WHAT IS IN A LEAF?

TEACHER BACKGROUND

Plants make leaves for the purpose of conducting photosynthesis. Because plants do not need to eat other organisms in order to get energy and nutrients, they are called PRODUCERS—they produce their food from the air using energy from the sun.

1. Leaves are thin—so that the sun can reach the cells where photosynthesis happens.
2. Leaves are full of PROTEIN—the machines that pull molecules apart and put them back together in photosynthesis are enzymes, a type of protein.

Leaves are full of SUGAR and STARCH—the products of photosynthesis, and how the plant stores energy.

3. Leaves are full of WATER—the roots take water from the soil, and the water is pulled up through the plant to the leaves, where most of it evaporates into the air through pores in the leaf called stomata, which let carbon dioxide IN to the leaf as water goes OUT into the air. Basically, leaves trade water for carbon dioxide, which they make into sugar. The leaves also break apart some of the water in the process of making sugar and oxygen.

Slide 2: WHAT DO Animals need to CONSUME (eat) in order to be healthy and survive?
(sugars, starches, proteins, fats, oils, water, fiber)
You can leave out fiber, starch, fats, or oils if you want to move along.

To a hungry insect or mammal, a leaf is an easily chewed package of protein, sugar, starch, and water—delicious and nutritious. Animals are called CONSUMERS because they cannot make sugar from air and sunlight like plants can—they have to eat other organisms.

To watch a deer eat:
http://www.arkive.org/white-tailed-deer/odocoileus-virginianus/video-08a.html#src=portletV3

To watch a beetle eat:
http://www.arkive.org/oil-beetle/meloe-proscarabaeus/video-00.html#src=portletV3

Student Activity—draw a leaf (it can be a leaf from grass, or a vegetable plant, or a tree), and list the leaf's ingredients (protein, sugar, starch, water). Then draw an animal that might like to eat the leaf. Label the producer and consumer.

TEACHER BACKGROUND

Plants and consumers are locked in competition for the contents of the leaves! Each side has developed TRAITS that will allow it to take or keep the resources in the leaf for itself.

--a TRAIT is a chemical, shape, structure, color, texture, or behavior specific to an organism.

Trait is a broad, vague concept: traits are usually defined in comparison between organisms. For instance, in telling me apart from a cow, an important trait that gives me an advantage is that I have hands and thumbs to pick things up; in telling me apart from my brother, an important trait is that I am left-handed and he is right-handed, giving me an advantage at playing first base in baseball.

PLANT DEFENSIVE TRAITS

Plants have come up with some traits to prevent consumers from eating their leaves. These traits are known as DEFENSES. Here I have divided some common plant defenses into two categories: difficult and disgusting.

There are some plant traits that act as **physical** barriers to hungry herbivores, and make it *difficult* for them to reach the leaves:

THORNS—(thorns, spines, and prickles are botanic terms that denote what plant tissue the sharp poking structure is derived from—see the Wikipedia page on thorns for more detail if you are interested.) This trait is one that most people know about, because it works very well at keeping humans away from plants too! Thorns are hard, often woody structures, usually on stems or branches, which provide painful sharp pokes in the soft mouths of large animals. (exercise: look at rose or blackberry thorns)

HAIRS—are common on leaf surfaces and stems, and to a small caterpillar or beetle, they are as terrible as thorns are to big animals. Hairs are hard and dry, and sometimes they are so thick that a small bug cannot even reach the green, delicious surface of the leaf. (exercise: rub and look at underside of magnolia leaf, or sage leaf, with a magnifying glass or dissection scope).

WAX—plants make wax as part of the cuticle—like the outer layer of our skin—that keeps water and disease out of the leaf. In some plants, the wax is so thick that it is very hard for insects to reach the soft cells of the leaf, and the surface is so slippery that the insects slide off. Large animals able to chew leaves into pieces and reach the soft center of the leaf. (exercise: rub the top of the magnolia leaf, or the kale leaf, or the grapes, or the blueberry—the whitish stuff on the grapes and the pale blue stuff on the blueberries that rubs off is wax)

Slide 13: Has the waxy covering ever kept you from eating a blueberry?

(wax stops insects, not mammals)

More reading on wax:
http://botanistinthekitchen.wordpress.com/2012/12/28/the-most-interesting-layer-of-wax-in-the-world/

http://www.fs.fed.us/wildflowers/ethnobotany/waxes.shtml

Exercise: Students carefully handle and examine different plant defenses:
Thorns: rose or blackberry branches, with leaves if possible
Hairs: fresh sage leaves (available in the grocery section), or fresh or dried magnolia leaves (hairs on bottom of leaf)—students can feel the fuzziness, or use magnifying glass to look at hairs
Wax: top of fresh magnolia leaf, kale leaves, whitish bloom on grapes or blueberries—students can rub wax onto their fingers

Exercise: The Big versus Small worksheet. Students will need metric rulers. The magnification exercise is an example of the same kind of math that adult scientists use to determine the size of very small structures discovered under the microscope.

CONSUMER ADAPTATIONS
TEACHER BACKGROUND

There are some **chemical** traits that keep plants from being eaten by hungry herbivores. These traits make the plant *disgusting* to herbivores who bite into it, so that they eat only a tiny bit:

LATEX—is a milk-colored liquid that flows through special, latex-only channels in the leaf, and when the leaf breaks and latex comes in contact with air it turns into sticky goo (note: rubber is made from the dried and chemically altered latex of a tree). A bug who gets a mouthful of latex may have its mouthparts glued shut, or it may end up glued to the leaf—either way, this can slow down or kill a bug. Note: the latex in lettuce is relatively mild after artificial selection by thousands of years of cultivation, but latex from other species can contain some nasty proteins (ie, latex allergies). Students can handle lettuce with bare hands, but other latex-containing leaves should be handled with gloves.
More reading on latex: http://www.fs.fed.us/wildflowers/ethnobotany/latex.shtml
Video: how bugs deal with latex, cutting a leaf to see latex:

https://www.youtube.com/watch?v=SbB5DnWWqF4

TANNINS—are a group of chemicals found in many plants, especially trees. Some plants make such high levels of these chemicals that you can taste them—they make your mouth feel dry and gritty. In high amounts tannins slow digestion down. Some humans like the taste of tannins, and drink tea, coffee, beer, or wine, which have enough tannin to give flavor but not enough to slow your digestion.
More reading on tannins:
http://www.fs.fed.us/wildflowers/ethnobotany/tannins.shtml

HYPERICIN—is a chemical found in the sap of St. John's Wort. When the sap is eaten or brushed on the skin, it breaks down the skin's natural defense against UV light, and terrible sunburn is the result. This can cause pain, blindness, sunburn, and death in mammals and can kill insects, and is a serious concern of dairy farmers. Note: St John's Wort is NOT a good plant to use in demonstration.

Exercise: Students experience chemical defenses. For latex: each student gets a romaine or maple leaf and can cut it to observe the latex, including after it dries and becomes sticky. Alternatively, students can observe latex by scratching sweet potatoes with a fork. The latex demonstrations will only work if lettuce leaves and sweet potatoes are intact and relatively fresh; otherwise, the latex will have already dried up inside the leaf. Consider showing the video on latex:
https://www.youtube.com/watch?v=SbB5DnWWqF4
For tannin: students can taste black tea (decaffeinated and unsweetened for full tannin flavor).

ANIMAL ADAPTATIONS
TEACHING BACKGROUND

Some consumers have TRAITS that allow them to eat well-defended plants; because these traits make them better able to survive and grow than other consumers, these traits are ADAPTATIONS.

ADAPTATIONS:

Deer

Tannins can slow digestion and make it difficult for the digestive system to extract nutrients, but deer are built for slow digestion: they have 4 stomachs and very long intestines. Deer eat acorns and bark, both relatively high in tannins, in addition to leaves.

For a video of deer eating: http://www.arkive.org/white-tailed-deer/odocoileus-virginianus/video-08a.html#src=portletV3

Monarch butterflies: the caterpillars of monarch butterflies eat milkweed plants, which have leaf hairs AND latex. The caterpillars have ADAPTIVE (helpful) behaviors for dealing with these plant defenses:

They use their mouths to cut the leaf hairs away so that they can eat the juicy nutritious part of the leaf.

They use their mouths to cut holes in the leaf so that all the latex flows out in one spot; then they move to another spot and eat that part of the leaf.

For more about monarchs and milkweeds, including pictures, see
http://www.eeb.cornell.edu/agrawal/documents/agrawal2012milkweedarmsrace.pdf
or
http://www.monarchlab.org/Lab/Research/Topics/Milkweed/Default.aspx
Videos:
http://www.arkive.org/monarch-butterfly/danaus-plexippus/video-09b.html#src=portletV3
For a great description and video about the adaptations of monarch butterflies, check out this video from milkweed expert Dr. Anurag Agrawal:
http://youtu.be/WXHeqxf1kDE

St. John's wort beetle (Chrysolina hyperici, there are a few species with this common name):
The St. Johnswort beetle actually tastes plants looking for hypericin, and will only feed upon plants with high levels of hypericin.

It avoids sun damage by staying in the shade. The adult spends its feeding time under the leaves, and its larval stages live underground, eating the roots of the same plant.

The advantage of eating a plant poisonous to everyone else is you always have plenty of food. Also, animal predators avoid these shiny beetles in case the beetles have a stomachful of poisonous plant that would make the bird or mammal predator sick.

Exercise: Students fill out the Animal versus Plant worksheet.

Exercise: Students play the Plant versus Animal game.

Consider concluding with the Yosemite Park Nature Note on Monarchs and Milkweed, it can lead into a discussion on conservation, on building butterfly gardens, or into pollination: https://www.youtube.com/watch?v=V3jpu2th34o

Note: While this lesson focuses on conflict between plants and animals, there are important ways in which plants and animals help each other, especially with pollination. For more resources and lesson plans related to pollination, see http://pollinator.org/education.htm

For more resources on conservation science and projects that students can complete, a great resource is http://www.fs.fed.us/wildflowers/kids/activities/index.shtml.