Lesson One
What's So Great About Plants?

Content Summary

In this first "Plants" lesson, students are introduced to the wonderful world of plants. The lesson begins with a look at some very unconventional plants and continues with an examination of how plants impact our daily lives, and why their very existence is important to our own survival.

Lesson Materials

- *Fresh Science* Plants DVD
- Lesson 1 ACTIViewer™ recording sheets (Pages 25 and 26); one copy per student
- "What's So Great About Plants?" Reading , Writing and Thinking Activities (Pages 19-22); one copy of each per student
- "Making Recycled Paper" Hands-on Activity (Pages 23-24); one copy per student
- Papermaking screens; single ply toilet tissue; four-quart bowls; measuring spoons; whisks; liquid starch; plastic bins or dishpans; newspapers; spatulas; rolling pin; cookie sheets; hot tap water; and hair dryer (optional).

Key Concepts

The following concepts are featured in **bold** in this lesson and appear in the DVD's Illustrated Glossary.

energy flow **plant**

Pacing

This video lesson should take about 30 minutes to complete, depending upon the degree of student interactivity. Additional time is required for the Reading, Writing and Thinking Activities; the Video Quiz; and the Hands-on Activity.

Student Objectives

- **Define a plant as an organism that typically has roots, a stem and leaves, is usually green and that makes its own food**
- **Give examples of how plants impact our daily lives through medicines, building materials, clothing and food**
- **Explain how trees become finished goods such as lumber and paper**
- **Describe energy flow using a food chain example**
- **Explain why only 10 percent of the sun's energy moves from one link in a food chain to the next**
- **Support the statement that plants make our very survival possible**

Appetizer

WHAT'S SO GREAT ABOUT PLANTS? (T)

Good or bad, everyone's got an opinion about plants, and your students are no exception. Ask students to take a few minutes to write a response to the question posed on the screen, "What's so great about plants?" It's quite likely that students will have negative thoughts about plants (who hasn't, at times?) and it's important to capture those notions, too. So, once students are finished writing why plants are so great, allow them to jot down a reason or two why someone (not them, of course) would think plants were not so great. Then, call on student volunteers to read aloud their pro and con statements about plants. Write their key words or phrases on the board.

Continue the discussion by asking some or all of the following questions.

- What's your favorite plant? Why? *[Students probably will focus on beauty and fragrance, though some may think about plants that are used for building materials, or to clothe or shelter us. It is hoped marijuana stays out of the discussion…]*
- What's your least favorite plant? Why? *[Students probably will focus on weeds, poison ivy and oak, prickly plants, and those plants that cause them personal heartache: trees with leaves that must be raked in autumn, grass that grows and needs cutting.]*
- Briefly, how do you see plants affecting our society? *[We eat them; other animals eat them; we farm them; agriculture creates jobs; building supplies, fabric, medicines all are integral to jobs and our society.]*
- What's the coolest plant you've ever heard of? *[Students may cite Venus's flytrap or some other meat-eating plant. Cool, for sure, but just the tip of the iceberg when it comes to amazing plants.]*

Assure students that as they study plants, they're going to see some of the most amazing plants our planet has to offer. But first, it's time to learn some fun facts about our green counterparts. SKIP

PLANT MUSEUM OF THE HARD TO BELIEVE (T)

This brief survey of the plant kingdom is designed to broaden students' appreciation for what lies ahead in the study of plants. Plants really are remarkable in so many ways; yet, so often in their study, emphasis is placed solely on naming the parts of a flower or describing the process of photosynthesis. Don't worry, all that and more will be covered in this and the following lessons. However, students also will be treated to some of the very fun aspects of studying botany in hopes of dispelling the almost universal perception that plants are boring.

Begin by telling students that they are going to make a quick visit to the Plant Museum of the Hard to Believe, where unusual and record-breaking plants are on display. Then, ask students what organism they think is the world's heaviest. Since this lesson is on plants, students probably will think of redwood trees, or they may mention the blue whale or African elephant. Anyway, let students exhaust the possibilities before showing the next image. SKIP

STAND OF GENETICALLY IDENTICAL ASPEN TREES (P)

Explain to students that when studying plants, there's often more to the story than meets the eye. Tell them that in the case of these trees, much of the story takes place under the ground. Explain that this "forest" of aspen trees (aerial view on the left, close-up view on the right) is actually an aspen clone in the Wasatch Mountains of Utah. It is composed of 47,000 stems of genetically identical aspen trees *(Populus tremuloides)*, and has a total weight of six million kilograms (6,500 tons), making it the world's heaviest organism. This colossal clone has developed through a process called suckering, where new shoots arise from a gigantic spreading root system. Above ground, the stems appear to be separate trees, but they all have grown from a genetically identical root system.

If that doesn't get students' attention, try this one: ask students just how small they think the world's smallest flower is. Suggest such possibilities as the size of a dime, the size of a pea or the size of a salt grain. Once students have weighed in, show them the next image… SKIP

MINUTE *WOLFFIA ANGUSTA* PLANTS FILLING A THIMBLE (P)

Tell students that according to Wayne P. Armstrong, adjunct professor of Biology and Botany at Palomar College in San Marcos, California, the world's smallest flowering plants belong to the genus wolffia, comprised of minute rootless plants that float at the surface of quiet streams and ponds. Professor Armstrong has devoted much of his life's work to studying these miniscule plants. He is known to many as Mr. Wolffia. *[If they don't know the terms already, explain to students that botany is the branch of biology that studies plants, and that a botanist is a scientist specializing in the study of plants.]*

Explain that this is not a picture of a bucket of grapes; instead, it is a sewing thimble holding thousands of individual wolffia plants.

Each plant is shaped like a microscopic green football with a flat top. An average individual plant of certain wolffia species is small enough to pass through the eye of an ordinary sewing needle. SKIP

FOUR WOLFFIA PLANTS IN THE EYE OF A NEEDLE (P)

Professor Armstrong has found that plants from the smallest species of wolffia average just six-tenths of a millimeter long (1/42 of an inch) and three-tenths of a millimeter wide (1/85th of an inch). They weigh about 150 micrograms (1/190,000 of an ounce),

the approximate weight of two to three grains of table salt. If the plants are that small, imagine the size of their flowers! SKIP

WOLFFIA PLANTS; YELLOW FLOWER BLOOMING (P)

Indeed, wolffia plants also produce the world's smallest flower. Can you see the beautiful yellow flower emerging from the plant at center? A bouquet of a dozen of these plants in full bloom will fit easily on the head of a pin… SKIP

TWO BLOOMING WOLFFIA PLANTS INSIDE LETTER "O" (P)

…and two *Wolffia angusta* plants in full bloom fit comfortably inside a printed letter "o." By the way, that "o" isn't the size of your television screen, it's the size of standard newspaper print. After pollination, the ovary within the flower develops into a teeny, tiny one-seeded fruit called a utricle. SKIP

ONE-SEEDED WOLFFIA FRUITS BESIDE SALT GRAINS (P)

And, as you might suspect, the wolffia utricle holds the record for the world's smallest fruit. Here are five fruits nestled among five salt grains, each of which is just about three-tenths of a millimeter across.

Tell students that as they've seen already, plants come in all shapes and sizes. Explain that the more students learn about plants, the more they will realize that despite their differences, plants actually have a lot in common with one another. SKIP

MISTLETOE BIRD (NVB); FIRST FRAME OF NARRATED VIDEO BITE

Here's a plant that's hard to believe… we all know that one way birds help plants make more of their own kind is by eating the plants' fruits and berries and then later discharging the seeds through their own waste products. (How's that for a delicate way of saying it?) Anyway, tell students that there's a type of parasitic plant that enlists the help of birds to attach its seeds to tree branches. Hard to believe? See for yourself. SKIP
[1 minute, 4 seconds duration]

MISTLETOE BIRD (NVB) • NARRATED VIDEO BITE

"A mistletoe is a plant that can exist only in partnership with a tree, for it has no roots of its own. The mistletoe has green leaves so it can make food, but it gets all the liquid it needs from the tree into which it's fastened itself. The mistletoe bird comes by its name naturally—it eats almost nothing except mistletoe fruit. The bird digests the fleshy coating of the seed with amazing speed. It takes less than half an hour to travel from beak to bottom, so to speak. When it comes out, the super sticky seed remains attached to the bird's behind by a long, sticky thread. So, it has to be wiped off. The bird has a special technique for doing so. Every time it needs to detach a seed, the mistletoe bird performs this little dance… Stickiness is the key to the mistletoe's success in getting from one tree to another. Once parked on a living branch, the seed quickly plugs itself in. Then, with a connection to its host's liquid supply, the mistletoe can build leaves and start making fruit for itself."

MISTLETOE BIRD (NVB); LAST FRAME OF NARRATED VIDEO BITE

That gives new meaning to the phrase, "Don't stand under the mistletoe," doesn't it? Tell students that plants have many strategies for survival, and that in their study of plants, students will see and learn about some of the more amazing relationships plants have with other organisms.

There's time to see one last exhibit in the Plant Museum of the Hard to Believe. SKIP

BABIANA IRIS AND HOVERFLY (NVB); FIRST FRAME OF NARRATED VIDEO BITE

Tell students that plants are a major food source for many other living things. This flowering plant, a type of iris that grows in South Africa, has a very clever way of guiding a particular animal to its nectar. Watch. SKIP *[52 seconds duration]*

BABIANA IRIS AND HOVERFLY (NVB) • NARRATED VIDEO BITE

"Each of these flowers has an incredibly stretched out, tubular base—the place where the flower is attached to the stem. Deep inside… is nectar. The tiny entrance to the tube is perfectly marked by these white arrows on the petals. And here is the only tongue that can reach the nectar. It belongs to a hoverfly. Well… it's not so much a tongue as a delicate tube. In proportion to body length, it's one of the longest feeding implements in the animal kingdom. The clear markings on the petals are essential—because the tongue is so long, even in the lightest wind its end blows about. And, for giving up its nectar, the flower gets a reward, so to speak. As the hoverfly reaches deep into the tube, its head collects pollen. The pollen is moved from flower to flower along with the hoverfly."

BABIANA IRIS WITH HOVERFLY (NVB); LAST FRAME OF NARRATED VIDEO BITE

Tell students that these irises bloom only for a couple of weeks each summer, so once they quit blooming hoverflies have to look elsewhere for their food. But no matter what flower they ultimately choose to feed from, you can be sure it has some form of nectar guides to help the hoverfly hit its target.

Nectar guides are one example of an adaptation some flowering plants have. Explain that *adaptation* in this case means a change over time to a structure, form or behavior to fit different conditions. Tell students that in their study of plants, they will see some amazing adaptations plants have developed over time to help them survive. By studying plants and their adaptations, we can gain a better understanding of how we and other animals can best help plants as they help us. The more we know about plants, the better neighbors we'll be to them in our shared environment.

Tell students that in this and the next three lessons, they will be introduced to plants and will discover quite quickly why we need them more than they need us. The Plant Museum of the Hard to Believe just scratches the surface when it comes to showing off some of the more interesting plants on our planet. Students will be treated to much more as they take a visual tour through the plant kingdom.

Now, distribute copies of the "What's So Great About Plants?" ACTIViewer™ recording sheets to each student.

Let the following narrative help steer your discussion with the students. Those of you who are unfamiliar with or uncomfortable with the subject matter might want to stick fairly closely to the prepared script—paraphrasing it and customizing it to fit your particular teaching style. The visuals on the DVD are ordered based on the lesson plan, so all you need to do is watch for video and print cues telling you when to advance the DVD.

Those of you who are well versed in the subject of plants can use these visuals to support your own lessons. If you prefer to use the visuals only, though, you might want to visit the Visuals a la Carte section of the DVD to help you navigate more easily through the images.

Regardless of how you choose to use the materials we've provided, remember that above all, *you* are guiding this lesson, it is not guiding you. Move through it at a pace that's comfortable for you and your students. Encourage questions and interactivity. If you're unsure of answers, have students further research their questions on the internet. Or e-mail the question to us at **Questions@FreshScience.com**. We're eager to help you succeed. SKIP

The Use Of Scientific Names In The Video Lessons

Please note that the text in the video lessons follows the style conventions set forth in the CBE (Council of Biology Editors) Style Manual, Fifth Edition, which states:

> ***"Use italic type for scientific names of genera, species and their subdivisions. Use roman type for the names of higher rank. Many plants are known by their vernacular or common names, as well as their scientific ones. Most common names are not capitalized, although a name derived from a proper noun may retain the initial capital letter, whether hyphenated or set as two words (Cupid's-dart, Dutchman's-pipe, English ivy). A generic name used as a vernacular name is neither italicized nor capitalized (Camellia, camellia; Iris, iris; Rhododendron, rhododendron), and is pluralized as though English (crocuses, not croci)."***

Main Course

WHAT IS A PLANT? (T)

What makes a plant a plant? Does it have to be green? Does it need to have leaves? Who would like to venture a guess at the scientific definition of a plant? *[Solicit ideas from students and write key words or phrases on the board.]* SKIP

DEFINITION OF A PLANT (I/D)

A **plant** *(IG L1)* is defined as a living thing that usually, but not always, has a root, a stem and leaves. The wolffia plant, of course, is an exception to that part of the definition, as wolffia are rootless. But, suffice it to say, most plants have similar plant parts. Also, most plants are green and they're green because they have a substance called chlorophyll in their cells. And, the chlorophyll plays a key role in what further defines a plant: a plant makes its own food. Now, we all know that there are some meat-eating plants out there, but those plants could survive even if they didn't eat an occasional bug or two. They still make food in their leaves.

We'll get into these and other areas about plants in more depth later on; first, let's talk a little bit about how plants respond to the world around them. SKIP

MIMOSA LEAF WILTING (VB); FIRST FRAME OF VIDEO BITE

A plant doesn't have a nervous system or sensory organs like animals have. But, plants do respond to external stimuli. Some plants even have adaptations that help them respond immediately to a threatening situation. Take this mimosa plant, for example. Watch how it protects itself from danger. SKIP *[10 seconds duration]*

MIMOSA LEAF WILTING (VB); LAST FRAME OF VIDEO BITE

The flame didn't damage the leaf. Its wilted condition is only temporary. In a few hours, the leaf will be full and upright once again. SKIP

MORNING GLORY TWINING; TIME-LAPSE (VB); FIRST FRAME OF VIDEO BITE

And, even though the definition of a living thing includes the ability to move, plants seem virtually motionless. But make no mistake about it, plants do move. It's just that they exist on a very different time scale from our own, so their movement is often undetectable. When you speed up the time factor, though, it turns out that plants move quite amazingly well. Take this morning glory, for instance... SKIP *[20 seconds duration]*

MORNING GLORY TWINING; TIME-LAPSE (VB); LAST FRAME OF VIDEO BITE

That movement, called twining, is common to climbing vines and related plants. Those tendrils, or shoots, called twining stems, help the plant obtain a strong foothold as it makes its way upward.

So now you know the basic stuff about what a plant is, and a little about what plants can do. We'll get into each of these areas in more depth later on; first, let's talk about how plants impact our daily lives. SKIP

OUR LIVES... STARRING PLANTS (T)

Plants really do star in our lives. Let's look at just a few of the ways. SKIP

PLANTS AS FOOD; PRODUCE SECTION (VB); FIRST FRAME OF VIDEO BITE

Most obviously, plants provide food for us and other animals. Rather than try to list every example, let's play a quick memory game instead. We're going to take a brief trip through a farmers market where literally hundreds of different fruits and vegetables are sold. When the one-minute trip is over, I'm going to ask you to recall as many different fruits and vegetables as you can. Ready? Here goes… SKIP *[1 minute duration]*

PLANTS AS FOOD; PRODUCE SECTION (VB); LAST FRAME OF VIDEO BITE

Well, how many of the 23 plant foods can you recall seeing? *[Solicit as many answers as possible. The following produce, in order of appearance, was shown: avocados, tomatoes, tomatillos, green peppers, iceberg lettuce, European cucumbers, cauliflower, cucumbers, russet potatoes, sweet potatoes, nectarines, black plums, garlic, yellow onions, zucchini squash, yellow squash, pineapples, parsnips, mustard greens, kale, lemons, oranges and limes.]*

Fruits and vegetables are easy to identify as plant foods. But many food plants work "behind the scenes," so to speak. In other words, the plants aren't consumed as is; they're altered in some way to become consumable food. SKIP

PLANTS AS FOOD; WHEAT HARVESTING (VB); FIRST FRAME OF VIDEO BITE

Wheat, is one such plant food. SKIP *[10 seconds duration]*

PLANTS AS FOOD; WHEAT HARVESTING (VB); LAST FRAME OF VIDEO BITE

The wheat is harvested, and the wheat berries are ground into flour… SKIP

PLANTS AS FOOD; BANANA BREAD INGREDIENTS (P)

… to be used for, among other things, baking. Here, in the lower right corner, you see one and a half cups of flour along with all the other ingredients you would need to make the best banana bread ever. Those three black things are bananas that are about three days past their peak… but they're still great for baking; they're very soft and sweet. SKIP

FRESH BANANA BREAD RECIPE CARD (I/D)

You'll also need four tablespoons of melted butter, a cup of sugar (from plants), one

teaspoon of baking soda, a teaspoon of salt, one egg, and one cup of chopped pecans (from plants). The nuts are optional, but they make the bread really delicious. SKIP

PLANTS AS FOOD; BANANA BREAD BATTER (VB); FIRST FRAME OF VIDEO BITE

Simply mash the bananas in a bowl, and then add all the other stuff. Mix it up, then pour the batter into a buttered loaf pan. Bake it in the oven at 325° for one hour or until a toothpick inserted into the middle of it comes out clean. SKIP *[2 seconds duration]*

PLANTS AS FOOD; BAKED BANANA BREAD (VB); LAST FRAME OF VIDEO BITE

Looks tasty, huh? SKIP

***GINKGO BILOBA* PLANT (P)**

While plants make up a large part of our diet, they enrich our lives in many other ways. Some plants are processed into herbal remedies and chemical compounds to create lifesaving medicines. The *Ginkgo biloba* plant has been growing on Earth for nearly 200 million years. For centuries, Chinese monks saw it as a sacred herb. During the past 30 years, many clinical trials in our country have tested whether ginkgo has legitimate medicinal qualities… SKIP

***GINKGO BILOBA* HERBAL PRODUCT (P)**

…and have found that it seems to help prevent or lessen the severity of many problems throughout the entire body. So the next time an adult family member in your household is experiencing dizziness, ringing in the ears, mental fatigue, stress, absentmindedness, lack of energy, or is just plain in a bad mood, suggest a *Ginkgo biloba* herbal remedy. SKIP

***CATHARANTHUS ROSEUS*; MADAGASCAR PERIWINKLE (P)**

This plant, the Madagascar periwinkle, is the source of traditional medicines that may help inhibit the growth of certain tumors and help treat leukemia in children. SKIP

***DIGITALIS PURPUREA*; FOXGLOVE PLANT (P)**

And this common foxglove plant is not only ornamental, it's the source of the cardiac drugs digitalin and digoxin. Be careful though; ironically the foxglove is an extremely poisonous plant. If you come across one, never put it anywhere near your mouth! SKIP

***EPHEDRA MAJOR* (P)**

Finally, this ephedra plant contains a nerve stimulant called ephedrine that's used in some nasal sprays and cold medicines. *[Note: on April 6, 2004, the Food and Drug Administration (FDA) issued a rule prohibiting the sale of dietary supplements containing ephedrine alkaloids because "such supplements present an unreasonable risk of illness or injury." While ephedra showed some effectiveness in promoting short-term weight loss, the substance also raised blood pressure and stressed the circulatory system. As a result, these over-the-counter dietary supplements were deemed as "simply too risky." Prescription drug*

products containing ephedrine alkaloids are regulated by the FDA.]

You've seen just a few of the thousands of known medicinal plant species growing throughout the world. The challenge is to preserve the habitats of these plants. It's possible that many cures remain undiscovered in plant species still to be investigated. SKIP

LUMBER MILL TOUR (NVB); FIRST FRAME OF NARRATED VIDEO BITE

So far, we've talked about plants that we ingest in some way. But, there are many other ways we use plants on a daily basis. Take building materials, for example. Raise your hand if your home is made of any plant products. *[Remind students about wood framing in doorways, wood flooring, wood lath that forms the basis for plaster walls, and so forth.]*

Let's take a quick trip to Whitehouse, Florida, and tour the Whitehouse lumber mill, operated by International Paper, to learn more about how trees are converted into useable lumber. SKIP *[3 minutes duration]*

LUMBER MILL TOUR (NVB) • NARRATED VIDEO BITE

"If you've spent any quality time riding on interstate highways, you've probably passed, at least once, a giant tractor-trailer full of freshly cut pine trees. Did you ever think about where it was going? Most probably, it was headed to a lumber mill much like this one. This mill, run by International Paper, produces high quality southern yellow pine lumber. Chances are, you have some yellow pine lumber somewhere in your house—perhaps in the framing, or making up a deck or a fence.

"Eighty truckloads a day are unloaded at the mill. Each load of logs produces between 4800 and 5000 board feet of lumber. Most of the logs entering the mill are unloaded and stored on the log mound. A giant crane moves logs from the log mound to the log processing yard. Logs shouldn't stay on the log mound longer than 10 days, or they could rot.

"To begin the process of turning logs into lumber, the logs are fed into a debarker that, you guessed it, strips the bark from the tree-length stem. The bark isn't thrown away… it's stored and then sold as mulch and other byproducts. After the log stems are debarked, they're conveyed to the cut-up saws where they're sawed into cut-size logs.

"And then the logs enter the saw mill where the fun begins. Computers and people work together to obtain the optimum amount of useable lumber from each log.

"Later that same day, the stacked lumber is transported by rail cars into giant kilns, where the boards are dried at high temperatures for 18 to 24 hours.

"The lumber then is planed to finish it. After the lumber leaves the planer, it is visually evaluated, and then graded according to national grading rules.

"Once the lumber is graded and trimmed to length, it is stamped and sorted. It's then packaged and placed into finished inventory, ready for that next home to be built."

LUMBER MILL TOUR (NVB); LAST FRAME OF NARRATED VIDEO BITE

When trees are processed into lumber, there's hardly any waste. Sawdust and wood shavings are recycled to help make such things as paper grocery bags and corrugated cardboard boxes.

According to the American Forest and Paper Association, more than 5,000 things are made from trees. Let's try to name them, shall we? Just kidding! But, think how much wood is a part of your lives. Most of you probably are touching wood, or some form of it right now. Are you holding a pencil? Is your desk or chair made of wood? Are there dollar bills in your pocket? Do you have paper on your desk? Yes, paper comes from wood fiber… SKIP

PAPER MILL TOUR (NVB); FIRST FRAME OF NARRATED VIDEO BITE

…but you probably knew that already. Still, for all the time you spend around paper, passing it out, writing and drawing on it, reading it, painting things on it, and making paper airplanes from it, do you know how a tree is turned into paper? Take a look. SKIP *[3 minutes duration]*

PAPER MILL TOUR (NVB) • NARRATED VIDEO BITE

"If you looked at paper under a microscope, you'd see thousands of tiny cellulose fibers all pressed together. Cellulose is the stuff making up plant cell walls. Paper takes form as cellulose fibers are deposited and overlap on special screens. Here's how that happens.

"Of course, the first step in papermaking is to bring wood into the paper mill. The wood is stored in large piles and then brought as needed into what's called a wood room. Next, the bark must be removed from the wood. In this particular mill, that's done with a machine that acts kind of like a giant pencil sharpener. It's got two, large rotating jaws that chew the bark from the wood. Then, the wood logs are fed into a chipper. The resulting wood chips can't be just any size; the design of the cutting knife is such that the chips are sliced on an angle, and come out about the size of a fifty-cent piece. Wood chips are made of cellulose fibers held together by a substance called lignin. The next task is to separate the lignin from the fibers. That's done in a giant device called a digester that works kind of like a pressure cooker.

"The chips are fed into the top of the digester. Then, they're mixed with certain chemicals and 'cooked' under high temperature and high pressure. As the chips move down through the digester, the lignin is dissolved away, releasing the cellulose fibers as pulp. At this early stage, the pulp still has the natural color of the wood. Chemicals are added to the wood pulp… soon, the brown wood pulp turns snow white.

"After the pulp has been bleached and cleaned, it's diluted with water and additives that will give the paper certain properties like strength, color and brightness. This mixture of future paper is pumped into a giant paper machine, measuring about 8 meters wide, and more than a football field long. The paper machine has several sections. The first is called a headbox. There, the pulp mixture is forced through a small slit and spread onto a moving,

continuous belt of wire screening. The screen vibrates to help the water drain from the mixture. And, vacuums underneath the screen use suction to pull away the liquid. The cellulose fibers that remain trapped on the screen stick to one another, and voila… you've got paper. Next, this newly created giant sheet of paper needs to be dried.

"The paper is still too weak to travel by itself without falling apart, so, it's placed on a cloth belt called a felt. The felt works like a thick towel to absorb water from the paper as it's being squeezed in the presses. What started out as pulp and more than 99 percent water in the headbox, is now paper with about a five percent moisture content.

"The next step is called calendaring—squeezing the paper between two steel rolls that are pressed together very tightly. Calendaring does two things: it squeezes the paper down to the right thickness, and it makes both sides of the paper very smooth.

"Finally, the sheet of paper is collected on a take-up roll and removed from the paper machine where it is inspected and readied for shipping. So how long do you think it takes the paper to travel from headbox to here? Believe it or not, the entire trip is less than a minute!"

PAPER MILL TOUR (NVB); LAST FRAME OF NARRATED VIDEO BITE

We're living in a world of paper. It's a good thing that trees are a renewable resource! Just don't forget to recycle! SKIP

COTTON PLANT (P)

Who recognizes this plant? It's a cotton plant, of course. How many of you are wearing cotton today? SKIP

BLUE JEANS; COTTON LABELS IN CLOTHING (P)

Cotton is yet another huge contribution to society made by plants. SKIP

SHADE TREE CANOPY (P)

At this point, what more can one say about plants? We could talk about how they provide shade… SKIP

PLANT TOPIARY; SWANS CARVED OUT OF HEDGES (P)

…and how they make possible such aesthetic diversions as topiaries *[point out the swans carved out of hedges]*… SKIP

PLANT TOPIARY; BUSHES CARVED TO RESEMBLE HOUNDS (P)

…*[point out that the bushes are pruned to resemble hounds]*… But we simply don't have enough hours in the day to talk about all the ways plants enrich our lives. SKIP

SUNFLOWERS (P)

So let's spend our final few minutes talking about the most significant way that plants impact us: they make our very survival possible. It doesn't get any more significant than that, does it?

We see all around us how plants enrich our lives. What we can't see, but what we experience every time we eat food, is the flow of the sun's energy into our bodies. This process, in which energy from the sun is turned into chemical energy that then is transferred from one organism into another… SKIP

ENERGY FLOW (I/D)

…is called **energy flow** *(IG L1)*. Plants are producers because, as we know, they produce their own food. Humans, and other animals, are consumers. We obtain food by consuming other organisms, both plants and animals.

For energy to flow through an ecosystem, we know that green plants capture energy from the sun and convert it into food—useable chemical energy in the form of simple carbohydrates—that can be stored and broken down later to be used as fuel. That makes plants the primary source of matter and energy entering most food chains. Who can describe a simple food chain? *[Solicit answers; energy moves from the sun to producers, then moves on to consumers as plant eaters (herbivores) are eaten by meat eaters (carnivores).]* One simple food chain, or flow of energy might be… SKIP

GRASS (P)

…from grass… SKIP

EASTERN COTTONTAIL RABBIT (P)

…to a rabbit that eats the grass… SKIP

RED FOX WITH PREY (P)

…to a fox that eats the rabbit. SKIP

FOX DECOMPOSING (VB); FIRST FRAME OF VIDEO BITE

Energy flow doesn't end there, though… When organisms die, the stored energy in their body tissues is passed on to such decomposers as bacteria, fungi and lesser animals like flies. Ultimately, these decomposers continue the flow of energy by releasing nitrogen into the atmosphere and nutrients into the soil.

Hold your breath, and if you're squeamish, look away. This dead fox's body has been invaded by maggots; the flow of energy from green plants is alive and well. SKIP *[30 seconds duration]*

FOX DECOMPOSING (VB); LAST FRAME OF VIDEO BITE

Time for lunch! Just kidding… So that's how energy can flow through our environment. Thanks to plants, the sun's energy is captured and converted into a useful form. SKIP

FRUIT (P)

To obtain that energy, we can either eat plants… SKIP

MEAT COOKING ON GRILL (P)

…we can eat plant-eating animals… SKIP

ENERGY FLOW (A); FIRST FRAME OF ANIMATION

…or we can consume their byproducts. For example, many people eat cow's meat, thereby obtaining the sun's energy. But, what's another way to get the sun's energy through cows? *[Solicit ideas; the answer of "milk" follows.]* Watch. SKIP *[17 seconds duration]*

ENERGY FLOW (A); LAST FRAME OF ANIMATION

Milk, of course! Milk and milk byproducts give us energy from the sun.

Now, here's the only catch about energy flow: not all the sun's energy that's captured by producers is passed along to consumers. Indeed, only about 10 percent of the sun's energy moves from one link in a food chain to the next. So what do you think happens to the "missing" 90 percent of the energy? *[Solicit ideas; answer follows.]* SKIP

ENERGY LOSS (I/D)

The "missing" energy simply has changed form. Some of the stored chemical energy has been used by organisms to fuel the activities of individual cells. Think about it, everything an organism does—moves, breathes, digests food, for example—is powered by cells that have turned stored chemical energy into mechanical energy. And that's not the half of it… most of the lost energy is in the form of heat energy that simply exits the body.

[If students are having difficulty with the notion of losing heat energy, remind them of the last time they were really active—running around, perhaps. Tell them that the cells in their bodies were converting stored chemical energy into kinetic energy, the energy of motion. But, ask them, what else happened to their bodies as they were running around? Remind them that their bodies warmed up. That energy, heat energy, eventually was lost from their bodies forever. Tell students that the same thing happens in nature. Lesser animals in a food chain use up stored energy to carry out their life processes. Plus, they use energy when escaping from predators. Predators also use stored energy to survive, and they use it when moving about in search of prey.]

By the time all is said and done, only about 10 percent of the energy in a food chain makes it from one level to the next. SKIP

ENERGY PYRAMID (I/D)

In summary, just a small fraction of the sun's energy is captured and processed by plants. Then, only about 10 percent of that energy makes it to the plant eaters. And finally, only about 10 percent of that energy makes it to the meat eaters.

And because of this significant energy lost, there need to be far more plants than plant eaters in an ecosystem, and far more plant eaters than meat eaters in an ecosystem. SKIP

MEADOW WITH BUTTERCUPS (P)

The good news for us is that, for now, plants are plentiful. And because we depend on plants for our very existence, it's a good idea to learn as much as we can about them. In our next science lesson, you'll find out what plants need as well as observe some of the very clever ways plants go about fulfilling those needs.

Dessert

You've got decisions to make!

Option 1. Hands-on Activity (25 minutes)

Have students complete the "Making Recycled Paper" Hands-on Activity (Pages 23-24). Students make paper using readily available materials and following a simple technique.

Option 2. Reading, Writing and Thinking Activities (25 minutes)

Have students complete the "What's So Great About Plants?" Reading Activity (Pages 19-20). The reading passage summarizes the information presented in the video lesson. Then, students can either complete a writing exercise (Page 21) or prepare a written response to one of the higher-order thinking questions (Page 22).

Option 3. Video Quiz (10 minutes)

Have students take the video quiz. It is intended to check students' mastery of concepts related to the importance of plants. The questions are designed so that you can present them in either of two ways.

Standard Mode { Show the question. Show students four possible answers. Have students choose the best answer and write it down. Show the correct answer.

Challenge Mode { Show the question. Have students write down their answers. Show the correct answer.

Option 4. Review ACTIViewer Recording Sheets (15 minutes)

Have student volunteers refer to their completed ACTIViewer recording sheets to make up questions and quiz fellow classmates. When they're finished, have students file their ACTIViewer recording sheets in a notebook or file folder along with the "What's So Great About Plants?" reading passage and related work.

Option 5. Online Research Project (1 hour)

Send students to **www.FreshScience.com/plants**. Once there, have students follow the directions provided for researching and then reporting on plants native to other countries that are important in terms of food, construction, clothing, medicinal reasons or decorative purposes.

Option 6. Unit Assessment (20 minutes)

Have students complete **Part One** of the Unit Assessment (Pages 143-144).

Hands-on Activity Teacher Notes
Making Recycled Paper

Student Objectives

- Conducting a simple investigation
- Exploring one method for recycling paper
- Analyzing how varying a process might change its outcome

Before You Begin

- Invite any parents who have a papermaking hobby to assist in the classroom.
- Because making paper can be a bit messy, you might have students bring in old shirts or aprons from home to wear when they complete this activity.
- Make a simple papermaking screen (also called a mold) for each group of students using aluminum screening material (usually sold by the roll at general merchandise, home improvement or hardware stores). For each mold, cut an 8" x 11" piece of aluminum screen. Using a straight edge as a guide, fold over each of the four sides approximately one-half of an inch. Repeat so that each edge has been folded two times (for a total of about one inch) and the finished size of the screen is about 7" x 10" *[Safety note: Folding each side helps minimize sharp edges and strengthens the mold.]* Note: more elaborate papermaking molds and kits are available from craft shops, art supply stores, toy stores and online.
- Gather the following materials for each group: papermaking screen (mold); 30 sheets of single-ply toilet tissue (single ply is the easiest to dissolve); four-quart mixing bowl; measuring spoons; wire or plastic whisk; liquid starch; plastic bin or dishpan; newspapers (two one-inch stacks per group); spatula; rolling pin; cookie sheet (or other flat surface); hair dryer (optional). Note: each group will need three quarts of hot tap water, which should be obtained just prior to use. *[Safety note: Because this activity works best when very hot water is used, you might want to distribute the hot water yourself. Otherwise, please caution students about handling hot water.]*

Procedure

- First, show the video "Paper Mill Tour" once again (Buffet • Lesson 1 • Screen 3). Remind students that when paper is made, wood is transformed into pulp, which then is forced through wire screening. Cellulose fibers from the pulp remain trapped on the screen and are dried to make paper. Explain to students that many types of paper products also can be recycled to make new paper products, helping to reduce the number of trees cut for paper production.
- Then, organize the class into groups based on availability of activity materials. Distribute activity materials to each group and a copy of the "Making Recycled Paper"

activity sheet to each student. Spend a few minutes to answer any questions students might have.

- Next, have students follow the directions on their activity sheets. Assist students with obtaining the hot water. Each group will need three quarts of hot water (each group's four-quart mixing bowl should be about three-fourths full). Students also will need help forming their paper and using the hair dryer (if you use one to dry the paper).
- Finally, have students complete the activity questions on a separate sheet of paper.

Answers to Questions on the Student Activity Sheet

1. What did you observe when you placed each piece of tissue in the water? *First, the tissue absorbed the water. Then, the cellulose fibers separated from the rest of the tissue.*
2. What do you think would happen if you used cold water instead of hot water to dissolve the tissue? *Cold water would not be as efficient in helping isolate the cellulose fibers in the tissue from other additive agents in paper.*
3. What did you observe when you added the liquid starch to the dissolved tissue? What do you think would happen if you made the slurry without starch? *The slurry became thicker when the liquid starch was added to the dissolved tissue. The starch helps to bind together the cellulose fibers in the tissue; paper made without it would be weaker, at best.*
4. In this activity, what was the role of the rolling pin? What about the newspaper? Why were they important? *Like the steel drums used in the drying and calendaring processes in a paper mill, the rolling pin helps flatten the paper and squeeze out excess moisture. The newspaper helps absorb that moisture from the slurry, mimicking the role of the felt in a paper mill. Properly drying and flattening the slurry (or pulp) are critical steps in making paper.*
5. How would you adapt this activity to make color paper? *Start with color tissue paper or add food coloring (or some other dye) to the slurry.*
6. Compare and contrast the process you used to make paper with the processes used in a paper mill. *Both processes are similar in their basic concept: pulp is made (in the activity students used a more diluted pulp called slurry); the pulp is forced onto a wire screen; then drained, flattened and dried, resulting in paper. The processes differ most in their speed and sophistication. Large machines and more elaborate processes are used in a paper mill.*
7. What do you think would happen if paper were not recycled? *More trees would need to be cut to make new paper. More paper would be discarded in landfills, burned or disposed of in other less environmentally responsible ways.*

Reading Activity

What's So Great About Plants?

What is so great about plants anyway? What have they done for you lately? How have you benefited from them just today? Maybe you ate cereal this morning made from rice, corn, wheat or oats. Cereal grains come from plants. But what link do plants have to the milk you may have had with that cereal? What about the box that the cereal came in?

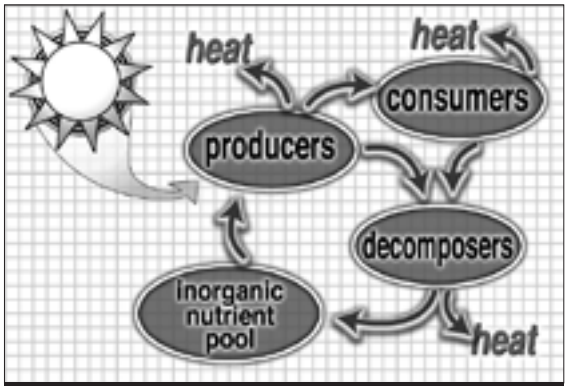
Plants affect our lives each day. They provide food for consumers like humans and other animals. Plants also are used in some building materials, clothing, paper and medicines. Most importantly, plants pass along energy from the sun.

A **plant** is different from an animal in many ways. A plant does not have a nervous system or sensory organs like animals have. Still, some plants respond to danger by curling or folding their leaves. Like other living things, plants have the ability to move… just not from place to place. Plants exist on a different time scale from our own. Plants move as they grow. Plants follow the sun's position in the sky. But plant movements are extremely slow, so are not detected easily.

Plants are producers, meaning they produce their own food. To help plants with this task, their cells contain a substance called chlorophyll. Chlorophyll is what makes most plants green.

Besides being colorful, plants play a key role in moving energy through an ecosystem. With respect to **energy flow,** plants are the primary source of matter and energy entering most food chains.

Indeed, through foods, plants help transfer energy from the sun to animals. First, green plants capture energy from the sun. Next, plants convert that energy into food, in the form of simple carbohydrates. Plants store this food, which they later break down to use as fuel. Then, energy is transferred to consumers when they eat plants, plant-eating animals or their byproducts.



Plants are producers and play a key role in moving energy through an ecosystem.

For example, cows eat grass and many people eat cow's meat. That is one way those people obtain the sun's energy. Cow's milk and its byproducts, like butter and cheese, also provide energy from the sun. Even if people do not eat meat, they get energy from the sun in other ways.

Energy flow is not very efficient. Plants capture and use only a small fraction of the sun's energy in the first place. From there, only about 10 percent of the sun's energy moves along each link in a food chain to the next higher level. Because of this energy loss, there need to be far more plants than plant eaters. And there need to be far more plant eaters than meat eaters in an ecosystem.

All of this is just the beginning when it comes to the wonderful world of plants. But one thing is certain—plants are not just for breakfast anymore.

Glossary

energy flow
n. the process in which energy from the sun is turned into chemical energy that then is transferred from one organism into another.

plant
n. a living thing, usually green, and usually having a root, stem, and leaves in which the plant makes its own food in the forms of glucose and sucrose.

Writing Activity
What's So Great About Plants?

Complete your Writing Activity on a separate sheet of paper.

Option 1. Narrative

Plants are an integral part of our daily lives. We eat them, we build with them, we wear clothing made from them. Choose one plant that's important to you. Write a story about what happened the day after that plant mysteriously disappeared from Earth.

Tell a story. Show a sequence of events over time. Portray a clear sense of beginning, middle and end. Tell "all about" events clearly and completely.

Option 2. Informative – "How To"

Tell how a lumber mill makes a tree into a finished 2' x 4' board.

Tell all about how to do something. Elaborate the steps so the reader could replicate the activity. Present a logical sequence of steps. Explain the activity and its steps completely and clearly. Remain on topic from beginning to end.

Option 3. Persuasive

Only about 10 percent of the sun's energy moves from one link in a food chain to the next. Write a letter persuading someone to adopt a vegetarian diet using energy flow as your primary argument.

Express your position on a topic. Indicate a position and support that position with reasons. Explain the reasons clearly and completely. Remain on topic from beginning to end

Option 4. Informative – Classification

Many jobs are linked to plants. Some are dangerous, others are relatively safe. Some jobs pay more money than others. Some jobs are more fun than others. Think about six jobs that are related to plants in some way. Write about them, classifying them based on their characteristics. Do dangerous jobs pay better? Are low-paying jobs more or less fun?

Group ideas clearly into categories. Present both sides of the topic (good/bad or positive/negative); however, there does not have to be a balanced presentation. Present information completely and clearly. Remain on topic from beginning to end.

Name _____

Thinking Activity
What's So Great About Plants?

Choose a question from one of the three options below. Write your response in the space provided.

Option 1. Analysis

What are the differences between a plant and an animal?

Option 2. Synthesis

What if trees didn't exist? How would that change a day in your life?

Option 3. Evaluation

In your opinion, of all the plants, which is the most important, and why?

Hands-on Activity
Making Recycled Paper

Background

Every year, millions of tons of paper are recycled. On average, each ton of paper made from recycled pulp can help to conserve as many as 17 trees. In this activity, you will investigate how recycled paper is made.

Materials

papermaking screen (also called a mold)
30 sheets of single-ply toilet tissue
four-quart mixing bowl
measuring spoons
three quarts of hot tap water *[Safety note: Use extreme caution when handling hot water]*
wire or plastic whisk
liquid starch; plastic bin or dishpan
newspapers (two one-inch stacks per group)
spatula
rolling pin
cookie sheet or other flat surface
hair dryer (optional)

Procedure

1. Place one of the stacks of newspapers onto the cookie sheet or other flat surface.
2. Your teacher will fill the mixing bowl with three quarts of hot tap water (the bowl will be about three-fourths full). Add one tissue square to the water. Using the whisk, stir until the sheet has dissolved. Add another sheet and continue stirring until it dissolves. Repeat until all 30 sheets are dissolved. Be sure to wait for each sheet to dissolve before adding the next one. The solution that results is called slurry, a less concentrated form of pulp.
3. Add one tablespoon of liquid starch to the slurry and stir with the whisk.
4. Pour the slurry into the large plastic bin. Use the whisk to spread the slurry evenly in the bin. In other words, make sure that the slurry is not more watery in some areas than in others.
5. Hold the papermaking screen (mold) by the edges. Slowly lower one edge of the screen into the slurry until the entire screen is resting flatly on the bottom of the bin. Move the screen back and forth in the slurry. Make sure that most of the tissue fibers are spread evenly on top of the screen.

6. Keep the screen flat and slowly lift it out of the bin. Hold the screen over the bin so that the excess water can drain back into the bin. As the water is draining, gently move the screen from side to side to help the fibers settle evenly. If the slurry is too uneven on the screen, return the screen to the bin and try again. [Note: You may need to make another batch of slurry and add it a little at a time to the bin until you have enough for even coverage. However, 30 sheets of tissue should make enough slurry for at least one finished piece of paper.]
7. When the water has stopped draining, place the screen onto the stack of newspapers. Top the screen with the other stack of newspapers. Using a rolling pin, gently roll the newspaper that is on top of the screen.
8. After five minutes, slowly remove the top stack of newspapers. [Note: The newly made paper on the screen will tend to stick to the newspaper. If this happens, carefully use the spatula to help separate the two.]
9. Allow the newly made paper to remain on top of the screen and dry overnight on the bottom stack of newspapers. You can speed up the process by using a hair dryer.
10. Once the newly made paper has dried, carefully remove it from the screen.

Questions

On a separate sheet of paper, write your responses to the following questions.

1. What did you observe when you placed each piece of tissue in the water?
2. What do you think would happen if you used cold water instead of hot water to dissolve the tissue?
3. What did you observe when you added the liquid starch to the dissolved tissue? What do you think would happen if you made the slurry without starch?
4. In this activity, what was the role of the newspaper? What about the rolling pin? Why were they important?
5. How would you adapt this activity to make color paper?
6. Compare and contrast the process you used to make paper with the processes used in a paper mill.
7. What do you think would happen if paper were not recycled?

Name _____

ACTIViewer™

What's So Great About Plants?

1. Write the definition of a plant. _____

2. Give three examples of how plants can be used to remedy illnesses.

3. Draw the process of converting trees into useable lumber for a new house.

4. What is cellulose?_____

_____

_____

5. Draw a simple food chain and illustrate energy flow.

6. Draw and label an energy pyramid.

7. About _____ percent of the sun's energy moves from one link in a food chain to the next.