to 20 feet (7 meters) tall in just a few weeks. When the waters stop rising, the lily starts growing giant leaves (lily pads).

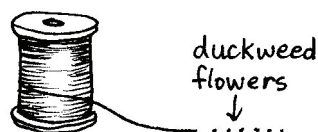
It's then a battle of lily versus lily, with each plant attempting to dominate its area. (Sibling rivalry happens even among plants!) Once a giant leaf has spread itself out over the water, any plant underneath it will die from lack of sunlight. A side benefit of this situation is that algae is also prevented from growing. This is why water lilies (usually varieties other than Amazon) are planted in outdoor water gardens. People would rather look at lily leaves than algae "scum."



One of the smallest aquatic plants on earth is called "duckweed" or "water lentils." Duckweed looks like tiny green dots floating on the surface of a lake or pond. They are bright green and look very clean. True to its name,

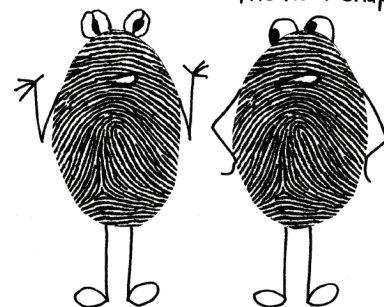
ducks love duckweed. Other water birds eat it too, as well as people in some parts of the world. It's a great source of protein, even better than soybeans, and it produces more starch per acre than corn! It's possible that duckweed could be turned into ethanol fuel, just like corn is. Some day our cars might run on fuel made from duckweed!

A duckweed plant consists of just a tiny leaf, with no visible stems or roots. (In some species, the leaves have very small root hairs dangling from the underside.) If duckweed doesn't have stems or roots can it still be classified as a plant? We decided way back at the beginning of lesson one that there are only two requirements for being a plant: 1) you must do photosynthesis, and 2) you must be made of more than one cell. Duckweed qualifies on both counts. In fact, it's even classified as an angiosperm since it occasionally produces flowers—the tiniest flowers in the plant kingdom, no larger than the width of a piece of thread!



It's kind of funny to think of cars and ducks both being powered by duckweed!

Yeah. Um... Those stomata are creeping me out. Can you get rid of them before the next chapter?



ACTIVITY 1: SIT LIKE A LUMP ON YOUR CHAIR OR COUCH AND WATCH VIDEOS

This activity should not be too difficult. Log on to www.YouTube.com/TheBasementWorkshop and enjoy the videos about desert plants and water lilies.

ACTIVITY 2: PLANT PUZZLE

Fill in the missing words in the clues, then transfer the letters to the numbered slots underneath the pictures. Assuming you've filled in the clues correctly, you'll find out the names of the succulent plants in the pictures. (We're counting cacti as succulents. Sometimes the word succulent is used as a more general term, with cacti being a subcategory.)

- Succulents have fewer _____ and more _____.
They also have gooey stuff called _____ in their stems and leaves.
68 18 94 1 31 11 22 65 45 36
52 54 9 32 84 2
- Cacti have bumps called _____ on their _____.
59 38 74 95 5
- Desert plants must use two other forms of photosynthesis: "____4" and "____."
90 53 39
- The water plant called _____ looks like tiny green dots. Even though
71 28 66 48 57
it does not have stems or roots, it is still a _____ because it does photosynthesis and
is made of more than one cell. 86 3 10
- Duckweed is very nutritious. Like soy, it is a good source of _____ and
like corn, it is a good source of _____.
47 7 19 96 20
67 49 41 62 56
- Like all plants, when a duckweed flower is pollinated, a _____ is formed.
35 46 70 24
- This type of animal loves to eat seagrass: _____.
72 16 55
- Plant hairs are called _____ and originate from the
50 87 13 63 33
_____ layer.
21 93 34 78 42
- The _____ side of an Amazon lily _____ is the color _____ and
37 15 97 81 25 8 79 61
has sharp _____ on the veins.
88 60 26
- When water evaporates out through the leaves, causing an upward flow of water from the roots,
this is called _____.
73 69 27 40 29 77 76 64 14
- The aloe plant is sometimes used to treat this type of injury: _____
6 92 58
- S _____ plants have very B _____ stems. This lets
91 23 43 80 75 30 44 51
them store water so they can S _____ in desert climates.
17 82 4 89
- This word root means "naked" in Greek: _____
83 98 12



1 2 3 4 5



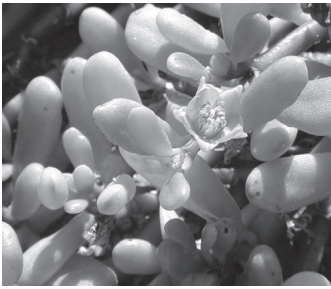
6 7 8 9 10 cactus



11 12 13 14 15 16 plant



17 18 19 20 21 plant



22 23 24 plant



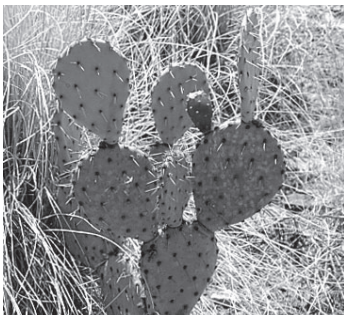
25 26 27 28 29 30 cactus



31 32 33 34 plant



35 36 37 38 39 plant



40 41 42 43 44 45 46
47 48 49 50



51 52 53 54 55



56 57 58 59 60 61
62 63 64 65 66 67



68 69 70 71 72 73 74



75 76 77 78 79 80
cactus



81 82 83 84 85
86 87 88 89 cactus



90 91 92 93 94 95 96 97 98
plant

LEVEL TWO

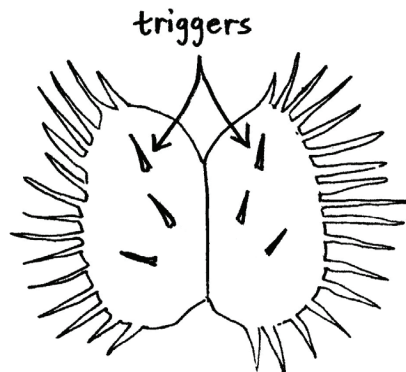
We now turn to the macabre (dark and spooky) side of plant adaptations — plants that eat animals, make poisons, and parasitize other plants. We'll meet several of the strangest plants on earth.

What would cause a plant to be carnivorous? (“Carn” means “flesh or meat,” and “vor” means “eat.”) Plants use photosynthesis to make all the food they need. They don't need an outside source of food energy. What else does a plant need besides carbon dioxide, water, and sunlight? Think about a chlorophyll molecule. Where does a plant get those nitrogen and magnesium molecules? As mitosis occurs and plants make new cells, they have to get the raw ingredients needed to manufacture more chlorophylls, plus many other types of molecules. Some of these molecules contain atoms such as sodium, phosphorus, potassium and calcium. Carbon dioxide and water only provide carbon, oxygen and hydrogen atoms.

Under normal conditions, plants take these minerals from the soil. Plants don't “eat” dirt, but they do take minerals out of it. If the soil doesn't contain enough minerals, the plants won't be able to grow there unless they have some alternate means of getting minerals. One alternative is to get the minerals from the bodies of animals (mainly insects and spiders).

The most famous of the carnivorous plants is the **Venus flytrap**. It's not uncommon to find these flytraps for sale in greenhouses in many parts of the world, but if you want to find a “wild” flytrap growing in its natural environment, you will have to go to the American state of North Carolina and find a bog within 60 miles of the city of Wilmington. Bogs are places that are wet and soggy all the time. The bogs where the flytraps grow have very little nitrogen and phosphorus in the soil. The flytraps are one of the few plants that thrive in these bogs. They get very little competition from other plants because of this lack of minerals in the soil. The flytraps appreciate not having any rivals in the area. In fact, Venus fly traps appreciate an occasional wildfire once in a while, too, just as a back-up to remove other plants from the area!

The leaf of a flytrap is the snappy trap on the end. The long flat part that looks like a leaf is actually the petiole. The petioles are the primary site of photosynthesis. As we mentioned in the opening paragraph, flytraps don't eat flies to get energy. They use photosynthesis just like all plants do. The flytrap is a flowering plant, as you can see in the picture. It's even a dicot. So in some ways, it's a very normal plant.



The hinged leaf on the end has two unique features that work together to catch flies. The first is a set of three trichomes (“hairs”) on the inside of each lobe, which function as motion detectors. These triggers will cause the trap to close suddenly if one of the hairs is touched twice very quickly, or if two separate hairs are touched within 20 seconds. The second feature is the ability of the two lobes to snap together in about 1/10 of a second.

Plants don't have muscles, so how is the flytrap able to do this? Scientists are still investigating, but it seems that the answer involves the sudden flow of water into and out of cells. Protons are a key to this rapid movement of water molecules. A sudden increase



or decrease in the amount of water in a cell changes its shape. An overall change in shape can be seen in a flytrap leaf after it closes. While the leaf is open, the lobes curve outward; after closing they are bent inward.

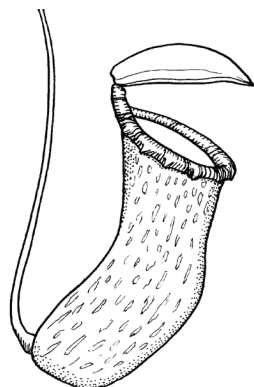
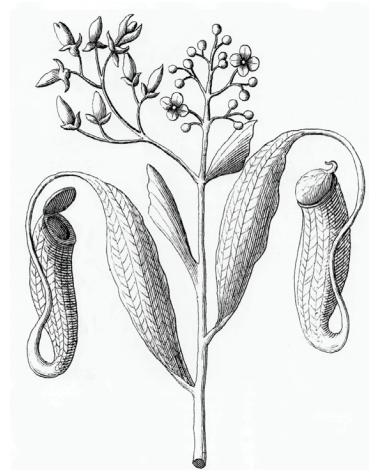
Once the lobes have closed and the prey is trapped, digestive glands on the surface of the lobes begin to make digestive enzymes. Basically, the closed leaf becomes a stomach! The leaf stays tightly shut for about ten days. During this time the body of the prey is reduced to a puddle of molecules, with maybe some bits of outer shell left over. After the trap opens, the rain will wash away the remains of the meal. If the prey is too small and manages to escape, the trap will re-open in about 12 hours.



Almost as well-known as the flytraps are the **pitcher plants**. Their leaves are shaped in such a way that a “pitcher” is formed. Like water pitchers, these plant pitchers can collect and hold water. Pitcher plants attract their prey using colors, odors, and nectars. The unsuspecting bugs crawl along the slippery edge of the pitcher and inevitably slip and fall into the water pit below. If they manage to swim over to the edge of the pitcher and try to climb out, they find the walls of the pitcher extremely slippery or covered with downward-pointing hairs that prevent them from escaping. The bugs drown in the water and their bodies eventually dissolve with some help from digestive enzymes secreted by the plant cells.

The pitcher plants shown in the illustration above are the kind you find growing in the warm, humid parts of the American continents. A very different type of pitcher plant grows in Indonesia, south China, and northern Australia. The scientific name (the genus) for these pitchers is **Nepenthes**. This name can be traced back to a book written by Carl Linnaeus in 1737. It comes from Greek mythology (Homer’s Odyssey), in a story where an Egyptian queen gives Helen a magic potion that causes her to forget all her sorrows. (“Ne” means “not,” and “penthe” means “grief.”) Carl Linnaeus explains his choice of this name for this plant:

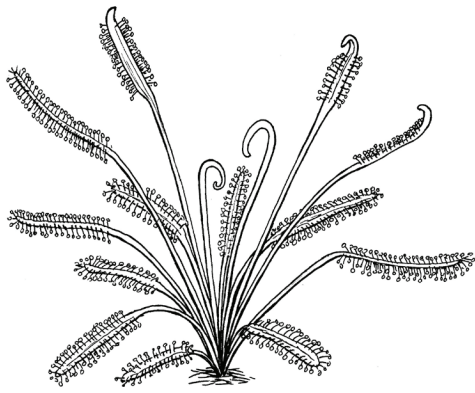
If this is not Helen’s Nepenthes, it certainly will be for all botanists. What botanist would not be filled with admiration if, after a long journey, he should find this wonderful plant. In his astonishment past ills would be forgotten when beholding this admirable work of the Creator!



The Nepenthes does not have to rely on rain to fill its traps. It produces a thick fluid that makes escape impossible for the unlucky victims that fall into it. Even small lizards and mammals can drown in Nepenthes pitchers. However, a few species have managed to outwit the Nepenthes and are able to steal some of its food. Carpenter ants like to nest inside the tendrils from which the pitchers hang. The tendrils are hollow so this does not harm the plant. The ants swim in the pitcher fluid and will work together for hours to pull dead prey out of the trap. (Yes, the ants are carnivorous, too!) The plant actually benefits from this living situation because the ants clean up after themselves and leave the edges of the pitcher spotless. Pitchers inhabited by ants survive longer than those that are not.

In some parts of the world, the Nepenthes is called the “monkey cup.” Monkeys and large apes are known to drink from these cups. (Ants? Yum, yum!)



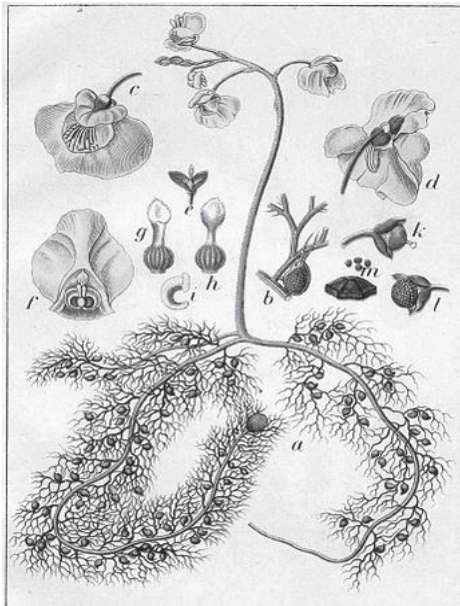
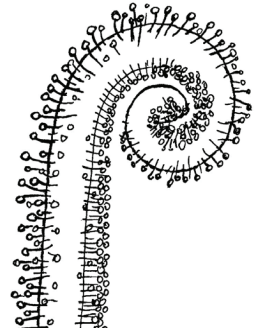


Another large family of carnivorous plants is the **sundews**. The sundews have trichomes on their leaves that produce droplets of clear sticky liquid. They look a bit like water droplets, as if dew droplets had formed on the tips of the trichomes. The droplets sparkle in the sun. (The “sun” part of the name could also come from the fact that the sundews are said to have flowers that turn towards the sun.)

The droplets produced by the sundew’s trichomes are both sweet and sticky. Insects are lured in by the sweetness and trapped by the stickiness. After the insect is stuck, the trichomes begin to coil around it, trapping it even further. The

motion can occur quickly, with the trichomes reacting in a matter of seconds. Within several minutes, the whole leaf can be completely curled up. Digestive glands on the leaves then release enzymes that dissolve the bodies of the insects, even their tough outer shell.

Other than their ability to trap and dissolve insects, the sundews (like all carnivorous plants) are normal flowering plants. They do photosynthesis and transpiration, they make flowers that get pollinated by insects (different species than the ones that get trapped) and make seeds that grow into new plants.



The things that look like roots are actually leaves. Both leaves and bladders remain under the water all the time. Only the flower sticks up out of the water. The plant does not need roots because the leaves are surrounded by water.

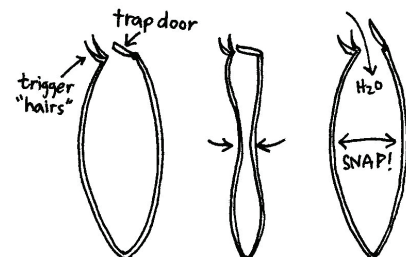
The last carnivorous plant on our list is the **bladderwort**. This plant has double adaptations. Not only is it carnivorous, it is also aquatic. In most bladderworts, the only part of the plant that sticks up above the water is the stem that has flowers on it. The flowers are shaped a bit like snapdragons and come in a wide variety of bright colors.

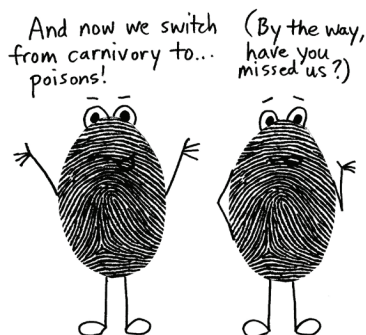
The bladders are tiny little sacs that grow among the underwater leaves. How tiny? On average, they are only about 1/4 inch (1/2 cm) in diameter. The word bladder is a very general term that means a water-filled or air-filled bag. The correct name for the bladder in your body is the urinary bladder. The word bladder itself doesn’t have any connection to urine. In the bladderwort, the bladders are pouches that act as high-speed traps. They catch aquatic animals small enough to fit inside the trap. Pond water is usually filled with semi-microscopic crustaceans (related to crabs) and insect larvae.

The bladders have a design that allows them to temporarily force their shape to curve inward, causing structural tension that is a bit like pulling back a spring. (Remember, plants don’t have muscles, so this movement is caused by water and minerals flowing in and out of cells.) The trap has some trigger hairs around the opening. When a small animal bumps into the trigger hairs, the shape of the trap suddenly pops back to its

normal open state, causing water to rush in. The animal is swept along with the mini-current and is sucked into the trap. The trap can snap shut in only 1/10,000 of a second!

As you might guess, there are digestive glands inside the trap that dissolve the animal’s body. When digestion is finished, the trap can eject the remains and reset itself, pulling its shape inward again.





Some botanists think of a plant's ability to make toxins (poisons) as an adaptation because it helps the plant survive. Plants have very few ways to protect themselves from getting eaten. Remember, plants "want" to survive, too, just as much as animals do. Plant DNA is engineered to cause them to try to reproduce as much as possible, and to adapt the best they can in order to thrive in their environment. (In fact, in a past chapter, we accused them of being bent on world domination!)

Toxins are a very effective way for a plant to make itself less likely to be eaten. A plant's primary enemies are insects, so the toxins are really targeted at them, not at animals or humans. Since insects are very small, it takes only a small dose of the toxin to kill them. The dose that kills a bug won't do much damage at all to a large animal or a person. However, there are some plants that produce toxins strong enough to damage even a large mammal.

It would be very boring (or perhaps a little scary) for you to read a list of toxic plants, so we'll just look at two plants that played a part in Greek and Roman history.



Perhaps the most famous poisonous plant in history is the hemlock. The Greek philosopher Socrates was forced to drink a cup of poison hemlock as punishment for his "impiety" (meaning he was teaching young people to think for themselves instead of just accepting whatever the members of the ruling class told them). This hemlock plant is not related to the tree called the hemlock. They are entirely different. The scientific name (genus) for Socrates' hemlock is *Conium*. This word comes from the Greek word "konas," meaning "to whirl." Apparently, being dizzy (feeling like you are whirling) is one of the symptoms of a mild case of hemlock poisoning.

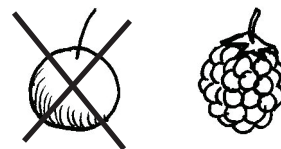


The scientific name of this plant, *Atropa belladonna*, sounds beautiful, but its common names tell you all you need to know about it: "devil's berries," or "devil's herb." More recently, it has been called "deadly nightshade." It belongs to the same family of plants as the tomato and the potato (*solanaceae*, the "nightshades"). The name "belladonna" comes from Italian and means "beautiful woman." When the juices of this plant are used as eye drops, they cause the pupils to dilate. Ancient Italian women liked to have their pupils dilated when they met an attractive young man. They thought this made them look more beautiful. When ground up and mixed into a potion, this plant does more than dilate your pupils—it kills you. The wives of the Roman emperors Augustus and Claudius are known to have used this plant to poison their enemies. Before they died, the victims would have experienced not only dilated pupils but also mental confusion, rashes, headache, loss of balance, blurred vision, racing heart, sweating, hallucinations and convulsions. Not fun.

Interestingly enough, cows and rabbits can eat this plant and have no ill effects. For the rest of us, a handful of these berries can kill us. Since the berries look pretty and taste sweet, this is a danger for small children. Fortunately, treatment is available if you get to a medical facility quickly. A chemical produced by the African calabar bean plant can reverse the effects of the belladonna toxin. But don't take too much of this bean chemical, because in high doses this cure can be toxic, too. The calabar bean's toxin is considered to be one of the most potent in the plant kingdom.

A GENERAL GUIDELINE FOR AVOIDING POISONOUS BERRIES:

Don't eat any berries you find growing in the wild if they have a simple, round shape. Berries that are lumpy, like raspberries, are never poisonous. Some smooth berries are okay, but lots of them are toxic. Don't take chances—just stay away from smooth berries!

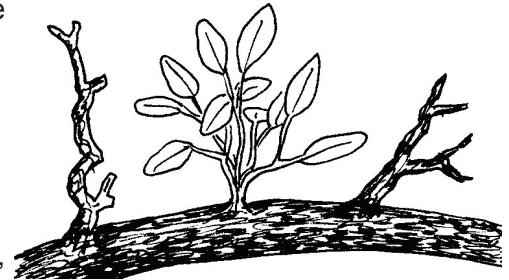


Our tour of the creepy side of botany ends with a look at plants that have become **parasites**. A parasite is any organism that must live in or on another organism. Many parasites end up harming their host to some degree, but not so much that they kill their host—or at least not until the parasite has had a chance to reproduce. We tend to have very negative feelings about parasites, but as we will see, some parasitic plants can be beneficial to the ecosystem they live in.



The most well-known parasitic plant is the mistletoe, the plant that has been part of Christmas celebrations in western cultures for hundreds of years. A branch of mistletoe is hung at the top of a doorway or suspended from the ceiling. Couples who “happen” to cross each other’s paths under the mistletoe are permitted a kiss. For each kiss, a berry is plucked off the branch. When the berries run out, so do the kisses.

You didn’t know mistletoe was a parasite? Most people don’t. The name “mistletoe” (originally “mistiltan”) most likely comes from the Anglo-Saxon words “mistel” meaning “dung,” and “tan” meaning “twig.” So that makes the real name for this plant “dung-on-a-twig.” The dung in question comes from birds. Birds eat the berries, and some of their dropping fall on tree branches. Mistletoe seeds happen to be very sticky, so they quickly adhere to the branch. When the seeds germinate, they can grow for a while in the bird dropping, as if it was dirt. As quickly as they can, though, the baby mistletoe plants start putting out special “roots” called **haustoria** (*hoe-STORE-ee-ah*). The haustoria somehow grow their way through the tree’s bark and get into the sapwood where the living xylem and phloem tubes are. They put their thin root-like tubes into the tree’s xylem and phloem, as if putting a drinking straw into someone else’s glass. The mistletoe slurps away, sucking water, minerals and sugars from the tree’s vascular system. Thus, the mistletoe is permanently attached to a tree, instead of growing in the ground.



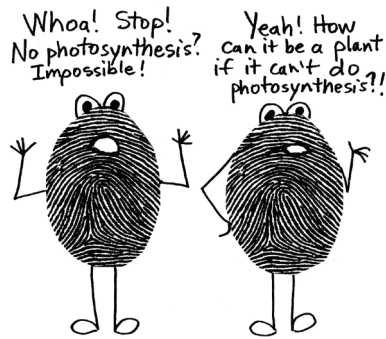
A mistletoe starting to grow on a tree branch.



The mistletoe is what botanists called a **hemiparasite** (“hemi” meaning “halfway”). The leaves can still do photosynthesis, so it is not completely reliant on the host tree. At first, the tree hardly notices the mistletoe and isn’t especially bothered by it. If rainfall is adequate, there is enough water for both plants. However, as the mistletoe grows larger and larger, there is a greater possibility that the tree won’t be able to keep up with the increasing demands the mistletoe places on it. Some trees do eventually die from mistletoe invasion, and, in general, gardeners see mistletoe as a threat. They usually prune off any tree branches that show mistletoe infestation.

Only recently have researchers discovered that in some places (Australia being a notable example) some species of mistletoe are quite a benefit to the natural environment. Though mistletoe berries are mildly poisonous to humans, birds love them. Areas with a lot of mistletoe will have a dense population of nesting birds. Also, the leaves and young shoots of mistletoe are a favorite snack for certain types of animals. Thus, areas with mistletoe tend to have more wildlife than areas without mistletoe. **Biodiversity** (the presence of many different forms of life instead of just a few) is considered to be a good thing. Ecologists all over the world are in agreement that it’s healthy for an ecosystem to have lots of different species living together.

Other parasitic plants are what scientists call **obligate parasites**. The word “obligate” is related to the words “obliged” and “obligated.” These parasites are completely dependent upon their host plant. In fact, these plants have lost the ability to do photosynthesis.



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Umm... well, how else can we classify them? They're not fungi, bacteria, animals or single-celled organisms. They make flowers with pistils and stamens—that's plant-like. Botanists guess that once upon a time these plants did do photosynthesis. Once they started feeding on other plants, their need for photosynthesis disappeared. The cells somehow sensed this and stopped making chlorophyll. This is just a guess, of course, as no one was there to witness this when it happened. It's just a theory. However, the possibility that this could have happened gives us license to go ahead and classify obligate parasitic plants as plants.

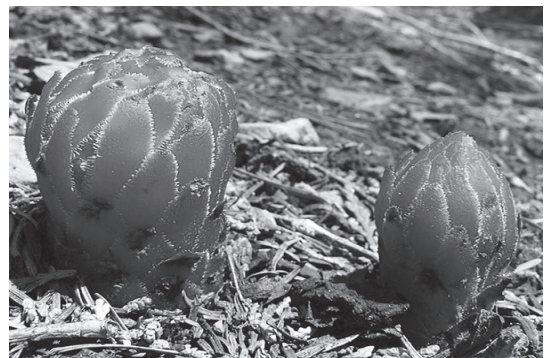


The most famous obligate parasite grows on the islands of Borneo and Sumatra. Its scientific name is *Rafflesia*, (and many people use this name), but it is also commonly called the "carrion flower." "Carrion" is a polite name for dead animals. Yes, this flower stinks like rotting animal carcasses. Why? Because any insect can pollinate a flower. It doesn't have to be cute little butterflies and bumblebees. In this case, the stinking flower draws flies. The flies are fooled into thinking that there is rotting meat inside the flower, and pollination is accomplished.

The *Rafflesia* holds the world record for being the largest flower in the world—which is kind of funny when you learn that the flower is the only part this plant really has. It has no leaves, no stems and no roots! (At least you knew that those parts aren't included in the definition of what makes a plant a plant.) The only other part the *Rafflesia* has is a network of haustoria. The haustoria are embedded into the veins of a vine plant, and

are invisible from the outside. The only time you can be sure the *Rafflesia* plant is there is when it puts out a flower bud. Otherwise, you never see this plant!

Our second and last obligate parasite is the "snow flower." (The buds often pop up early in the year, poking up through the snow.) Like *Rafflesia*, this type of plant has no leaves, no stems and no roots. It consists of nothing but haustoria threads living inside a fungus that lives on other plants. Since these plants live on a fungus, some people like to call them "fungus flowers." The snow flower takes its nourishment from a fungus that is taking its nourishment from a plant. So indirectly, the snow flowers are feeding on a plant, but through the fungus. Very strange, indeed.



These snow flower buds were found in Yosemite National Park in California.

Picture credits: *Rafflesia* by *ma_suka* on Wikimedia Commons, snow flower by *Walter Seigmund*, posted on Wikipedia article: *Sarcodes*.

ACTIVITY 1: "O" THAT RAGWORT IS A PROBLEM!



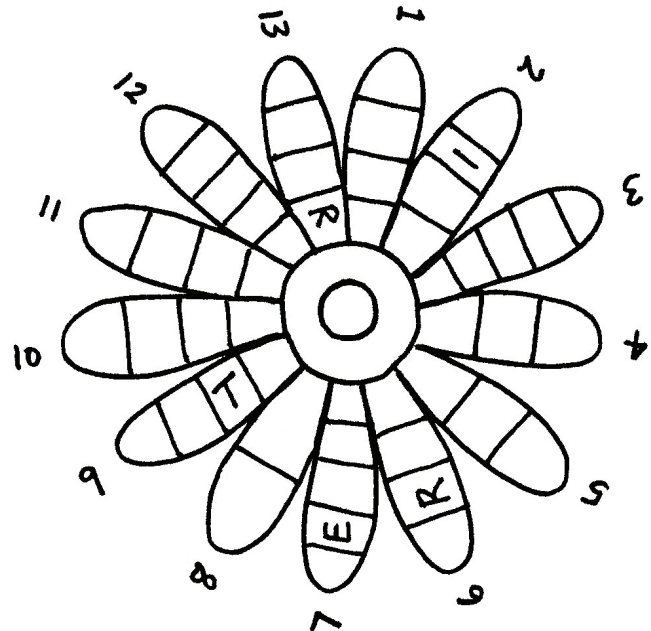
Ragwort is a wildflower in the aster family (same family as daisies). It has pretty yellow flowers and looks nice growing by the roadside. It is native to Northern Europe, but can now be found in places all over the world, including Australia, New Zealand, Argentina, India, northern Africa and some states in America. There are certain moths and flies that love to feast on the leaves and nectar. In fact, they won't eat anything else. These insects don't reflect the opinions of the animal kingdom in general, however. Ragwort is very bitter and most animals won't willingly eat it.

Farmers all over the world are on a mission to try to make this plant extinct (much to the dismay of insect enthusiasts). The bitter taste of ragwort is due to toxins (poisonous chemicals) it produces. These toxins help the plant by keeping it safe from hungry animals. However, as the plant dries out, the toxic chemical taste less bitter. If dried ragwort gets mixed in with horse or cow's hay supply, the animal won't be able to detect the ragwort in its food. They will accidentally eat the ragwort and the toxins will get into their bloodstream and poison their livers, making them very sick. In some places (such as the UK and some US states) if you find ragwort growing on your property you are required by law to destroy it.

One way you can identify ragwort is by counting the petals of its flowers. Ragwort flowers have 13 petals. There aren't too many things in the natural world that come in 13's. One of the few places where the number 13 shows up in flower petals. Other common petal numbers are 4, 5, 8, 10, and 21. Mathematicians think it is interesting that petal numbers roughly correspond to "Fibonacci" numbers: 1, 2, 3, 5, 8, 13, 21, 34... (add the two previous numbers to get the next one).

This ragwort's 13 petals correspond to 13 botanical "root words" from Latin or Greek. The easy part is that all of these root words end in the letter "O" which already appears in the center of the flower. Fill in the rest of the letters starting at the outside of the petal and going towards the "O." You may have to turn your paper sideways and upsidedown! (If you need a hint, a page number is given where you can find the answer.)

- 1) light (pg 1)
- 2) very small (think of a scientific instrument that lets you see very small things)
- 3) green (pg 8)
- 4) middle (pg 38)
- 5) one (pg 31)
- 6) turn (pg 36)
- 7) tree (pg 40)
- 8) life (think of the branch of science that studies life)
- 9) flower (pg 44)
- 10) naked (pg 50)
- 11) vessel or container (pg 52)
- 12) yellow (pg 39)
- 13) air or breath (pg 8)



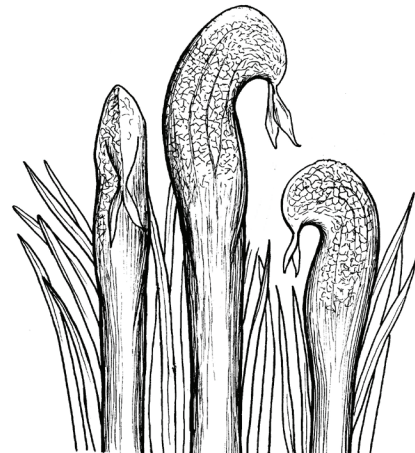
ACTIVITY 2: MORE VIDEOS! (unless you watched them already)

Get comfy, go to www.YouTube.com/TheBasementWorkshop, and watch some fascinating videos on carnivorous plants.

ACTIVITY 3: TRUE OR FALSE?

Can we trick you? See if you can determine whether each statement is true or false.

- 1) ___ Flytraps can survive wildfires.
- 2) ___ Bogs have mineral-rich soil.
- 3) ___ Various species of flytraps live all over the world.
- 4) ___ Flytrap leaves have no petioles.
- 5) ___ Flytraps have muscle cells.
- 6) ___ *Nepenthes* have parasitic ants that destroy their pitchers.
- 7) ___ *Nepenthes* were not discovered until the 20th century.
- 8) ___ All carnivorous plants have digestive glands.
- 9) ___ Pitcher plants can be found growing on several continents.
- 10) ___ *Nepenthes* plants have a symbiotic relationship with a particular species of tropical spider.
- 11) ___ Sundew trichomes can move.
- 12) ___ Carnivorous plants produce poisonous chemicals to paralyze their prey.
- 13) ___ The bladderwort's trap is probably the fastest-acting mechanism in nature.
- 14) ___ Bladderworts have no roots.
- 15) ___ Bladderwort traps can be used only once.
- 16) ___ Socrates died by drinking a potion made from the hemlock tree.
- 17) ___ A *Conium* plant makes cones.
- 18) ___ Some animals can eat deadly nightshade and survive.
- 19) ___ Sometimes animals are not bothered by plant toxins that are fatal to humans.
- 20) ___ Never eat wild raspberries.
- 21) ___ The mistletoe plant does not have roots.
- 22) ___ A hemi-parasitic plant can still do photosynthesis.
- 23) ___ Mistletoe plants ruin wild habitats.
- 24) ___ The *Rafflesia* has only two parts: haustoria and flowers.
- 25) ___ "Snow plants" are really a type of fungi.



This is a species of pitcher plant called the cobra lily.

LESSON 7

Level 1

Activity 1: 1) stomata, cuticle 2) areoles 3) C4, CAM 4) duckweed, plant 5) protein, starch
6) zygote 7) manatee 8) trichomes, epidermis 9) bottom, pad, red, spines
10) transpiration 11) burn 12) succulent, bulky, survive 13) gymno

PLANTS from left to right, top to bottom:

First row: agave, brain, cocoon, stone Second row: ice, pencil, aleo, zebra

Third row: prickly pear, yucca, hen and chicks Fourth row: saguaro, barrel, organ pipe, curiosity

Level 2

Activity 1: 1) photo 2) micro 3) chloro 4) meso 5) mono 6) tropo 7) dendro 8) bio
9) antho 10) gymno 11) angio 12) xantho 13) spiro

Activity 2: 1)T 2)F 3)F 4)F 5)F 6)F (pitcher is not destroyed 7)F 8)T 9)T 10)F
11)T 12)F 13)T 14)T 15)F 16)F (not the hemlock tree, but rather the conium hemlock)
17) F 18)T 19)F 20)F 21)T (haustoria instead of roots) 22)T 23)F 24)T 25)F

LESSON 7

1) FUN GAME: “Don’t Sink the Lily Pad!”

You will need:

- Aluminum foil
- A pan or large bowl of water (several inches deep is best)
- Scissors
- A large bowl of pennies (a couple of dozen for a small pad, several hundred for a pad that is the size of a dinner plate) You could also use dried lima beans or other small objects.

How to prepare:

Cut three foil circles: a small one (just a few inches across), a medium-sized one (more like 4 or 5 inches across) and a large one (7 to 10 inches across). Fold up the edges to make it look like a real Amazon lily pad. Refer to the picture in the chapter to see that these pads have a very steep “lip” all around the edge. (Tip: The higher the lip, the more pennies you will be able to place on the pad before it sinks.)

How to play:

Place the smallest pad in the pan of water. It should float very well. Let the players take turns placing pennies on the pad. The idea is to be able to place a penny without sinking the pad. (You could pretend that the pennies are frogs or birds that might be found sitting on a lily pad.) The person whose penny sinks the pad is the loser. (You can avoid having a loser by just making it fun to see how many pennies each lily pad will hold.) As the game progresses, the players will start seeing strategy—how to add pennies without upsetting the balance of the pad. Players who like physical science will like this game.

After trying the small pad, move up to the medium pad, then the large pad.

During the game, ask the players what they notice about how the pad holds weight. What happens when the pad finally gives way? Where is the weakest point on the pad? (Usually the lowest point on the lip.)

As an additional investigation, puncture a small hole in one of the pads and try it again. How much difference does a small hole make? Puncture a few more tiny holes. Any difference? What about a large hole?



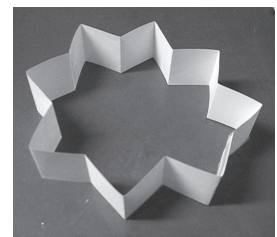
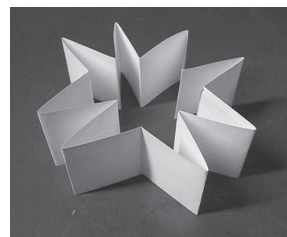
2) MAKE A PAPER MODEL THAT SHOWS HOW A CACTUS STEM EXPANDS

You will need:

- Paper
- Scissors
- Tape

Cut two long strips of paper (from the long side of a piece of paper). Fold them back and forth (“accordion” style). Tape the ends together and adjust the shape so it looks like one in the picture.

Experiment with the model. Demonstrate how a cactus is able to expand suddenly.



3) PLAY A GAME ABOUT POISONOUS PLANTS: “Where Sheep May Safely Graze”

The name of this game comes from a piece of music written by J. S. Bach (Canon No. 208). He probably wasn't thinking about poisonous plants when he wrote it, but the title was just too tempting to resist.

The board is designed for 1-4 players, so if you will have more than 4 players, make two copies of the game board. All players can still play as a group, but on separate boards.

You will need:

- Copies of the game board pieces and copies of the sheep tokens (one sheep per player)
- Tape (a glue stick might also be helpful for assembling the sheep tokens)
- Scissors
- Optional: colored pencils or markers so players can color their sheep in order to identify it

How to set up the game:

Tape together the two game board pages. Cut out, fold and assemble the sheep tokens. Each player should either write his name on the sheep, or color the fleece so that he will be able to keep track of his sheep.

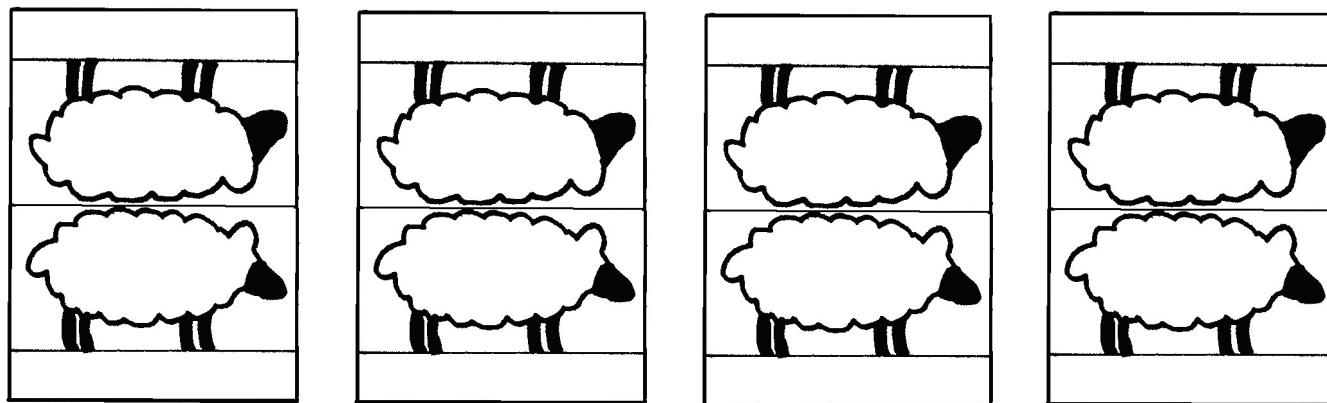
How to play the game:

The object of the game is to get your sheep across the long meadow without eating any poisonous plants. This will be difficult because three out of four plants in each row are toxic to some degree. Only one is considered by botanists to be edible. Not all the toxic plants are equally toxic. Some will just cause stomach upset or headaches, others will kill you. As with all things, “The dose makes the poison,” as Paracelsus stated back in Renaissance times. In most cases, the amount you eat has a lot to do with the outcome. Each plant has been given a numerical estimate of how toxic it is, using a scale of 1 to 3. (This is not an official number you'll find anywhere. These numbers were created for this game and should not be construed as scientifically valid toxicity estimates.) Edible plants have a toxicity score of 0, so the goal is to end up with a score as close to 0 as possible.








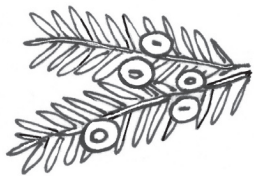










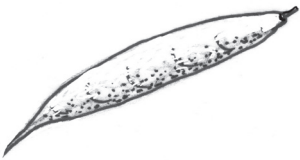




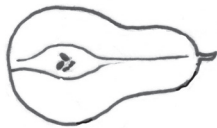
Disclaimer at this point: Even though the token is a sheep, we've erred on the side of choosing to define edibility by human standards, not grazing animal standards. In most cases, humans and animals will react in a similar manner, but if there was any discrepancy, the human factor was given more consideration since the players are humans who might find this information helpful at some point in the future.

This game requires a leader (most likely the teacher/adult in charge, but it could be a student, especially if you have an older student and some younger ones). The leader will give the correct answers after each move and will also be able to add some extra information at his/her discretion from the extra info sheet.



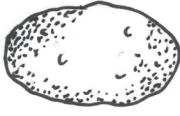

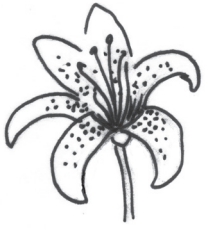


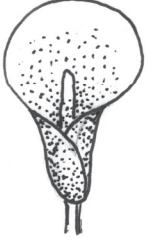
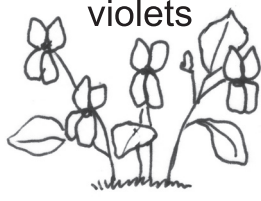



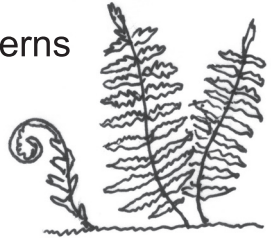

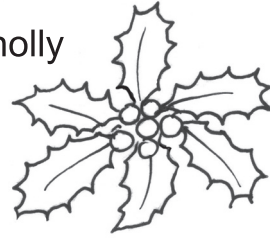









All players move at the same time. The leader calls out the number of the row the sheep will be grazing, moving from 1 to 12. The players then place their sheep on the plant in that row that they hope is edible. After all sheep have been placed, the leader reads the answers and gives the toxicity rating for each plant. The players write down their score for that row. As they progress up the rows, they keep adding up their points so that after row 12 they will have a final score. The lowest score wins.



Where Sheep May Safely Graze

12	azalea 	hibiscus 	rhododendron 	hydrangea 
11	gooseberries 	asparagus berries 	pokeweed berries 	yew berries 
10	tulip bulbs 	orchid bulbs 	daffodil bulbs 	hyacinth bulbs 
9	maple tree leaves 	dogwood tree leaves 	cherry tree leaves 	oak tree leaves 
8	raw kidney beans 	raw lima beans 	raw green beans 	raw Mung beans 
7	cherry pits 	grape seeds 	apple seeds 	pear seeds 

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6	potato leaves 	potato stems 	green potatoes 	red potatoes 
5	tiger lily 	lily of the valley 	Jack-in-the-pulpit 	calla lily 
4	violets 	buttercups 	foxglove 	larkspur 
3	ferns 	ivy 	holly 	cattails 
2	white snakeroot 	jimson weed 	ragwort 	nettles 
1	wild carrots 	dandelion leaves 	rhubarb leaves 	tomato leaves 

Three of the plants (or plant parts) in each row are toxic. One is edible.

Good luck, sheep!

Where Sheep May Safely Graze

<p>potato leaves (1)</p> <p>Potatoes belong to the Solanaceae family, the nightshades. All nightshades produce solanine chemicals, at least to some degree. This chemical is most abundant in the green parts of the plant.</p>	<p>potato stems (1)</p> <p>Since potato stems are green, they contain some solanine, a chemical that can affect both the digestive system and the nervous system. Cooking does not destroy this chemical.</p>	<p>green potatoes (1)</p> <p>Eating a few bites of green potato won't make you terribly sick, but eating a lot of them isn't good for you. The green color indicates the presence of solanine, a toxic chemical.</p>	<p>red potatoes (0)</p> <p>The tubers of potato plants do not contain much solanine as long as they are white or red in color.</p>
<p>tiger lily (0)</p> <p>Tiger lilies are edible and are sometimes used to garnish salads and desserts. They belong to the family of daylilies, which are chemically different from other plants we call lilies.</p>	<p>lily of the valley (2)</p> <p>Though it looks great in your flower garden, all parts of this plant can cause abdominal pain, vomiting, and reduced heart rate. Eating a large amount can be deadly.</p>	<p>Jack-in-the-pulpit (1.5)</p> <p>This plant contains saponins, which cause severe irritation to the mouth, throat and stomach. In severe cases, swelling causes problems with breathing. When cooked properly, the root can be edible.</p>	<p>calla lily (3)</p> <p>This type of lily contains oxalic acid (also found in rhubarb leaves) and causes digestive distress. The acid can affect other organs, also, and a dose of as little as 5 grams can be fatal to small children.</p>
<p>violets (0)</p> <p>Violets are often used to add color to a green salad. They are high in vitamin C.</p>	<p>buttercups (1)</p> <p>These lovely flowers can be a danger to grazing animals. They can cause colic in hoofed animals and digestive distress in all animals. They can also irritate the skin.</p>	<p>foxglove (2)</p> <p>This plant contains digitoxin, a chemical that will make you nauseated, then cause serious heart problems. However, in small doses this chemical is used as a heart medication.</p>	<p>larkspur (2)</p> <p>The toxins in this plant cause problems to muscles and nerves, and can be fatal. This plant causes problems in grazing animals. In late summer, the plant becomes less toxic.</p>
<p>ferns (.5)</p> <p>People in Asia eat fern fiddleheads with no apparent ill effects. However, all ferns have been shown to be carcinogenic and they are probably contributing to Japan's high rates of digestive cancers.</p>	<p>ivy (1)</p> <p>Ivy leaves and berries are mildly poisonous, causing digestive discomfort and labored breathing. Their bitter taste helps to keep humans from eating them.</p>	<p>holly (1)</p> <p>Holly looks nice as a holiday decoration, but don't eat it. It will give you nausea, vomiting and diarrhea.</p>	<p>cattails (0)</p> <p>All parts of the cattail are edible. Some people grind the roots into a flour. The stems are tender and taste like cucumber. The brown spikes can be eaten like corn on the cob.</p>
<p>white snakeroot (2)</p> <p>All parts of this plant are toxic due to a chemical called tremetol, which causes severe trembling and vomiting and can be fatal. The toxin can pass through a cow's udder and into its milk causing "milk sickness."</p>	<p>jimson weed (3)</p> <p>Like deadly nightshade, jimson weed contains a chemical called atropine, which interferes with the normal functioning of the nervous system. In very small amounts, this chemical can be used as a medicine.</p>	<p>ragwort (2)</p> <p>This plant is most dangerous to grazing animals. It is bitter and therefore unlikely to be consumed by humans. It causes liver damage because of its many alkaloid chemicals.</p>	<p>nettles (0)</p> <p>Though they have a reputation for being nasty stingers (because of the hairs on their stems), cooking them removes the sting and makes them completely edible.</p>
<p>wild carrots (1)</p> <p>The carrots we grow in our gardens are far removed from their wild cousins. It is advisable not to eat things you find in the wild that look like carrots. They can be poisonous.</p>	<p>dandelion leaves (0)</p> <p>Dandelion leaves are a great source of vitamins, minerals, and fiber. All parts of the plant are edible, either cooked or raw. Many people use the leaves as salad greens.</p>	<p>rhubarb leaves (1)</p> <p>Rhubarb leaves contain oxalic acid, which can cause kidney damage, convulsions and coma. However, you'd have to eat quite a few of them to achieve these extreme effects.</p>	<p>tomato leaves (1)</p> <p>These contain solanine, which can cause stomach upset and nervous system distress. Tomatoes are in the nightshade family of plants, Solanaceae, along with Atropa belladonna, jimson weed, and potatoes.</p>

<p>azalea (2)</p> <p>The azalea is a small rhododendron. The nectar of the azalea flowers is also toxic, so if bees make honey from azaleas, the honey will be toxic.</p>	<p>hibiscus (0)</p> <p>Hibiscus plants are famous for their huge flowers. Since the flowers are edible, they can be used as disposable plates!</p>	<p>rhododendron (2)</p> <p>Rhododendrons are the larger group of plants to which azaleas belong. Rhododendrons are large bushes with huge ball-shaped flowers. As long as you look and don't taste, you're OK!</p>	<p>hydrangea (1.5)</p> <p>Hydrangea are distantly related to rhododendrons, but contain the same toxic chemicals found in the <i>Prunus</i> family (fruits with pits). These chemicals mainly affect the digestive system.</p>
<p>gooseberries (0)</p> <p>Gooseberries are one of the few simple, round berries that are edible. They are related to currants and are native to Europe and Africa. They are used in salads, desserts and jams.</p>	<p>asparagus berries (.5)</p> <p>Asparagus berries are somewhat controversial, but the general consensus is to refrain from eating them, as they have been reported to cause toxic effects.</p>	<p>pokeweed berries (1.5)</p> <p>The pokeweed plant is a common weed. The ripe berries are dark purple and can be used as a natural dye. Eating more than a few berries can cause nausea and headache.</p>	<p>yew berries (2)</p> <p>These bright red berries are found on bushes that have soft, flat needles, like an evergreen. Eating more than a few berries can cause vomiting, diarrhea and dizziness. Eating a lot of them can be fatal.</p>
<p>tulip bulbs (1)</p> <p>Most of the tulip bulb is moderately toxic. During WW II people in Holland ate the outer parts of tulip bulbs when faced with starvation. The knew the central part of the bulb was toxic and did not eat it.</p>	<p>orchid bulbs (0)</p> <p>Orchids are not closely related to these other bulbs, so their chemistry is different. All parts of the orchid plant are edible and the flowers are often used in salads and desserts.</p>	<p>daffodil bulbs (2)</p> <p>Daffodils are related to tulips but their bulbs seem to be more toxic than tulip bulbs. Eating daffodil bulbs causes intense vomiting and diarrhea.</p>	<p>hyacinth bulbs (2)</p> <p>Related to tulips and daffodils, hyacinths are also to be avoided. The alkaloid chemicals cause intense digestive misery, and can also affect other systems of the body.</p>
<p>maple leaves (2)</p> <p>These are more of a danger to grazing animals than people, as horses find them tasty and people do not. The leaves get more toxic as they wilt and turn colors. Only a few pounds of them will poison a horse.</p>	<p>dogwood leaves (0)</p> <p>The leaves and berries of the dogwood tree are non-toxic.</p>	<p>cherry leaves (2)</p> <p>The leaves of the cherry tree contain the same toxic chemicals found in the seeds. Horse owners are very careful to keep cherry tree leaves out of their animals' pastures.</p>	<p>oak leaves (1)</p> <p>Oak leaves contain high levels of tannic acid, which causes digestive upset and possibly other symptoms at high doses. It can cause grazing animals to cholic. Pigs are not affected.</p>
<p>raw kidney beans (2)</p> <p>Raw kidney beans contain a substance called lectin, which is beneficial to the plant, but not to you. Even 4-6 raw beans can cause great distress to your digestive system. Boiling beans for 10 min. destroys the lectins.</p>	<p>raw lima beans (1)</p> <p>Raw lima beans contain a substance called linamarin, which is fairly toxic. When boiled for just 10 minutes, this chemical is broken down and becomes harmless.</p>	<p>raw green beans (.5)</p> <p>We've all eaten a few raw green beans once in a while. Don't panic! A few won't harm you. Just don't eat a bushel of raw beans or you'll get some distressing digestive disturbances.</p>	<p>raw Mung beans (0)</p> <p>Mung beans belong to the genus <i>Vigna</i> and come from India. The other beans in this row are genus <i>Phaseolus</i> and are native to the Americas. Mung beans can be eaten raw or cooked.</p>
<p>cherry pits (1)</p> <p>All members of the <i>Prunus</i> family have cyanogenic glycoside chemicals that attack the cells in your digestive system. A large dose of these chemicals can affect other organs, as well.</p>	<p>grape seeds (0)</p> <p>Grape seeds are not only non-toxic but they are beneficial. Grape seed extract is a powerful anti-oxidant, protecting your cells from dangerous molecules called "free radicals."</p>	<p>apple seeds (.5)</p> <p>Apple seeds contain small amounts of a toxic cyanide chemical, but you'd have to eat hundreds of seeds to produce any noticeable symptoms.</p>	<p>pear seeds (.5)</p> <p>Pear seeds have the same issue as apple seeds, since they are somewhat related. Again, eating an occasional apple or pear seed is not a problem.</p>