



Native Flags

Native flags is participatory eco-art project by FIU College of Architecture + The Arts Artist-in-Residence Xavier Cortada.



Eco-art by Xavier Cortada

Plants

Sunshine State Standards:

SC.4.L.17.4; SC.912.L.17.8; SC.912.L.17.17; SC.912.L.17.12; SC.912.L.17.18;
SC.912.L.17.8 SC.4.P.8.2, SC.5.E.7.1, SC.5.E.7.2, SC.6.E.7.2, SC.7.E.6.6, SC.7.L.17.3,
SC.8.L.18.1, SC.912.L.17.11, SC.912.L.18.12

Background

Career Focus:

- Botanist; Biologist

Objectives:

- Students will recognize the role of light in the process of photosynthesis.
- Students will understand that plants use the sun's energy to produce food through photosynthesis.
- Students will understand the importance of water for plants
- Knowledge of pigments in leaves

Vocabulary:

- **Anther:** The male part of a flower which produces the pollen.
- **Carbon Dioxide:** A gas green plants use to make food. Plants get this from the air.

- **Carpels:** The female organs of a flower. They have three parts: 1) an ovary, holding one or more egg cells. 2) Style and 3) stigma which is at the tip of the style and receives the pollen.
- **Cells:** One of the building blocks of which living things are made. Plants consist of many cells. Some may be specialized for particular jobs.
- **Chlorophyll:** Chlorophyll is the green matter that is needed to make food for the plants
- **Chloroplasts:** Chloroplasts are in the leaf cells and are full of chlorophyll (green matter).
- **Cotyledon:** The hard outer case of the seed which holds the embryo (baby part of the plant) and gives it a food supply.
- **Cortex:** In the root, it is the layer of cells between the center and the edge.
- **Dicot (DICOTYLEDON):** A flowering plant that has 2 cotyledons in the embryo. The bean seed is a dicot. It has two special structures called cotyledons which are part of the embryo.
- **Dissemination:** The act or process of scattering or the state of being scattered widely. The process of seeds traveling from one place to another.
- **Dormant:** When a seed falls to the ground and may lie there "asleep"
- **Embryo:** The developing life of a new plant or animal, due to the combining of male and female reproductive cells. The "baby" plant. The part of a seed that develops into a new plant.
- **Endangered:** Anything whose existence is threatened.
- **Endosperm:** Monocot plants store food in a part of the seed called the endosperm.
- **Epidermis:** The out layer of cells on a plant. It protects the inside parts. It is like our skin.
- **Fats:** An oily liquid or greasy substance making up the main bulk of the tissue of animals, and widely distributed in the seeds of a plant.
- **Fertilize:** To put manure or certain chemicals put in the soil as food for the plants.
- **Germination:** A seed begins to grow. The growth of a seed of a first tiny shoot and root.
- **Gamete:** The egg or the sperm in the flower.
- **Hitchhike:** A seed travels by attaching itself to an animal or person.
- **Monocots:** A plant that has only one cotyledon. The corn seed has only one cotyledon.
- **Ovary:** The female part of the flower, which produces the eggs that are needed for making seeds
- **Oxygen:** A gas that has no color or smell. Oxygen makes up one-fifth of the air. Living things need oxygen to live, and fires need it to burn. Oxygen is a chemical element. Green plants make this gas when they make food.
- **Petal:** One of the parts of a flower that is arranged in a circle. They are the colored part of the flower.
- **Photosynthesis:** The process by which green plants use carbon dioxide, water and sunlight to make their own food. Made up of two words: photo, which means light, and synthesis, which means putting together. A plant puts water and carbon dioxide together. It uses light as its helper. It also uses chlorophyll as a helper. When these things are put together they make sugar and oxygen.
- **Pistil:** The female seed-producing part of a flower.

- **Pollen:** The fine powder produced by the anther inside a flower that contains the male sperm cells.
- **Pollen tube:** A tube that grows from a pollen grain on the stigma of a flower down through the style into the ovary.
- **Predators:** An animal that lives by eating other animals.
- **Protein:** A substance that is found in all living cells of animals and plants. It is necessary for growth and life.
- **Root Hairs:** They are like hair. They come out of the root like a branch. They absorb the water and food for the plant.
- **Seed Coat:** The outer covering of a seed.
- **Sepal:** The outer green parts of the base of the flower. They protect the flower bud before it opens. Inside the sepals are the colored petals.
- **Stamen:** The male organ inside the petals. The part of a flower that produces pollen.
- **Starch:** A white food substance (sugar) that is made and stored in most plants.
- **Stele:** The center of the root. It holds the veins that carry water and sugar.
- **Stigma:** The tip of the female part of the flower, which receives the male pollen grains
- **Stomata:** Tiny pores on the underside of the leaves (stomata-plural for stoma). Carbon dioxide and oxygen enter and leave the plant through these tiny pores.
- **Vascular Plants:** Cells in the root that carry water sideways.
- **Veins:** Tubes which take water to each and every cell of the plant. The veins help to strengthen and support the plant.
- **Xylem:** Veins that carry water and food to the plant.
- **Biogeography** - The study of the geographic distribution of organisms.
- **Edge Effect** - habitat conditions (such as degree of humidity and exposure to light or wind) created at or near the more-or-less well-defined boundary between ecosystems, as, for example, between open areas and adjacent forest.
- **Fragmentation** - the process of transforming large continuous forest patches into one or more smaller patches surrounded by disturbed areas.
- **Habitat** - the place where an organism lives and/or the conditions of that environment including the soil, vegetation, water, and food.
- **Immigration** - the arrival of new individuals into a habitat or population.

General Information

What is photosynthesis?

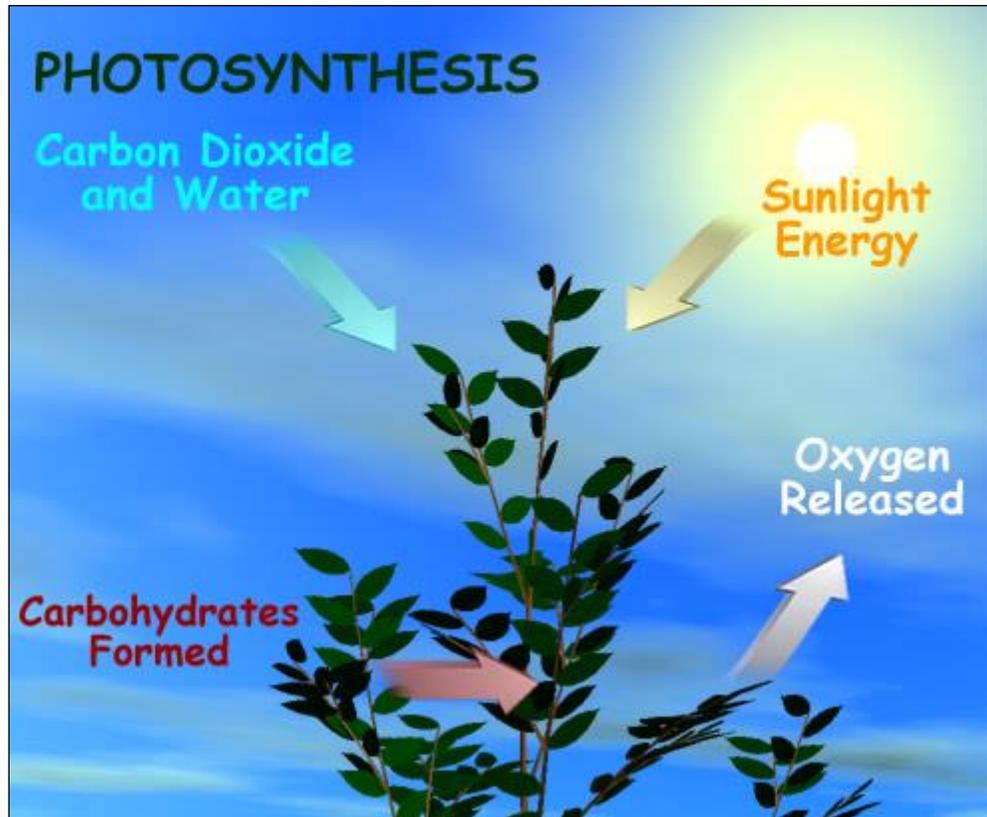
Have you ever noticed that plants need sunlight to live? It seems sort of strange doesn't it? How can sunlight be a type of food? Well, sunlight is energy and photosynthesis is the process plants use to take the energy from sunlight and use it to convert carbon dioxide and water into food.

Three things plants need to live

Plants need three basic things to live: water, sunlight, and carbon dioxide. Plants breathe carbon dioxide just like we breathe oxygen. When plants breathe carbon dioxide in, they breathe out oxygen. Plants are the major source of oxygen on planet Earth and help keep us alive.

We know now that plants use sunlight as energy, they get water from rain, and they get carbon dioxide from breathing. The process of taking these three

key ingredients and making them into food is called photosynthesis.



1 Photo Credit - Michigan Tech University

How do plants capture sunlight?

Plants capture sunlight using a compound called Chlorophyll. Chlorophyll is green, which is why so many plants appear green. You might think at first that it's green because it wants to absorb and use green light. However, from our study of light, we know that the color we see is actually the color of light that is reflected. So Chlorophyll actually reflects green light and absorbs blue and red light.

More details on Photosynthesis for kids

Inside the plant's cells are structures called Chloroplasts. It's in these structures where the Chlorophyll resides. The first thing that happens is that sunlight is captured and the energy is stored in a chemical called ATP. Later ATP is used to create sugar and organic compounds which are the main food plants use to live and grow. The first part of the process must have sunlight, the second part can happen without light and even at night. The second part is called Calvin Cycle because it was discovered and described by scientist Melvin Calvin.

Even though plants need sunlight and water to live, different plants need different amounts of each. Some plants need just a little water while others need a lot. Some plants like to be in

the direct sunlight all day, some prefer the shade. Learning about the needs of plants can help you learn where to plant them in your yard and how best to water them so they will flourish. (*Ducksters*)

PART I: THE SUN AND LIGHT

Not all of the light from the **Sun** makes it to the surface of the Earth. Even the light that does make it here is reflected and spread out. The little light that does make it here is enough for the plants of the world to survive and go through the process of **photosynthesis**. Light is actually energy, electromagnetic energy to be exact. When that energy gets to a green plant, all sorts of reactions can take place to store energy in the form of sugar molecules.

Remember we said that not all the energy from the Sun makes it to plants? Even when light gets to a plant, the plant doesn't use all of it. It actually uses only certain colors to make photosynthesis happen. Plants mostly absorb **red** and **blue** wavelengths. When you see a color, it is actually a color that the object does NOT absorb. In the case of green plants, they do not absorb light from the green range.

PART II: THE CHLOROPLAST

We already spoke about the structure of **chloroplasts** in the cells tutorials. We want to reinforce that photosynthesis happens in the chloroplast. Within this cell **organelle** is the chlorophyll that captures the light from the Sun. We'll talk about it in a bit, but the chloroplasts are working night and day with different jobs. The molecules are moved and converted in the area called the **stroma**.

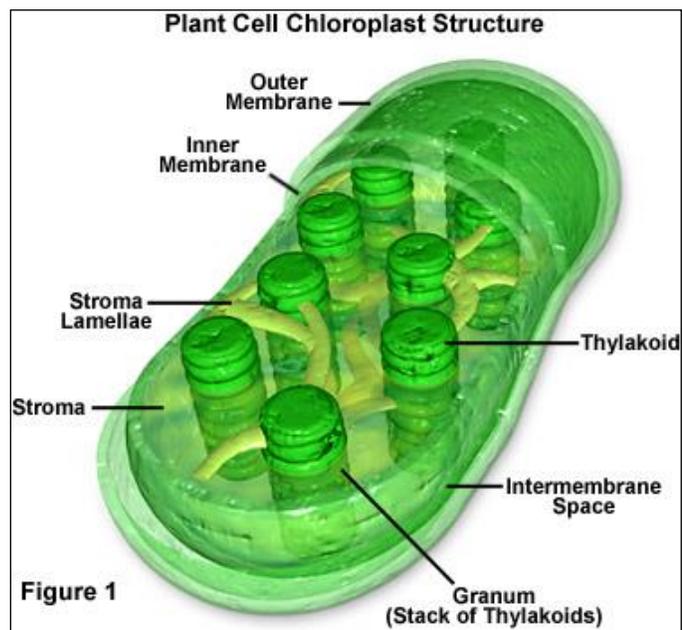
PART III: THE MOLECULES

Chlorophyll is the magic compound that can grab that sunlight and start the whole process. Chlorophyll is actually quite a varied compound. There are four (4) types: a, b, c, and d. Chlorophyll can also be found in many microorganisms and even some prokaryotic cells.

However, as far as plants are concerned, the chlorophyll is found in the chloroplasts. The other big molecules are water (H_2O), carbon dioxide (CO_2), oxygen (O_2) and glucose ($C_6H_{12}O_6$). Carbon dioxide and water combine with light to create oxygen and glucose. That glucose is used in various forms by every creature on the planet. Animal cells require oxygen to survive. Animal cells need an aerobic environment (one with oxygen).

PART IV: LIGHT AND DARK REACTIONS

The whole process doesn't happen all at one time. The process of photosynthesis is divided into two main parts. The first part is called the **light dependent reaction**. This reaction happens when the light energy is captured and pushed into a chemical called ATP. The second part of the process happens when the ATP is used to make glucose (the **Calvin**



2 Photo Credit - Florida State University

Cycle). That second part is called the **light independent reaction**.

A GENERAL PLANT STRUCTURE

We're going to look at plant structure in this section. The plants we discuss will be vascular plants that have systems of tubes (xylem and phloem) for the transport of nutrients and water. Remember that there is a wide variety of plants on Earth and even a whole group that doesn't have **vascular systems**. Mosses and liverworts may still have photosynthesis, but they do not have that 'classic' plant structure. Then you will find species such as cacti that don't have leaves. They conduct **photosynthesis** in their stems. Anyway, just remember that there are many other possibilities in the plant kingdom.

ALIKE BUT DIFFERENT

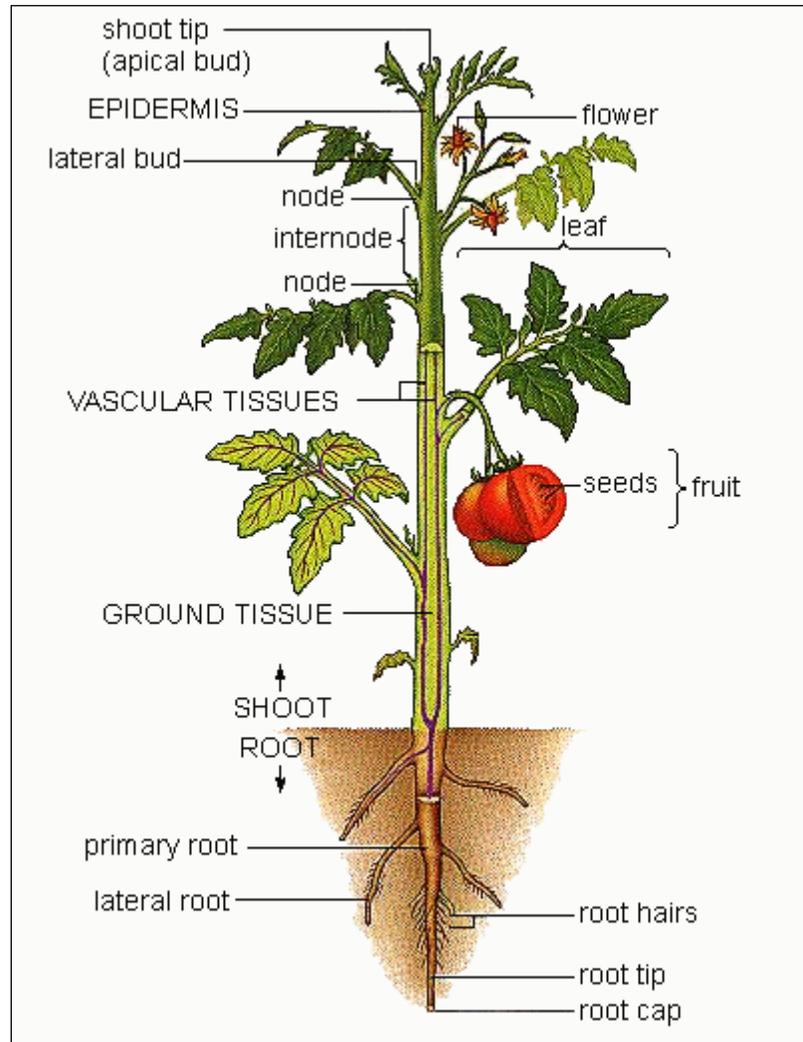
We just told you about the many exceptions to the basic plant structure, so let's look at some similarities. An easy

similarity is on a cellular level. Plants conduct photosynthesis. This process of converting the Sun's energy into molecular energy happens in chloroplasts with the help of chlorophyll molecules and a variety of enzymes. Vascular plants share a similar set of structures called roots, stems, and leaves. Many plants have specialized versions, but the basics are there. One specialization might be the petals of a flower. Those flower petals are specialized leaves that surround the reproductive structures of the plant.

THE ROOTS BELOW GROUND

We'll start at the bottom with the **roots**. These structures are designed to pull water and minerals from whatever material the plant sits on. For water plants, the roots may be in the water. For traditional trees, the roots go deep into the soil. There are even plants called epiphytes that live in trees and their root system clings to branches. Humans often capitalize on the roots of plants for food. Carrots are just one big orange root.

Root systems also provide support for plants in the form of an anchor in the soil. If the wind blows hard, those roots keep the plant from falling over. Some plant species have roots above ground that provide support for the entire plant. Roots are further broken down into the



3 Photo Credit - University of Illinois at Chicago; Biology

primary root and lateral roots that each has **apical meristem** at their tips. **Root hairs** are also a common structure on roots. They make the roots look fuzzy and help in the absorption of water and nutrients.

SHOOTS ABOVE GROUND

Sure we said that there are some roots above the surface, but the majority of the plant you see is made up of **stems** and **leaves**. Think about a tree. The stems are the trunks and branches. Leaves are self-explanatory. Stems are all about transporting food and water and acting as support structures. Leaves are all about photosynthesis, creating food molecules and absorbing carbon dioxide for the plant. These parts are connected by the vascular system of xylem and phloem that spreads through the entire plant.

The tip (**terminal bud**) of the main stem has a specialized structure that is the source of new growth for plants. You will find the apical meristem that develops into young leaves (**primodium**). There are other points of growth at each **node** where leaves and branches develop on the stems. Those branching points are home to **axillary buds** that can also develop into new branches.

Plant Kingdom

Let's take a few minutes to look at plants of the world. What do plants have in common? They have cell walls made of **cellulose** and **chlorophyll** in their cells. That chlorophyll is the key compound involved in **photosynthesis**. Beyond those facts, plants come in a variety of sizes from tiny mosses to redwood trees that are over one hundred feet tall. The giant sequoias are the largest living organisms on Earth while one species of **angiosperm** (flowering plant) can fit into the eye of a needle.

The greatest variation among plants is found in the way they reproduce. Flowers come in thousands of varieties and even simpler **gymnosperms** have thousands of cone types. The most important contribution of plants is their ability to convert carbon dioxide into oxygen through photosynthesis. Not only do animals need the oxygen they produce, but plants also use the oxygen when they perform cellular respiration.

With the exception of a few areas of the planet, you will find plants everywhere. They were colonizing the planet long before the first animals. Through the process of natural selection, plant species adapted to every climate type. They are now able to thrive in areas from under the surface of the ocean to the tops of mountains.

Algae

All **algae** were once classified as plants because they had **chloroplasts** and conducted photosynthesis. As botanists studied single and colonial algae more, they realized that not all of them belonged in the plant kingdom. After a major shakeup, **green algae** were the only ones left in the plant group. The others were moved over to the **protist** kingdom.

The green algae divisions Chlorophyta and Charophyta are thought to be the original plants. The first true plants such as mosses and liverworts developed from those early green algae species. You can find algae in both fresh and saltwater environments. Classification of algae is very difficult because there is such a great variety in species. Just remember that some are classified as protists.

Mosses

Let's start with a look at true plants with the **mosses** and **worts**. This image shows a lovely moss we found on a rock. These plant species are known as **bryophytes**. They are different from all other plant species because they do not have vascular systems to transport nutrients and water. Without this system of transport tubes, mosses and worts are destined to be very small plants. They can cover a wide area, but rarely get taller than an inch or so.

They are like other plants in that they have chloroplasts and conduct photosynthesis. Beyond the lack of a vascular system, bryophytes also lack seeds for reproduction. Mosses release **spores** (from stalks) into the air and when conditions are right, the spores generate new mosses.

Horsetails

Can you have a forest of **horsetails**? Sure. We found this small population near a freshwater lake in California. Horsetails and **ferns** were the first plants to develop vascular systems to transport nutrients and water. This system of tubes allowed horsetails and ferns to reach very tall heights. The forest we were talking about was only a few feet tall. Extinct species of horsetail forests could reach 70 feet tall. Those were the good old days for horsetails. There are only about 15 living species today.

Beyond being vascular plants, there are some other interesting traits of horsetails. They don't have traditional leaves. You can see a close-up of needle-like leaves radiating from a **whorl** (location where leaves branch out). Instead of seeds, they reproduce using **spores**. The spores of some species develop into **rhizomes** that are buried deep underground and grow new stalks every year. Horsetails are very sturdy plants and even some cannot be killed with traditional pesticides.

Ferns

It's time for the **fern** species. We have two slides on ferns, one looking at the general makeup of ferns and a second on cool structures.

There are about 20,000 species of ferns across the world. You will often find them in shady moist areas. Ferns don't produce seeds and release spores so a regular source of water in the area is important for reproduction. We often find ferns on forest floors. This image was taken in a forest of Oregon. Fog rolled in regularly, keeping the ground and plants moist. The easiest place to see ferns is probably in someone's house. They make great indoor plants.

Unlike horsetails, ferns have **true leaves** with large fronds to gather the Sun's energy. While they are rarely used in today's societies, extinct fern forests are very important. Much of that biological material became coal over millions of years.

Fern Structures

Let's take a look at this image of specialized fern structures. The top image should be easy to identify. It's a fully developed **frond** showing the true leaves. The deep green color comes from the chlorophyll in the chloroplasts. Fern leaves and branches are usually called fronds. You will find two types of fern fronds, those that make spores and those that don't. The top example shows no **spores** while the bottom one shows developing spores.

The center image shows a frond unfurling. This structure is called a **fiddlehead**. As the hairy fiddlehead unrolls, the leaves fan out and begin conducting **photosynthesis**.

The bottom image shows a frond that has developed spores. Even though these fronds are reproductive structures, they look almost identical to the true fronds of ferns. Sperms and eggs are released on the leaves. The sperm swim (through a moist surface) and meet up with eggs. The resulting **zygote** can then develop into a new fern. One of the results of this type of fertilization is a clumping of ferns. Plants that might use the wind to spread seeds can release seeds over a greater area. Fern spores tend to land close to the parent plant.

Cycads



4 Photo Credit - National Wildlife Federation; Cycad

Now we're moving into the groups of plants that produce **seeds**. While these **cycads** might look a bit like ferns, they are very different. According to fossils, the first cycads appeared over 250 million years ago.

You can recognize cycads because they have central stem with frond-like structures radiating from the center. The fronds are thick, **waxy**, and **evergreen**. In the center of the plant, a cone structure can develop. The **naked seeds** are released from that central **cone** structure. They are naturally found in warm areas and some can even survive mild desert conditions.

Conifers

Other plants that release seeds without cotyledons include the **conifers**. You'll find pines, redwoods, junipers, and cedars in this group of plants. The image on the right shows a Sequoia tree from California. While not the tallest, some Sequoias have grown into the largest living things on Earth. Redwood specimens now hold the title for tallest trees. Redwoods are also conifers.

More than seeing them in evergreen forests, you might know conifers from your furniture or floors. Many conifers are a source of **hardwood** used in homes. That strong wood allows the trees to grow to enormous heights. You can only imagine the amount of strength needed to support several tons of tree.

Conifer Structures

Let's take a look at some special structures of **conifers**. With over 600 living species, they have developed a wide variety of structures. What do they share in common? They all have **cones** of one type or another. Those cones are used in reproduction. As you study conifers, you will find species with male and female cones. Male cones release **pollen** into the air. As female cones are pollinated, they develop seeds that can then be released. Open pinecones fall to the ground after the seeds are released.

The image above shows two different types of cone structures. They both develop seeds and often open when the temperature increases in late summer. Each cone can hold a few or several dozen seeds. Even the seed sizes for each species are different. Sequoias may be

the largest living trees, but they have much smaller seeds than pine trees.

The center image shows a close look at some new waxy **needles** from a pine. They are branching out from one of the male reproductive structures in mid-spring. If you visit boreal forests in spring, you will probably wind up covered in the yellow pollen released from these structures. The needle structures allow the plants to stay green year-round, even in very cold winter months.



5 Photo Credit - DENISE POVEROMO/NATIONAL GEOGRAPHIC MY SHOT/National Geographic Stock

Angiosperms

You've made it to the largest plant grouping. The division **Magnoliophyta** is home to all of the **flowering plants** of the Earth. These species range from tiny grasses in a field to large oak trees to flowering rose bushes in your yard. Every plant that uses flowers to reproduce or has seeds with seed coats can be found in this division.

You will also hear the term **angiosperm** used to describe these plants. For almost 150 million years, angiosperms have been specializing and becoming the dominant plant group on the planet. There are two basic groups of angiosperm, divided by the number of cotyledons and other factors. You will hear about **monocots** that include grasses, reeds, and bamboos. The **dicots** include complex flowering plants such as roses, many wildflowers, and fruit trees.

The image above shows a variety of angiosperm wildflowers in spring bloom. As you learn more, you will discover that many angiosperm species can occupy the same areas and eventually compete for the same resources.

Monocotyledons

We'll start with the **monocot** species of **angiosperms**. These species are found in the class **Liliopsida**. Even though we're only showing species with large flowers, there is a wide variety in this class. There are about 60,000 species to choose from and you will find grasses, lilies, orchids, and most grains. The grain species are probably the most important to man. Much of our food comes from the monocot species of corn, rice, and wheat. Structurally, you can identify monocot species by their seeds, flowers, and leaves. The flowers come with **petals** in sets of three and the seeds only have one **cotyledon** (monocot). Compare a piece of corn (monocotyledon) to a lima bean (dicotyledon). The leaves of dicots are usually complex while monocots have simple leaves with parallel vein patterns. Think about the leaves of grasses. They are long and straight. The leaf of a rose plant has a very complex shape with veins going in every direction.

As with all classification, you should remember that these rules always have some grey areas. Some dicots look and behave like monocots. The opposite is also true.

Flower Structure

Flowers are the most obvious difference between angiosperms and other species of plants. Sure there are the seeds, fruits, and structure, but it's the flowers that people (and bees) remember. They are small, large, with **petals**, without petals, simple, and **compound** (daisy or sunflower). If you can imagine a shape, a flower probably already makes it.

Even with the variety of flower shapes, they have very similar structures. The area of pollination is usually at the center and there is a structural or color cue that tells you where to look. The top image shows a compound flower. This really isn't one flower, there are dozens of flowers in the center of those petals. Each of those mini-flowers can be pollinated and become a seed.

The center image shows a very simple flower. Along the outer ring, you can see a combination of white and purple petals with different shapes. As you get to the center, you can easily see the five stamens and three stigmas. **Stamens** hold the pollen and the **stigmas** receive the pollen.

The bottom image from a cactus shows very bright red petals that are easy to see in a spring desert bloom. In the center are dozens of lighter stigmas and styles and five stamens (greenish).

There are too many different types of flowers to show here. You can recognize a flower because they usually have petals or sepals. In the center, you will find the stamens (with pollen) and **pistils** (receive pollen). At the base of the **style** and pistil you will find small **ovules** and ovaries that eventually develop into the **fruit** and seeds. Some flowers have developed so that they can **self-pollinate** and others have developed to attract specific insects.

Dicotyledons

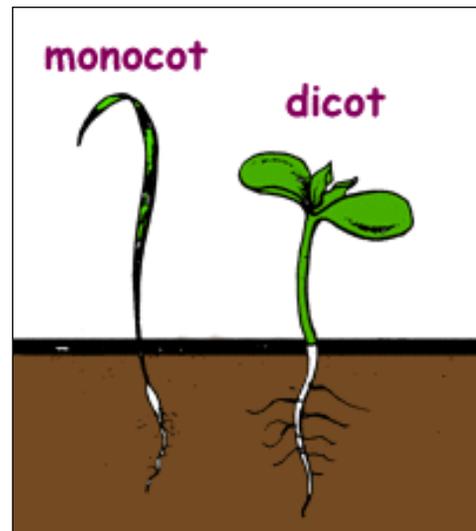
Looking at the **Magnoliopsida** class can be a little overwhelming. There are about 200,000 living species and still many to discover. This class is home to the group of flowering plants called **dicots**. These plants have flowers and seeds with **two cotyledons**. There are divisions within the larger group that are based on larger plant structure and the shape of the pollen.

Compared to monocots, there are many more species of dicots across the planet. They are found on land and in the water. They also have a variety of shapes. The smallest dicots are smaller than an inch while the largest include eucalyptus trees at over 100 feet.

The dicot flowers have petals with sets of four and five. They also have more complex **leaves** than the parallel-veined monocots. The leaf complexity is known as **reticulation**. Even the stems of dicots are different. If you look at a cross section of a dicot stem, you will see that the vascular tissue forms rings around the center.

Monocots vs. Dicots

We already covered some of the basic structural differences between monocotyledons and dicotyledons. This image is a good example of the differences in leaf structure. The palm leaves on the left image are long and have **parallel** veins. Even though you might not know the species, you could identify this plant from the **Liliopsida** class. The leaves on the right have the traits of a dicotyledon plant. There is a complex leaf shape with a web-like vascular system. There are also multiple leaves attached to the same stem. From this evidence, you could guess that it is from the **Magnoliopsida** class.



6 Photo Credit - University of Illinois

Scientists believe there may be over 300,000 species of plants across the planet. There is still a lot to learn and discover about plants. They are in all environments that have light. You will find plants in the hottest deserts and small plants popping up from the snow during Antarctica summers.

As you study more plants and watch them grow, you will see trends. Succulents with thick water-holding **stems** are found in deserts. Rainforest plants often have very large **leaves**. Plants that are found in dry areas often have small and oily leaves that help slow the loss of water (transpiration). Forests at higher latitudes have more **conifers** that stay green year-round, even through snowy winters. Plants are everywhere and in every size and shape. Is anything the same about them? **Photosynthesis**.

With so many plants, they seem indestructible. How could our actions ever hurt them? Well, we can hurt them. While there is a debate on how much influence we have on global warming, this trend is altering the world. **Climates** across the planet are slowly changing. If things continue to warm, rainforests will have less rainfall, hurricanes can become stronger, and sub-arctic regions will begin to lose snowy winters. These climate changes all increase the stress on plants. Larger plants might fall over in stronger storms or plants that require cold winters to bloom will start to die out. Even our best scientists cannot predict the many possible changes. Be careful and conserve where you can. Plants are your friends.

(Photosynthesis)

Habitat Loss & Fragmentation

Habitat loss is one of the biggest threats to biodiversity. Roads, shopping centers, housing developments, agricultural fields and other types of development are breaking up our large forests and other natural areas into smaller and smaller chunks—a problem conservationists call fragmentation. Many scientists compare the remaining habitat fragments to islands because they are so isolated. And like islands, habitat fragments are often too small and isolated to support a large number or a wide variety of species. Conservationists have the tough job of trying to figure out how fragmentation is affecting biodiversity. They're asking questions like "How small is too small?," "Which species are we losing?" and "How can we balance our need for development with other species' need for space?"

Development and fragmentation can be difficult concepts for students to understand. Seeing the relationship between the two will help students realize there are certain tradeoffs that result from our decisions to develop natural areas. Most development occurs to fill people's needs for schools, homes, roads, food and income. While most people recognize that developers are not trying to destroy biodiversity when they build roads or homes, many people also feel that the value of biodiversity is not factored into our decisions to develop. Many conservation biologists would like to see communities consider how development impacts biodiversity and work to accommodate natural systems as much as possible.

Island Hopping

In the 1960s, two scientists, Robert MacArthur and Edward O. Wilson, studied how many species lived on islands of different sizes at different distances from the mainland. Their theory, called the theory of island biogeography, has helped ecologists think about the effects of habitat fragmentation. Although the theory's name sounds complicated, its point is very simple: more species can live on islands that are large and close to the mainland than on islands that are small and far from the mainland.

Why is this theory still important to scientists today? Because it relates directly to the study of the numbers of species in habitat fragments on the mainland. In many areas, fragments of forest and other habitats are all that remain where the landscape used to be covered with vast areas of continuous natural vegetation. Scientists compare these fragments to islands because they are so isolated.

(Resources)

Leaves and their colors

We all enjoy the colors of autumn leaves. The changing fall foliage never fails to surprise and delight us. Did you ever wonder how and why a fall leaf changes color? Why a maple leaf turns bright red? Where do the yellows and oranges come from? To answer those questions, we first have to understand what leaves are and what they do.



7 Photo Credit - TIM LAMAN/National Geographic Stock

Leaves are nature's food factories. Plants take water from

the ground through their roots. They take a gas called carbon dioxide from the air. Plants use sunlight to turn water and carbon dioxide into oxygen and glucose. Oxygen is a gas in the air that we need to breathe. Glucose is a kind of sugar. Plants use glucose as food for energy and as a building block for growing. The way plants turn water and carbon dioxide into oxygen and sugar is called photosynthesis. That means "putting together with light." A chemical called chlorophyll helps make photosynthesis happen. Chlorophyll is what gives plants their green color.

As summer ends and autumn comes, the days get shorter and shorter. This is how the trees "know" to begin getting ready for winter.

During winter, there is not enough light or water for photosynthesis. The trees will rest, and live off the food they stored during the summer. They begin to shut down their food-making factories. The green chlorophyll disappears from the leaves. As the bright green fades away, we begin to see yellow and orange colors. Small amounts of these colors have been in the leaves all along. We just can't see them in the summer, because they are covered up by the green chlorophyll.

The bright reds and purples we see in leaves are made mostly in the fall. In some trees, like maples, glucose is trapped in the leaves after photosynthesis stops. Sunlight and the cool nights of autumn cause the leaves turn this glucose into a red color. The brown color of trees like oaks is made from wastes left in the leaves.

It is the combination of all these things that make the beautiful fall foliage colors we enjoy each year.

(Simple)

Plant pigments play an important role in capturing light for photosynthesis. These pigments give leaves their colors. Chlorophyll pigment makes leaves green and allows the plant to capture energy from the sun for photosynthesis. Anthocyanins make leaves red. Carotenoids make leaves yellow.

In the fall, trees prepare for winter by shutting down photosynthesis. As this happens, the chlorophyll disappears from the leaves. As this happens, the green color fades and we begin

to see yellow and orange – colors that have been there all along, but were hidden by the green pigment. Sugars trapped inside the leaves react with the light and other chemicals to reveal new colors.

(See the Colors in Leaves)

Activity 1: Plants, Soil, and Nutrients, Oh My!

Objectives:

- Utilize the scientific method
- Learn the importance of water in photosynthesis

Materials:

- 10 white carnations or **carrots & celery sticks** and several extras for additional experiments
- 5 small containers of food coloring (red usually works best)
- Scientific method data sheet
- 5 small vases or clear glasses
- 2 pitchers of water
- 1 knife or exacto blade - optional (teacher will maintain possession of the knife at all times)
- Several flower plants with the roots attached

Procedure:

Before class begins, place 4 different colored flowers in pop cans full of water. In a fifth can pour a food coloring into the water (I suggest red) and place a white carnation into the can. Over several minutes, the carnation will change color and appear either light pink or red. Place the arrangement of different colored carnations at the front of the room. Say to the class, "these are a type of flower called carnations. Perhaps you have seen them before. As you can see, they come in a variety of colors. However, one of these carnations is not really the color that it appears to be. I need you to write down the colors that you see and try and guess which of the carnations is not really the color that it appears to be. When you have guessed, explain how you think the flower came to be the color it currently is. Allow students to inspect the flowers but do not allow them to look in the cans.

Total time: 5 min.

1. When the timer goes off, ask students for their guesses and make tally marks on the board next to the colors. After several have guessed, ask other students for their explanation of the phenomenon. These do not need to be written as they already have them on paper.
2. Tell the class the correct answer, but do not explain how the flower came to have the color it does; only state that the flower used to be white. Explain that they will discover the answer later on their own. Total time: 3 min.
3. On the board write, The Scientific Method. Check for prior understanding or knowledge of this concept.

4. Explain the separate aspects of the scientific method: hypothesis, experiment, collection of data, evaluation of data, and re-testing. Ask how this is used in science and why it's important to use. Try and direct the discussion towards understanding that scientists must first ask questions, state what they believe the answer is, try an idea out (experiment) to see if their answer works, collect the information from their experiment, decide if their answer was correct. Total time: 8 min.
5. Hand out the scientific method data sheet. Inform the students that they are going to practice the scientific method. Also inform them that the question they are going to be trying to solve is, "how can the color of the flower be changed and how does this happen?" Read the directions aloud as they follow along and have them write the question down in the space provided. Explain that they are going to be working in their groups and that each person needs to come up with an answer to the question (hypothesis); they may use the answer they had written earlier or come up with a new one. Also explain that they need to follow the directions carefully, work together, and decide on three of the hypotheses to test. All three hypotheses can be tested at the same time.
6. Pass out the white carnations, food coloring, glasses, and place the water pitchers on the sink or your desk. Have plenty of paper towels handy.
7. Check for understanding and answer questions. Set the timer for 15 min and go! Total time: 17 min.
8. After the timer has gone off, have students clean up their areas, and prepare to discuss their results.
9. Have each group report what hypothesis they used, how they tested the hypothesis, and what the results of their experiment were. Total time: 5 min.
10. Assuming that someone figured out how to get the carnation to change color, have that group direct the rest of the class in performing the experiment. If students did not figure this out, ask for other options from the rest of the class until someone mentions the correct procedure or you can give them a clue. Total time: 5 min.
11. Once everyone has had the opportunity to view the change, show the class the food coloring in the can of the colored carnation and ask, "what do you think will happen if I placed clear water back in the can?" Take answers, dump out the food coloring, and put clear water in the can. Eventually, the carnation will return to being white as the students have hopefully predicted.
12. Ask, "why do you think the carnation changed color?" Begin a discussion on how the stem has veins that move the nutrients throughout the plant's body, like the veins in the human body. Use the posters or transparencies at this time. Pass out the plants with the roots still intact so that they can see and feel the roots.
13. Continue to discuss how the plant uses sunlight to manufacture energy and food, how carbon dioxide is taken in and oxygen expelled, and how soil types affect the type of plants that either flourish or perish. Give examples of plants that live in the arid, tropical, mild, cold, or aquatic settings. Total time: 8 min.
14. Ask, "what does learning about plants have to do with our colonization of Mars?" Take responses and lead a discussion on the importance of plants as providers of oxygen, food, and prevention of soil erosion. Inform them that tomorrow they will continue working with plants. Total time: 5 min.

15. Inform the students that the remaining 5 minutes will be their own to explore the plants, continue working on their NASA research, or ask questions about anything that has been covered thus far. Also write on the board the journal assignment for the following day; "How do people grow plants in places that cannot support plants?"

The Scientific Method Worksheet

Experimenter's name: _____

Date of experiment: _____

1. The question:

2. Hypothesis (Your answer to the question):

3. Experiment (explain what you are going to do):

Step 1: _____

Step 2: _____

Step 3: _____

Step 4: _____

Step 5: _____

Step 6: _____

4. Collection of data (record what you observed):

5. Evaluate data (explain why you think the data supports your hypothesis or why it does not):

6. Re-test (explain why you think you need to retest your hypothesis or why you do not):

Activity 2: Oxygen & Elodea

Objectives:

- Demonstrate oxygen as a by-product of photosynthesis

Materials:

- Elodea plants- available from shops that stock supplies for aquariums (they are water plants)
- 2 wide-mouthed jars or beakers
- 2 test tubes
- 2 glass funnels
- Toothpicks or similar wooden splints
- Lighter



8 Photo Credit - Rutgers University - Virtual Biology Labs

Procedure:

1. Fill a sink with water and set the beaker in it. Put some elodea in the beaker and cover it with the funnel.
2. Now submerge the test tube in the water so that there is no air inside it. While holding it under the water, carefully place it over the neck of the funnel. Don't let its mouth break the surface of the water.
3. Lift the whole apparatus out of the water. You can tip a little water out of the jar so it won't spill. Set the jar on a sunny windowsill or outside in the sunlight. As soon as the elodea begins to photosynthesize, you will see tiny bubbles appearing on its leaves and then floating upwards into the test tube. These bubbles are oxygen produced by photosynthesis!
4. Leave the jar on the windowsill for several hours. The rate of photosynthesis will vary depending on the intensity of the sunlight and other factors, but slowly the oxygen will collect in the test tube.
5. When the test tube is about half full of gas, put on safety goggles and use a match to light the wooden splint. Gently blow it out again and then immediately lift the test tube straight up and insert the splint up into it, without touching it to the sides of the test tube. The splint should glow brightly or even burst back into flame! This is proof that the gas you collected is oxygen, which is flammable.

Activity 3: Space for Species

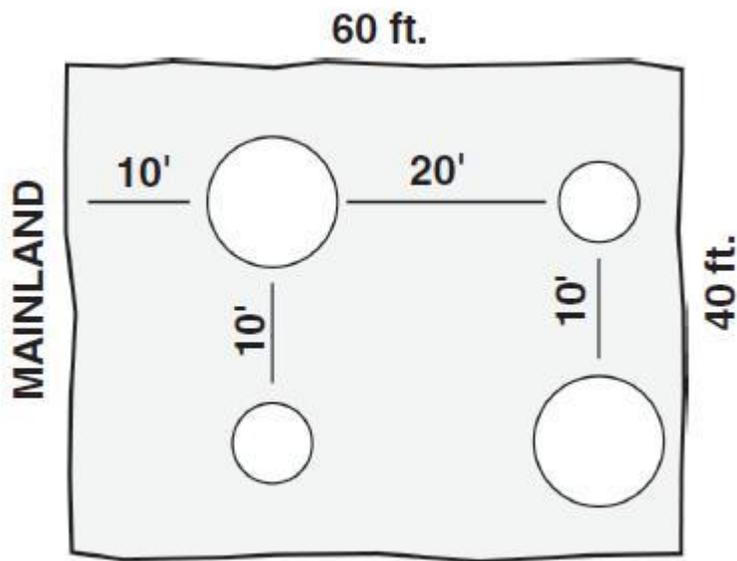
Objectives:

- Identify things in an urban forest that makes it difficult for trees to grow
- Learn how to manage an urban forest

Materials:

- 4 cones or visible markers
- Two 25-ft. ropes
- Two 40-ft. ropes
- 2 colors of tokens or poker chips (about 20 of each color)
- Poster paper
- Markers
- Stopwatch

Procedure:



In this part of the activity, your students will learn the basics of island biogeography by imagining they are species trying to get to different-sized “islands” at different distances from the mainland.” Then they’ll apply the concepts of island biogeography to habitat islands.

They'll explore some of the threats facing species in habitat islands and think about ways we can reduce those threats by planning development with biodiversity in mind.

1. Introduce the activity.

Explain to the students that they'll be investigating a well-known ecological theory called the theory of island biogeography. Briefly explain that scientists Robert MacArthur and Edward O. Wilson wanted to study species that traveled from the mainland to nearby islands in the ocean. (You might want to introduce the scientific term "immigration" here, explaining that MacArthur and Wilson were studying species that immigrated to islands from the mainland.) The scientists wanted to know how many species from the mainland lived on islands of different sizes at different distances from the mainland. They were also interested in those species that became "locally" extinct, which means they were no longer living on the islands but could still be found living on the mainland.

Tell students that they'll be doing a similar investigation outside. Some students will be animals immigrating to "islands." Other students will be playing predators, diseases and different forces out in the "open ocean" that can cause animals to become extinct.

2. Explain the rules.

Familiarize the students with the playing area. Show them the islands and their sizes and distances from the mainland. Select about 22 students (or three-fourths of the group) to be species immigrating to the islands and about eight students (or one-fourth of the group) to be taggers that represent threats that can cause immigrating species to become extinct. Explain that immigrating species will have one minute to run from the mainland to an island, but they'll have to avoid being tagged by the students in the playing area because being tagged will make them extinct on the islands. As you select students to be the extinction taggers, you can have them think of some of the causes of extinction (predators, diseases, pollution, severe weather and so on) they might represent to species immigrating across the ocean.

Explain that once you give the signal, species on the mainland should begin immigrating to the islands by making a run for them. Species can be tagged out of the game only when they are out in the open ocean. If they are on an island or the mainland, they can't be tagged. Although they're safe on the mainland, tell students that at the end of the game you'll only count the species that successfully have made it to an island.

3. Play Round One: Immigrate!

Tell the taggers to spread out in the playing field and make sure they keep moving all the time that students are immigrating. Explain that, as in nature, threats to species are spread all around the landscape, so the taggers should also be spread out. Keep taggers from crowding around islands and not allowing any students to pass. Try to make the game fair for everyone. Yell "Immigrate!" to let students know when to begin. Keep time and tell the students to stop after one minute. Ask any students who become extinct to help you monitor the game.

4. Evaluate the results.

Have the students count the number of animal species on each island. Keep track of the results on a piece of easel paper (poster-sized). You can make a chart or a graph, or you can write the number of species on each island in a diagram of the playing area.

Have the students gather around to go over the results of Round One and to talk about what they'll do in Round Two. Figure out the percent of students who survived (divide the number of students who made it to an island by the total number of students who started on the mainland, then multiply by 100) and record the percentage on the poster-sized paper.

Tell the students that, according to MacArthur and Wilson, the large island close to the mainland should have the most species. Is that what your group found? Why are there more species close to the mainland? Ask students to think about their experiences while immigrating. *(Those who tried to run to the farthest islands faced many more threats on their journey than those who traveled only to a nearby island.)* If your students found different results than MacArthur and Wilson found, talk about some reasons they may have had a different outcome. *(Your students may have been better at getting to islands than most species are, or the extinction taggers could have made more species extinct than happens in nature.)*

Regardless of how many species made it to islands at different distances, more students should be on islands that are large than on islands that are small. Ask students why this is true. *(Small islands don't have the space or variety of different habitat types to support many different species, just as the small islands in the game were not big enough to hold many students. If a small island was overcrowded, a student could have been pushed out and, while moving to another island, would have been open to an extinction tagger.)*

5. Discuss habitat islands.

Ask the students to think about what's happening to many of our natural areas and what that may have to do with ocean islands. Why might conservationists use the MacArthur and Wilson model when they think about designing reserves in natural areas? *(Explain that many of our forests and other natural areas have been separated from each other. Only small patches of the continuous vegetation that once covered much larger areas still remain. And the things that separate these habitat islands, such as roads, buildings and agricultural fields, are often even more difficult for species to cross than the ocean.)*

Ask the students why animals need to move between habitat islands. *(Many islands are too small for all the species living in them, and they can become crowded. Competition for resources may force animals to move to find more food or shelter. Some animals need to migrate. Others may be looking for mates.)* Then ask the students what kinds of barriers the animals might face. *(Animals are often killed trying to cross roads. Many animals also become easy targets for predators to spot when they leave their habitat. Animals traveling a long distance through developed areas may not be able to find enough food and could become pests to humans by rummaging through garbage cans or waiting for people to provide food.)* Record the students' ideas on poster-sized paper if you can.

6. Play Round Two: habitat island hopping.

Round Two will demonstrate what it's like for species trying to move between habitat islands. Tell students that the playing area now represents habitat islands in a sea of development rather than in an ocean.

For this round, you'll need two-thirds of the class as species in habitat islands and one-third as extinction taggers. (Have the students think about how the extinction factors might be different in habitat islands as opposed to oceanic islands.) You might make the species that were tagged out in the last round become taggers, and you might move some taggers into habitat islands so that the students get a chance to experience both roles. Have the students think of what the taggers might represent in the sea of development by going over the threats they came up with in their discussion in step five.

Tell students that the two different colors of tokens you have represent some of the things that species need. The tokens may be food and water, shelter and mates, or any of the other needs you discussed in step five. Tell the students that they'll be competing for these resources in the habitat islands. Count out enough tokens so that there is one of each color for every student in the habitat islands. Scatter the tokens throughout the four islands so that larger islands, which can hold more resources, have more tokens. State the following rules:

- Students must collect at least one token of each color to survive, but they can collect more if they like.
- Students can pick up only one token at a time from any island. So if a student picks up a token on the island he or she starts from, the student must run to at least one other island for another token. Students can return to their first island for tokens if they need to.

Shout "Immigrate!" to start the game again. This time give students as much time as they need to move between the islands. Stop the game when every student either has been tagged or has collected at least two tokens. Tell taggers they should spread out in the landscape, just as threats to species are spread out. They shouldn't stand in front of moving species and keep them from passing. Use your judgment about how to keep the game fair. After they finish the round, count the number of students who survived and record it on poster-sized paper.

7. Go over the results of Round Two.

Have the students gather together to figure out the percent of species that survived. Most likely, a large percent became extinct. Ask students why they think so many species didn't make it. (*There were more extinction taggers out to get them, and they were forced to leave their habitat to get all the resources they needed. Species that had to travel to several islands to get their tokens faced many threats, and most probably didn't survive.*)

Ask the students who didn't survive why they think they were tagged. Were the extinction taggers faster than they were? Did they have to go to several islands, leaving themselves open to taggers each time? Were they forced out of a small island that was too crowded? Ask them if real species are also affected by the same things. (*Species that are slow-moving are often hit by fast-moving cars; some species are forced to travel between many habitat islands to find all the resources they need and are thereby open to threats when they leave their habitat; and many species can be pushed out of overcrowded habitat islands and forced to move to other habitats.*)

Ask the students who survived why they think they were never tagged. Were they faster than the taggers? Did they have to go to only one or two islands to get their tokens? Did the taggers see them? Tell them that in real habitats, just like in the game, not every species becomes extinct. Ask the students if real species can survive in the same way that they did.

(Some species can avoid many threats that other species face. For example, birds can fly over cars that might hit other species. Some species need only a very small amount of space to get what they need, so they might not ever need to leave their habitat island, or they might not have to look far outside their habitat. Still others might not be affected by the main threats in an area. If, for example, there was a predator killing many small animals in an area, a larger species might be too big to be eaten by that predator.)

8. Introduce edge effect.

Now tell the students that there is an additional threat that species face when living in habitat islands. Species are at risk not only when they travel between islands, but also while they're inside their habitat island. Many species can be lost to something called the edge effect.

The conditions at the edge of a patch of forest (as well as some other ecosystems) are quite different from those in the interior of the patch. Ask the students if they can think of some of the ways the edge of a habitat might be different from the middle. *(Often, more wind and sunlight make the edge much hotter and drier than the interior. The difference in conditions can change the plant species living in the area, and plants that are better suited to the edge might out-compete plants that would normally grow in the forest. Some of the plants that are lost could have been a source of food or shelter for animals in the forest, so these animals could be lost with the plants. Also, it is often easier for predators to find prey on the edge, so some prey species can have a hard time living on an edge.)*

The figure above illustrates the impact edge effects can have on habitats of varying sizes. Smaller habitats will have a larger proportion affected.

9. Play Round Three: Life on the edge.

Tell students that they'll play another round to find out how the edge effect can affect species in habitat islands. Start the round with the same number of species and tokens that you started with in Round Two. Let some of the students who have been taggers since the first round become moving species. Collect the tokens and scatter them throughout the habitat islands as you did for Round Two. Tell the students that the rules for this round are the same as they were in the last round, except for one major change. Now the taggers will simulate the edge effect by reaching an arm's length into the islands to tag species. Their feet can't cross the rope that marks the island—they can only reach in.

Shout "Immigrate!" to start the round, then give the students as much time as they need to collect their two tokens. Once the round is over, count the students that survived and record the number on your poster-sized paper.

10. Go over the results of Round Three.

Have the students gather together to calculate the percentage of surviving species. Did more or fewer species survive this round? What did the students expect would happen? Explain that in most cases some species can be lost to the edge effect, so they would expect that the percentage of surviving species is lower than in Round Two when they didn't consider the edge effect. Ask students who were tagged if they were tagged on the edge or outside an island. Students tagged on the edge are much like species that can't adapt to the new conditions or like species that are easily spotted by predators, and so can't survive as well on

the edge. Had any students who were tagged outside an island been pushed out of an overcrowded island? Did they notice that their amount of “safe,” or healthy, habitat had been decreased by the edge effect?

Tell the students that although many of the original species didn’t survive in the game, the total number of species in real habitat islands with lots of edges can actually go up. Ask if anyone knows how this could happen. (*Many species that are well adapted to the conditions on the edge can move in and take the place of a smaller number of species that were adapted to the interior and not to the edge.*) In the game, when a species was tagged out, it wasn’t replaced with another species, but in nature this can happen. Some disturbed habitats actually have more species than healthy ones, but they don’t necessarily play the same ecological roles as these species do in a healthy habitat. And the disturbed habitats often contain widespread, nonnative species rather than the more rare local species that are important in the area.

11. Discuss reserve design: Making a good plan.

Tell the students that the challenge of understanding species’ need for space is in building developments like roads, homes and schools so that both people and wildlife can get the things they need. Because it’s not always easy to do, many species are in trouble. But it can be done. Ask the students to think about how we can help wildlife in fragmented areas, whether in reserves or in developments. For example, one way to make sure that there’s enough habitat for species is to set aside land in reserves. Ask the students if they can think of any potential problems with reserves. (*If they have trouble thinking about problems, lead them back to the concepts they learned in the game. Many reserves are like habitat islands—they are surrounded by developments and can become isolated. Small reserves might be too small to support many species. And wildlife moving between reserves can face many threats. Your students may come up with other problems not related to the concepts of the game, but be sure that the ones listed here are covered.*)

Draw the diagrams on the previous page on poster-sized paper or on the chalkboard. Each diagram represents a possible reserve design, but in each set one is a better choice than the other. Ask the students which design in each pair they think is best, based on what they learned in the game. Ask them to explain their choices, and then give them the answer and explanation provided. Remember that there are many different ways of thinking about reserves, and your students may have many different issues in mind. The answers provided are the best choices according to what we know today about island biogeography. As long as the students can justify their answer with an explanation that demonstrates that they understand the material, they’re right. But let them know that there are many ways of looking at the problem. If you have time, you can test these different designs with more rounds of the game. Use the same rules and see if more species survive with the recommended designs.

Tell the students that these designs are often the best way to protect the largest number of species. But they’re not always realistic, and they’re not always the best plan because they don’t consider the needs of specific species. Emphasize that there are many factors to consider when planning reserves. For example, does land need to be purchased? How much will it cost? What else might the land be used for? Does anyone live in the area? What species are using the area? Planners of reserves must weigh the costs and benefits of development and protection of natural areas, which can be a very complex and time-consuming process. If there are any current plans for the purchase of land for either

protection or development in your area, you might discuss them here. How do your students feel about the different options available?

12. Talk about how people can help species in developments.

Most animals probably don't live their whole lives in reserves. Even if they use the reserves most of the time, chances are they'll need to leave them to find food, mates or other things at some point. Do your students think wildlife has a good chance of surviving outside reserves? Are there things we can do to increase the animals' chances and help preserve biodiversity? Refer to the threats to species moving between habitat islands that your group identified in Round Two of the game. Talk again about the threats and ask students to think of ways we can help reduce them. Some ideas are listed on the following page.

On roads:

- Post wildlife crossing signs to alert drivers that they are likely to encounter an animal on the road.
- Construct highway underpasses so animals can cross roads without the threat of being hit by a car.
- Where possible, use less salt, or use an alternative to salt, on roads in the winter to reduce damage to plants along the road.

In backyards:

- Plant native plants so that the yard is more like the surrounding habitat and attracts natural species.
- Put up bird feeders for birds traveling between habitat fragments in search of food.
- Cut down on the use of pesticides so that birds and invertebrates can use backyard habitats without the threat of being poisoned.
- Keep pet cats indoors so that they do not prey on the lizards, snakes, birds, squirrels and other wildlife that may be living in the backyard habitat.

Around the school and other buildings:

- Convert part of your schoolyard or community center to a wildlife habitat.
- Provide water sources such as bird baths, marshy areas or ponds.
- Put up boxes that birds can use for nesting.

In the community:

- Plan "greenways" such as bike paths and hiking trails that preserve habitat in tracts that could provide wildlife with passageways, or corridors, connecting different reserves that are far apart.
- Encourage members of the community to become involved in making decisions about what land will be developed and how it will be done. Once your students have come up with some ideas, give them the option of taking some type of action—from conducting more research to creating a wildlife habitat area nearby. You may want to try some of their ideas as part of a class or group project. The National Wildlife Federation's Backyard Wildlife Habitat Program, which has a Web site at www.nwf.org/nwf/habitats, can give your group ideas about how to create or enhance wildlife habitat. Whether or not you decide to take action as a group, make sure that your students understand that although habitat loss and fragmentation are serious problems for wildlife, making the decision to build roads, homes or schools doesn't mean we have decided not to protect biodiversity. There are many ways we can share space with other species.

Activity 4: Falling Leaves

Objectives:

- Identify different shapes of leaf
- Understand leaf pigments
- Why do leaves change colors?

Materials:

- 4–5 spinach leaves
- 1 drinking glass
- Spoon
- Nail polish remover
- Coffee filter
- Scissors
- Tape
- Pencil
- You may also take the kids on a hike and pick some leaves to do this with as well (just remember to crush up the leaves into very tiny pieces)

Procedure:

- Tear the leaves into small pieces.
- Place the pieces into the bottom of the glass and mash them together with a spoon.
- Add several teaspoons of nail polish remover to the leaf mush. Wait until the leaves settle at the bottom of the nail polish remover. If the remover does not cover all the leaves, add enough so that they are totally covered.
- Cut a rectangle from the coffee filter. It should be slightly narrower than the glass.
- Tape the rectangle to the pencil and, when the leaves are settled, place the pencil across the top of the glass so that the coffee filter rests in the nail polish remover without touching the leaves.
- Let the glass sit for several hours.

WHAT'S HAPPENING

You should see many colors work their way up the coffee filter. The green you see comes from the chemical that makes leaves green — **chlorophyll**. But you should also see other colors, like red, yellow, and orange. These come from different chemicals that are also found in green leaves.



During the spring and summer, **photosynthesis** produces so much chlorophyll you can see only the green color in the leaves. But as the days get shorter, less chlorophyll is produced and the green fades away so that you can finally see the other colors. When the green is gone, the leaf is not far from falling to the ground.

Assessments

- What do plants need to conduct photosynthesis?
- What was, Robert MacArthur and Edward O. Wilson, experiment about?
- What pigment within plants makes the leaves green?
- Why do the color of leaves change in the fall?

Accommodations

Accommodations: Notebook Quick List

A general list of accommodations designed for lesson plan books

Instructional methodology and materials

- Needs alternate format to obtain information—Braille, large print, oral, simplified text
- Needs assistance with note taking – copy of notes, outline, note taker
- Needs concrete objects, pictures, or graphics
- Needs appropriate assistive technology: _____
- Needs advanced organizers or study guides
- Needs adapted materials—uncluttered, fewer items, highlighted
- Other: _____

Assignments and assessments

- Needs to use alternate response mode—tell, draw, write, point
- Needs appropriate assistive technology: _____
- Needs guides or prompts for specified tasks: _____
- Needs extended access to instructional resources and equipment
- Needs personal assistance – teacher, aide, peer, volunteer, interpreter
- Other: _____

Learning environment

- Needs adapted environment—acoustical treatment, lighting, barrier-free
- Needs preferential seating or study carrel
- Needs individual system for behavior management
- Needs to have instruction in small groups or one-to-one
- Needs individual planner or assistance with organization
- Other: _____

Time demands and schedules

- Needs additional time to complete course or grade
- Needs additional time to complete assignments and tests
- Needs to have independent or group work sessions in short time segments
- Needs reduction in number of required practice or assessment items
- Other: _____

Communication systems

- Uses Total Communication
- Uses American Sign Language, Finger spelling, or Signing Exact English
- Uses augmentative communication system: _____
- Needs instruction in home language other than English:
- Other: _____

Source: Beech, M., McKay, J. P., Frey, N., & Ward, T. (2000). Dealing with differences: Strategies that work! Trainer notebook, Tallahassee, FL: Florida Department of Education.

Resources

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