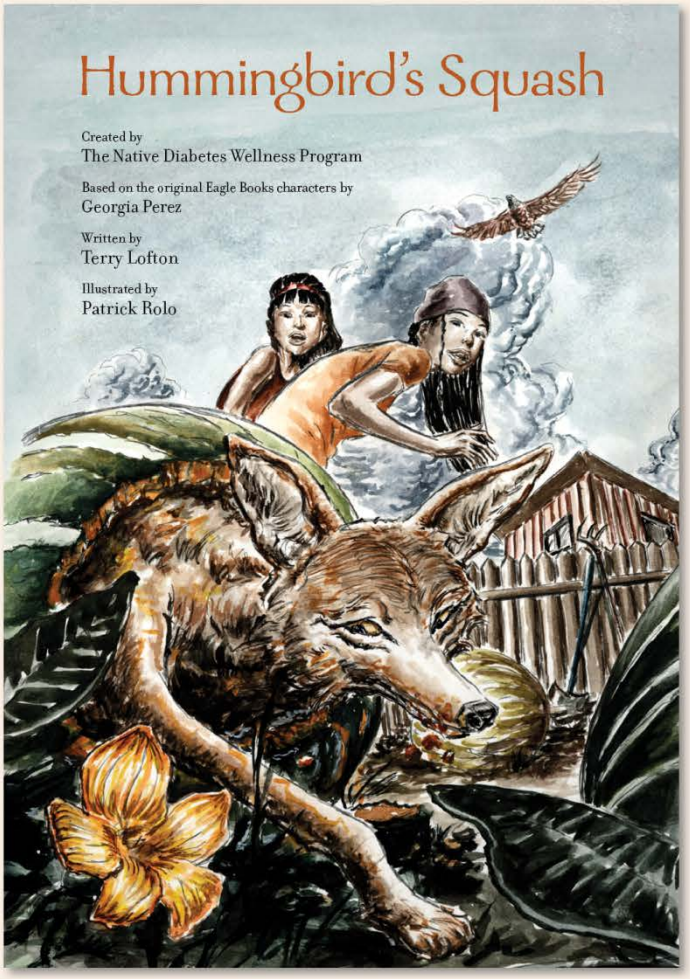
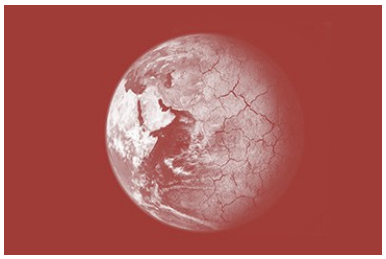
Eagle Books

Youth Novels: Educators and Community Guide

For Hummingbird's Squash



Science



PART 1: INVESTIGATING EARTH'S ENVIRONMENT
BALANCE IN NATURE

OBJECTIVES

- Identify the components of an ecosystem and explain the importance of maintaining biodiversity (the degree of variation in life forms in an environment) and a balance in the natural processes that create health in an ecosystem.
- Understand that there is a fixed amount of matter in our environment and that it is constantly recycled by natural processes.
- Identify and explain important cycles that occur in nature.
- Understand how ecosystems evolve (change) naturally over time through changes that pressure animals and plants to adapt, develop into new species, or go extinct.
- Identify the influences that humans have on natural processes that affect the health of ecosystems.
- Describe biodiversity and the role it plays in healthy ecosystems and the production of healthy foods.
- Identify the resources that provide the foods we eat and how humans manage these resources.
- Compare traditional American Indian farming techniques to the farming techniques in the 21st century; discuss current trends in farming and gardening that that focus on local markets, sustaining resources, and more diversity in agricultural products.

Background for Teachers

The earth's environment—including the land, water, and atmosphere— is mostly "closed;" that is, while we occasionally exchange matter with the outside universe, the resources to support life on the planet are mostly fixed except for the energy we get from the sun. As a result, it is very important to understand, respect, and manage our natural resources to sustain the balance of life.

All matter and energy are recycled by different cycles in nature. Understanding these cycles is essential to appreciating how nature maintains balance and how human activities can sometimes interfere with or disrupt this natural balance. It is also important to understand that there are forces such as major weather changes or geological events that can disrupt the balance in nature. The natural world is dynamic, having amazing ability to adapt and repair itself. However, sometimes changes are so abrupt or profound that nature cannot adapt, and species must adjust or they will die out.

There is evidence in the geological and evolutionary records of both large- and small-scale environmental changes. For example, much of the current landscape in North America shows that vast areas were once covered in glaciers. There is also evidence in the fossil record that at various times in the ancient past most of North America was covered in oceans or had a very tropical environment. The plant and animal species that inhabited North America have changed with these environmental shifts. Plant and animal species have either evolved to adapt to the changing environment or become extinct.

Natural events play the largest role in changing the environment, but humans also influence and change the environment on large and small scales. The purpose of some changes that humans have made was to make their lives easier and more predictable, such as clearing land to plant crops, channeling water to cities and farms, and building dams for flood control and power generation. However, in order to make good decisions about these changes, we need to consider the benefits to humans as well as any negative effects we might make on the environment as a whole. Unfortunately, we do not always understand the effects of humans on the environment until after we have interfered in many natural processes. Examples are dams blocking spawning runs for fish, the drop in soil nutrients that occurs when flooding no longer replenishes the land, and human interference that disrupts the balance in predator and prey populations.

Our ability to harness nature by domesticating both plants and animals to provide a stable food source has affected both the quantity and quality of food sources. There are both positive and negative aspects of this domestication. While we have more plentiful and stable food resources, the nutritional value of many foods has decreased. For example, cattle raised on corn have a much higher fat content in their meat than do free-roaming grazers. Domesticated animals (like chickens) tend to need antibiotics to prevent diseases when they are housed closely together. Another environmental concern about modern farming is the nutrient runoff caused by over-use of fertilizers and disposal of animal wastes in relatively small areas. Excess nutrient runoff can lead to overgrowth of algae in water ways, and animal excrement can lead to bacterial infection of life forms that live in water.

Developing plants and breeding animals to have desirable traits (they grow fast and taste good) may produce animals or plants that are all alike, leaving them susceptible to being wiped out by insects, diseases, or climate change. The potato famine in Ireland in the mid-19th century is a good example. The variety of potato species grown and eaten by the Irish was very limited. When the potatoes were infected by a fungus, they rotted and the people starved. In more recent times, a variety of banana (the Big Mike) that was cultivated almost to the exclusion of all other varieties for the U.S. market was wiped out in South America and Africa by a fungus called Panama Disease. It disappeared from grocery stores by 1960. Growers replaced it with the Dwarf Cavendish, a smaller banana tree that was resistant to the fungus, but unfortunately is

now infected by another strain of Panama Disease. As one would suspect, Dwarf Cavendish bananas are all just alike. They have little biodiversity—not a promising future for kids' cereal bowls everywhere.

However, susceptibility to disease is not the only drawback of plants and animals that are grown to the exclusion of other varieties and breeds. They may also promote bad health. Plants grown only for their higher starch or sugar content may taste good, but they offer much less nutrition, and animals bred to have higher fat content produce meat that is not good for human health.

Low genetic variability can also affect animals in the wild whose population has decreased because their habitat (like tall prairie grass, meadow, or forest) has been destroyed and replaced by cropland. They have a hard time producing healthy offspring. An example of this is the near extinction of the Greater Prairie Chicken in Canada and the United States.

Selective breeding of animals and selective planting of certain crops reduces *biodiversity*. Plant biodiversity is needed because of the wide range of climates and soils that exist in different ecosystems. If all plants in an area were the same, then a single microbe or predator could wipe out the entire population. Diversity in *plant* life is what allows and supports the diversity of *animal* life. It is nature's way of protecting life on our planet.

While some species might die out over time, new species are always replacing them. The earth has a natural capacity to heal itself over time. For example, when habitats are destroyed by fire, there is a natural succession of plants that begin to grow, allowing the area to recover and repair itself. Humans sometimes can disrupt these natural processes because of our ability to engineer our surroundings and because we have very few natural predators. The biggest killers of humans are other humans and diseases. Because we have the ability to control our environment, we do not experience the same checks and balances that other species do. Humans put great stresses on the natural environment by our sheer numbers and our efforts to manipulate it. We build dams to control flooding and provide power. We strip forests for wood and prairies for agriculture. We build homes, factories, and electronic devices to make our lives easier. As a result, we need ever-growing sources of energy which we obtain from the environment. Humans are also the biggest polluters of the environment because of our industries which contaminate the air and water. Because of population growth and industrialization, we now have a huge responsibility to preserve and respect our environment, avoid wasting the resources we have, and repair the damage that we have caused.

There is much to be learned from Native traditions which promote biodiversity and efficient use of natural resources. Native peoples today are calling on their traditional values to help them restore seed diversity and promote sustainable forestry, organic farming, and free-range animal husbandry.

In Part 1, Investigating Earth's Environment—Balance in Nature, students will learn in Investigation 1 about ecosystems, primarily food chains, natural cycles, and predator/prey relationships. In Investigation 2 they will look at soils and composting, and in Investigation 3 they will focus on ecosystem producers and consumers, principally plant producers. Throughout, the class we will explore more about the wisdom of Native traditions that promote the health of the earth and all living things, including ourselves.

Career Connections

Careers related to management of ecosystems and agriculture can be found in the Career Connections section of the Guide.

Online Resources

USDA National Resources Conservation Service. This site provides links to a multitude of lesson plans and teaching resources related to agriculture and the environment.
http://soils.usda.gov/education/resources/7_12/index.html

Biodiversity for Kids: Stage 2 Science—Teacher's Guide. This teacher's guide provides a wealth of lesson plans about biodiversity. This teachers' guide provides a wealth of lesson plans that address biodiversity
http://www.environment.nsw.gov.au/resources/education/BiodiversityTeachersGuide.pdf

Biomes. A comprehensive site for kids that provide descriptions of all the different "biomes," or large geographical areas characterized by certain plants and animals.
http://www.cotf.edu/ete/modules/msese/earthsysflr/biomes.html

Native Americans and the Environment, National Council for Science and the Environment. A comprehensive resource about environmental issues; farming, ranching, and fisheries; and conservation affecting tribes across North America
http://www.cnie.org/nae/index.html

Geography for Kids, the Study of Our Earth: Ecosystems.
Kids Geo: The Totally Free Children's Learning Network provides an extraordinary array of earth sciences resources, games, and movies.
http://www.kidsgeo.com/geography-for-kids/0164-ecosystems.php

Sustainable Table Issues. Sustainable approach to farming and gardening.
http://www.sustainabletable.org/intro/

Biodiversity for Kids. An amazing resource from Mrs. Mitchell's Virtual School that provides a large number of links to Web sites describing the issue of biodiversity around the world.
http://www.kathimitchell.com/biodiver.htm

Native Americans Modified American Landscape Years Prior to Arrival of Europeans. Impact of Native American cultural practices on the environment in the past.
http://www.sciencedaily.com/releases/2011/03/110321134617.htm

Science

INVESTIGATION 1
INVESTIGATING ECOSYSTEMS

Background for Teachers

An ecosystem is a set of relationships among the living resources, habitats, and residents of an area. An ecosystem like a forest would include plants, animals, micro-organisms, water, climate and soil. Ecosystems can be very large like a forest or a desert, or small like a pool of water. Even the surface of our skin has a variety of mini-ecosystems. For instance, dry skin, oily skin, and moist skin create different environments that host different kinds of bacteria and fungi. The energy driving an ecosystem usually comes from solar energy (the sun) that is harnessed by plants and provided to animals. There are, however, other ecosystems, based on geothermal and chemical energy, that do not use sunlight. Ecosystems that develop around hydrothermal vents in the ocean floor are an example. These cracks in the earth's surface eject or leak water heated to scalding temperatures by volcanic activity inside the earth. Bacteria living in or near these vents are fueled by chemicals dissolved in the hot water. Strange animals, like giant tube worms and blind shrimp, live near hydrothermal vents called black smokers. They feed on the bacteria and thrive in total darkness.

Plants and bacteria trap solar or chemical energy and are consumed by animals, moving the energy along a chain where animals eat other animals. As organisms get their food by consuming other organisms, energy cycles through the ecosystem. We can show this movement of energy by looking at *food chains*. A food chain based on solar energy is a system in which a producer (a plant) makes starch and passes it along to a number of consumers (a grasshopper eats the plant, a frog eats the grasshopper, a snake eats the frog, and a hawk eats the snake). When food chains overlap, they become part of a *food web*. A food web shows how the food chains of different plants and animals are interconnected.

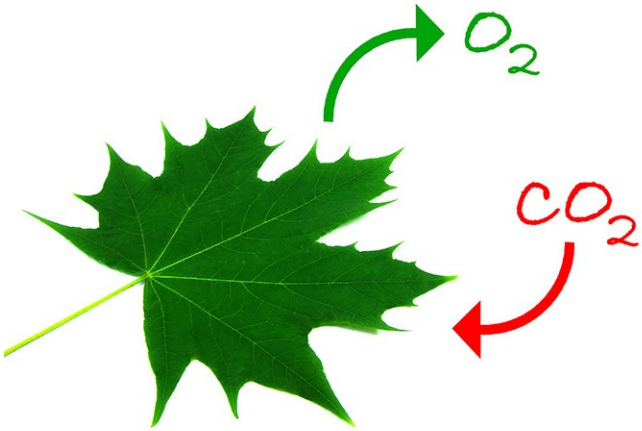
Inorganic (non-living) materials also cycle through an ecosystem in a similar manner. Teachers may want to present information on the carbon, nitrogen, and water cycles, and discuss the flow of these substances through an ecosystem. Point out how these cycles are related to each other, the food chain, and an ecosystem. Teachers may also want to review or present how oxygen and carbon dioxide are kept in balance by the photosynthesis of plants and the respiration of animals.

An interesting "getting started" discussion would be to ask students why the balance between plant and animal life is so critical to the health of our planet. Introduce the concept of carrying capacity (the maximum number of organisms of various kinds that an ecosystem can support). When an ecosystem tries to support more plants and animals than it is capable of—exceeding its carrying capacity—organisms will begin to die off. What happens to the balance between predators (wolves) and prey animals (deer) when the predators are removed? What happens to the predators when the prey animals die off from disease or loss of habitat?

ACTIVITY 1
Create an Ecosystem—Terrarium in a Bottle

Duration: 45 minutes for set-up
One to two weeks of observations

Observing a terrarium is an excellent way to see an ecosystem in action. It gives a close-up view of the parts of an ecosystem, the recycling of energy through the system, food chains within the ecosystem, and how the ecosystem can change.



Materials

For each group:

- An empty 2-liter plastic bottle
- Small plastic cap from another bottle (about one inch in diameter)
- Good top soil from outside
- Small plants about 2 to 3 inches in height
- Seeds (herb and coleus seeds work well)
- Small worms, snails, or insects
- Stream, lake, or river water
- Clear packing tape, 2 inches in width (to seal up bottles)

Procedure

1. Cut the plastic bottle in half about 4 inches up from the bottom. Make four vertical half-inch cuts that are equally spaced into the bottom edge of the upper half of the bottle. These cuts will allow the top half of the bottle to fit back inside the bottom half when re-assembled. (See Appendix 6, Activity 1).
2. Fill the bottom of the container with about 3 inches of soil.
3. Insert the small plants and seeds in the soil.
4. Invert the bottle cap and bury it into the soil close to one side of the bottle. The edge of the cap should be even with the surface of the soil. The cap should form a small well.
5. Carefully water the soil with the water from the stream, lake, or river, making sure the soil is moist but not overly wet.
6. Fill the small cap with some of the water.
7. Fit the top half of the bottle inside the bottom half, overlapping it about ¼ to ½ inches. Seal the halves together using the clear packing tape.
8. Add insects, snails, or worms through the top opening and reseal the bottle's cap.
9. Place the terrariums on a well-lit shelf or table in the classroom.

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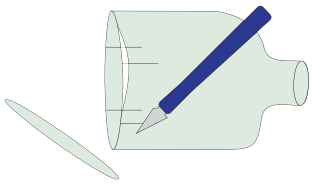

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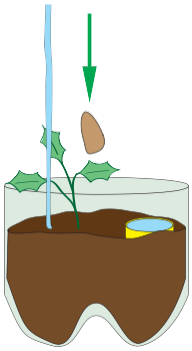

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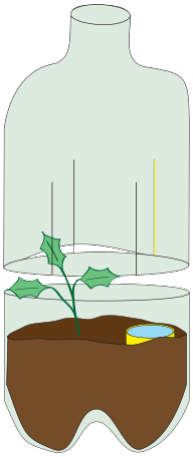

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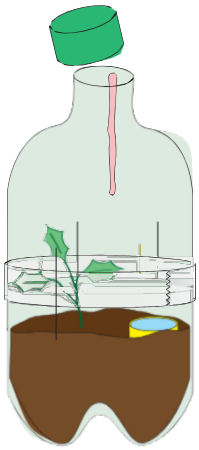


Follow-Up Activities

- Now watch what happens over the next few weeks! How does the ecosystem in the terrarium grow and change? Write down your observations.
- What observations indicate that the ecosystems are active and healthy? Did the seeds sprout? Is there any evidence of stress? Are any plants or animals dead? Is there something out of balance?
- What evidence is there of the water cycle in the ecosystem?

At the end of the 2-week period, allow students to take their terrariums home for future observation.

Online Resources

Ecosystems.
http://library.thinkquest.org/11353/ecosystems.html

Herbivores.
http://education.nationalgeographic.com/education/encyclopedia/herbivore/?ar_a=1

Earth's Water Cycle.
http://education.nationalgeographic.com/education/activity/earths-water-cycle/?ar_a=1

The Water Cycle for Kids: A Placemat.
http://ga.water.usgs.gov/edu/watercycleplacemat.html

The Water Cycle.
http://www.epa.gov/ogwdw/kids/flash/flash_water cycle.html

US Geological Survey Ecosystems.
http://www.usgs.gov/ecosystems/?item=ecosystems

Nitrogen Cycle.
http://extension.missouri.edu/p/WQ252

Kids Corner Ecosystems.
http://forest.mtu.edu/kidscorner/ecosystems.html

Nitrogen Cycle Animation
http://www.classzone.com/books/ml_science_share/vis_sim/em05_pg20_nitrogen/em05_pg20_nitrogen.swf

An Ecological System.
http://www.geography4kids.com/files/land_ecosystem.html

Carbon Cycle.
http://www.elmhurst.edu/~chm/vchembook/306carbon.html

ACTIVITY 2
Investigating Food Chains—Energy and Matter Cycling

Duration: 60 minutes (class time)

Materials

- Pictures of various plants and animals (printed photos from Web sites work well)
- Construction paper or poster board
- Colored pencils and markers

Procedure

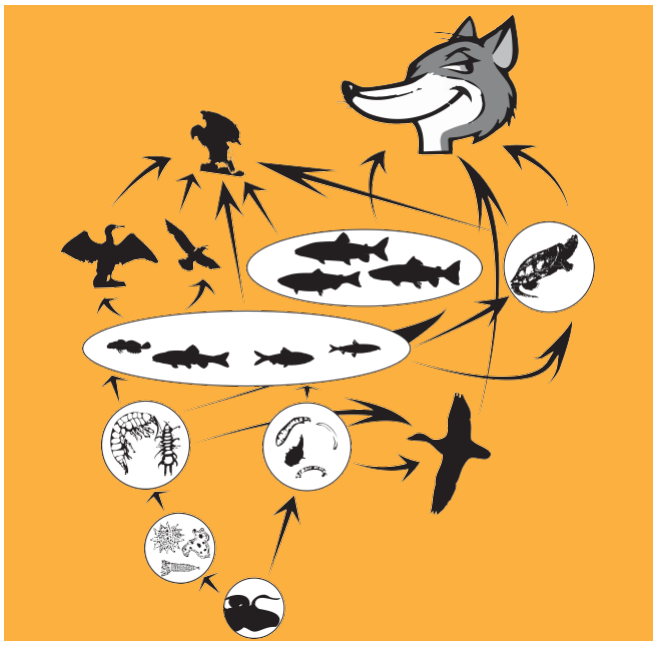
1. Each student, a two-partner team, or a small group of students will research one animal online or from a library book. Animals can be those in *Coyote and the Turtle's Dream* or *Hummingbird's Squash* (the bald eagle, eastern cottontail rabbit, box turtle, coyote, and bison), or students may select any animal (large or small) of interest to them.

2. Students will gather information about the animal's habitat, which plants it eats, which animals prey upon it and which animals does it prey upon, its various other behaviors, special adaptations that enhance its survival, and anything else of interest about that animal. For instance, who were its ancestors? Did it originate in another location and migrate to its current territory? Which animal is its closest relative? (In *Coyote and the Turtle's Dream*, the kids were very interested in Miss Swallow's poster of the different bison species that existed in the past. Students may enjoy looking up Bison antiquus, the giant ancestor of today's bison.)

   On a large sheet of poster paper construct a food chain to show where the selected animal gets its energy and where its energy goes. Start with sunlight and plants (primary producers) that the animal eats or that its prey would eat, then include who the animal provides energy to—that is, which animals eat your animal. Students should also include what happens to their animals when they die. Remind them that their animals, even when dead, remain a part of a larger food web. What types of other animals and plants consume or decompose animals that have died?

Follow-Up Activities

Have students share their food chains with the class. Then create a larger food web by arranging the food chain posters on the classroom wall to show how the food chains of the different animals living in the same ecosystem relate to each other. Identify where the food chains of the chosen animals overlap.



Online Resources

Food Chain (a food chain game).
http://www.ecokids.ca/pub/eco_info/topics/frogs/chain_reaction/

Another Link in the Food Chain.
http://www.geography4kids.com/files/land_foodchain.html

ACTIVITY 3
Owl Pellet Lab—Everybody is Somebody's Lunch

Background for Teachers

The Owl Pellet Lab is a standard lab done in many biology classes. Owl pellets are the remains of a meal that the bird coughs up. They tell us what kinds of animals a predator like the owl has been eating. Owls are carnivores, animals that eat other animals. There are, of course, birds (the fruit and seed eaters) that don't eat other animals. They are herbivores, animals that eat plants. Like the owls, we can see what they have been eating by examining their droppings. And guess what? Their droppings are full of seeds! They spread the seeds over the land as they fly. The seeds germinate in soils to which they are adapted and new plants will grow. Birds are very important, therefore, to the health of many ecosystems.

Predators are a very important part of the ecosystem, too. They eat animal prey like rodents that reproduce quickly and need to have their population kept in check—so they don't overpopulate and throw an ecosystem out of balance. What do you think would happen if the mouse population suddenly exploded! What would they do to the plants?

But animals like our friend Coyote are special. They are omnivores—animals that eat everything. They eat animals and plants. In *Hummingbird's Squash*, Coyote eats the seeds in the fruit of the coyote squash and plants them in the hills near the town of Thunder Rock. His scat (another name for animal poop) would contain little bones and hair of the animals he ate, as well as seeds and other plant parts. This material is an excellent fertilizer and gives seeds a good start when they germinate. Raccoons and bears also spread seeds in the same way. Animal scat can play a very important role in an ecosystem. Check out this Web site for a photo of coyote scat (Tip: it's the one with the red seeds) http://eternalyouthofnature.blogspot.com/2009/11/animal-poopie-doobles.html.

Materials

Information on where to order owl pellets, background explanations, and lab procedures are given in the links below. There is also a Web site below which provides a Virtual Owl Pellet dissection. It is not as exciting as really cutting apart an owl pellet, but you don't have to wash your hands!

Extension Activity

In *Hummingbird's Squash*, Thistle says, "Eeewww" when Coyote tells her that he is going to fertilize the coyote squash seeds he has eaten with his own fertilizer. Coyote reminds her that rabbits eat their food twice. But Thistle interrupts him, stating that he is getting into "private rabbit business." Have students check out how rabbits produce cecal pellets, a special kind of nutrition pellet that rabbits re-eat to extract all the nutrition from their food. Rabbits obviously take recycling very seriously.

Instructor Notes

Safety Note: *If doing the real lab (not virtual), students should wash hands thoroughly after handling the owl pellets even if they haven't touched samples directly. Tables and counters should be disinfected (diluted bleach works well) even if the samples have not had direct contact with table surfaces. Samples should be disposed of properly by burning, composting, or bagging for proper trash disposal.*

Online Resources

The Mystery of Rabbit Poop.
http://www.bio.miami.edu/hare/poop.html

What is a Cecal Pellet?
http://www.sandiegorabbits.org/diet/cecals.html

Owl pellets and lab materials can be ordered at the sources listed below:

Mountain Home Biological.
http://www.pelletlab.com/barn_owl_pellet

Genesis, Inc. Product Catalog.
http://www.pellet.com/catalog.aspx?id=4

Other sources of information about owl pellet labs:

Owl Pellet Dissection: Virtual Simulation.
http://www.kidwings.com/owlpellets/barnowl/index2.htm

Owl Pellet lab: Student Instructions and 'Worksheet.
http://www.biologycorner.com/worksheets/owlpellet.html

Owls: Top of the Food Chain. Lesson plan using an Owl Pellet lab to illustrate the food chain.
http://sciencenetlinks.com/lessons/owls-top-of-a-food-chain/

ACTIVITY 4
Understanding Adaptations—Predator/Prey

Duration: 40-60 minutes

In *Hummingbird's Squash*, Thistle always tries to conceal herself as she moves about in her environment. An eastern cottontail, her brownish-gray fur blends in well with a number of habitats. She also uses a mound of brush to camouflage the location of her nest. One might say that the success of Thistle's species is due, in part, to the fact that rabbits hide so well within a wide variety of ecosystems. In the activity below, we see how important adaptation to an environment is to the survival of a species and how the predator/prey relationship is affected when the environment is changed.

Materials

For groups of students

- A 24-inch square of multicolored printed fabric with a dark background (See Instructor Notes)
- A 24-inch square of white fabric
- Construction paper of six different colors, plus white (The colored paper should match the colors in the multicolored fabric square). The number of colors can be less than six, but the activity becomes more complex as the number of colors increases.
- Hole punch
- Small containers for mixing colored dots
- Graph paper

Procedure

1 Punch 20 dots for each color, plus white, from the construction paper. (Each color represents a different prey species.) Make 200 dots for each student group (6 x 20 dots = 180 dots + 20 white dots). Ask student volunteers to help make dots for this activity.

2 Divide students into small groups. The groups will include three to four "predators" and a student assigned to be the "dot distributor" and "counter/record keeper."

3 Give the dot distributor for each group a data table (like the Sample Data Table in Appendix 7), a container with a mixture of the 20 dots for each color, plus white, and the colored fabric "ecosystem." Lay the fabric smoothly on a flat surface for each group.

4 The dot distributor for each group should shake the container of dots to mix randomly. Then he or she should pour them out evenly over the fabric. Make sure the dots are spread out and not overlapping each other. The predators should have their backs turned during this process. No peeking!!

5 Have the first student predator turn around and quickly remove the first five dots he or she sees from the fabric. (The student should not be given time to study the fabric.) The other predators should have their backs turned as the first predator picks up his/her prey. After the first predator has finished, he or she will give the selected dots to the dot distributor (who is also the record keeper) and turn around again. The record keeper will subtract the number of each color removed from the beginning set of 20 dots for each color. The number remaining for each of the six colors, plus white, will be recorded. The record keeper should then carefully rotate the fabric square, trying not to disturb the dots. (The rotation keeps the predators from remembering where the remaining dots are located.)

6 The second student predator will turn around and **quickly** remove the first five dots he or she sees from the fabric. The other predators should still have their backs turned. The second predator will turn his or her back to the fabric "ecosystem" and give the selected dots to the record keeper. The record keeper will repeat the procedure in Step 5

7 Each predator in succession should remove five dots, until it is the first predator's turn again. Repeat the steps above, until most of the dots are removed.

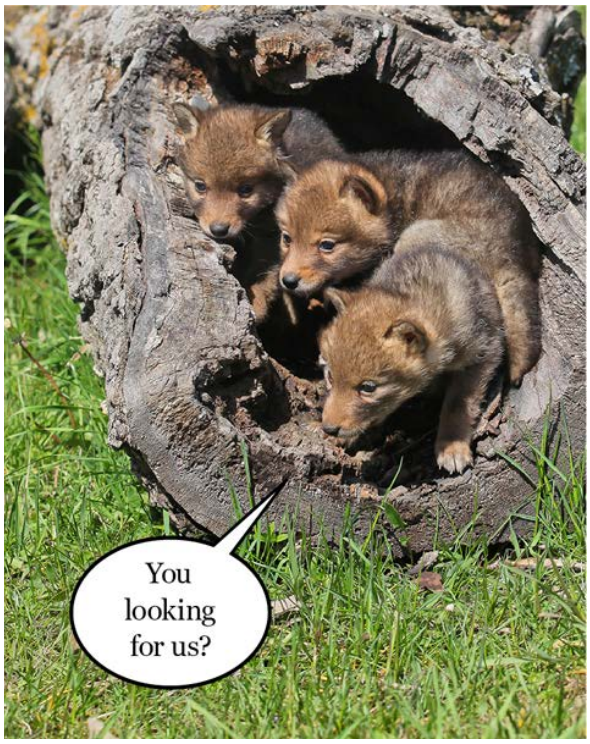
8 Lay down the white fabric "ecosystem." We have now changed the environment in which the predators and prey are struggling to survive. Have the groups repeat steps 1-5 using a new set of containers, each with 20 dots of the six different colors, plus white. (A set of 200 dots of the same colors will be required.)

9 The data recorded by the record keeper will then be tabulated.

Help students graph their groups' results for the colored fabric and the white fabric activities. Remember, each dot color represents a different prey species. Graph the number of each species remaining after each pick-up by predator 1, 2, 3, and 4. See the Sample Bar Graph in Appendix 7. (Teachers: note that in the Follow-Up Activities there is a data validation exercise associated with the bar graph in Appendix 7.)

Follow-Up Activities

- In each "ecosystem" (colored vs. white fabric) determine the first species to become extinct. Discuss why that species disappeared first.
- What was the biggest difference between the colored fabric and white fabric activity?
- Identify any patterns that developed as the selections were made. Discuss what might have caused them.
- What do these graphed data indicate about adaptations to the environment and predator/prey relationships?
- Ask students to identify any species in their area that have developed camouflage adaptations to protect them from predators. Discuss why these adaptations are successful.
- Make a graph like the sample data graph provided in Appendix 7. Ask students to interpret the data. If they do not identify the problem, point out that some of the bars representing different species are higher in Period 2 than Period 1. In Period 2 the number of dots for each color should remain the same or be smaller, not larger. This graph represents a recording error. Emphasize how important it is for students to check their data!



ACTIVITY 5
Why "Many" and "Different" Are Healthy—A Look at Biodiversity

Duration: 60-75 minutes

Background for Teachers

Variety is essential to the health of ecosystems. The purpose of this activity is to find and identify as many animals and plants as possible within a specific area, in this case a square meter. We will try to determine the amount of biodiversity within a square meter–a very small ecosystem. Students may have to go to different locations to identify the different ecosystems in their community–the shoreline of a pond, a meadow, a woodland area, a rocky outcrop, a swamp, a desert area, a garden plot, or the lawn in front of the school. Even the beaten down dirt of the playground could be an ecosystem! This activity works well for a science club, a traditional culture or heritage program, or youth leadership organizations like 4-H or Future Farmers of America. A small area ecosystem will most likely yield information about plants and small animals like insects, spiders, and worms.

Materials

For each group

- A hula hoop or a 1-meter square made of wood
- Notebook
- Graph paper
- Tweezers
- Camera (optional)
- Garden gloves (optional)
- Sandwich-size plastic baggies (optional)
- Field guide for local plants and insects (optional) or ability to look them up online
- Site Survey and Species Key
- Plot Map

Procedure

1. Divide students or club members into groups. Each group will mark an outdoor area with the hula hoop (or square meter). The areas should be chosen somewhat randomly and have different levels of biodiversity and human impact. The groups should write up and draw a general description of the area surrounding their sample area as well as include some details about what they see inside it. (See the Sample Plot Map, Appendix 8, Activity 5.)

2. Make a site survey which includes the name and number of the plants and animals found. Also make a species key, giving a unique number to each plant and animal. (See Appendix 8, Activity 5). Using the species key, plot where the plants and animals were found within the square meter. (See the Sample Plot Map, Appendix 8, Activity 5.)

3. Take a picture (if a camera is available) or make a sketch of each plant and animal species found. An indicator sample of each species can be collected in plastic baggies and brought back to the classroom to examine and identify later. If animals or plants are collected, students should wear gloves and an adult should be supervising to assure that children do not collect or touch poisonous species.

4. Identify each species using a field guide or online resources. For any species students can't specifically identify, they can give it a general ID (grass #3, bug #2, etc.).

5. Have students determine the percentage of each species in their sample area using this formula:

   Number of a single species/Total number of all species

   Example: 3 grasshoppers/54 (total number of all species) = 5.6%

   Total number of all species = Animals: 5 caterpillars, 2 earthworms, 16 ants, 3 spiders, 1 ladybug, 4 beetles, 3 grasshoppers. Plants: 4 bottlebrushes, 5 switchgrasses, 3 oxeye daisies, and 8 golden rods.

6. Help students graph their results on graph paper. Record the type of species on the X axis and population of the species on the Y axis.

7. Calculate the biodiversity index for the sample area. 0 = no diversity and 1 = highest diversity.

   Number of different types of species/Total number of all individuals (plant and animal)

   Example: 11 species/ 54 individuals = .20

8. Share results with other groups. Have students summarize the plant, animal, and nonliving components in the area they studied. Where were the most diverse areas? The least diverse? Was the biodiversity index related to the kind of area chosen to sample? For instance, was there more diversity in areas of less human impact? Which were the healthiest ecosystems? Did they discover any ways that different species depend on each other in the ecosystem that they studied? If so, what were they?

Follow-Up Activities

- Discuss the relationship between biodiversity and maintaining a healthy ecosystem.
- Predict what would happen in a larger ecosystem if one of the primary consumers became extinct. How might the natural balance be reestablished? Tip: It would be reestablished more easily if there were other animals similar to the extinct primary consumer that could move into its niche. (A niche is the specific area where an animal or plant lives and the role it plays in an ecosystem.) What would happen if the balance couldn't be reestablished?
- Investigate natural and manmade extinctions. Discuss how manmade extinctions may have been prevented.
- Many peoples, including American Indians and Alaska Natives, have long respected the majesty of eagles. Bald eagles were once an endangered species. Find out how they became endangered and what was done to help them recover and flourish in some areas.
- Identify any extinct or endangered plant or animal species in your area. Discuss ways that the endangered species might be replenished. Who or what group would decide whether the time and money should be invested in their recovery? What factors may have to be considered in making such a decision?
- Discuss the importance of maintaining healthy ecosystems and how humans can have both positive and negative influences on the delicate balance in nature. Research how Native peoples are working to protect the natural environment, thereby maintaining their culture and values.

Online Resources

Living in the Everglades. The Seminole's Everglades Restoration Initiative that promotes biodiversity.
http://sofia.usgs.gov/sfrsf/plw/living.html

Greater Everglades Partnership Initiative, Florida.
http://www.fws.gov/southeast/evergladesheadwaters/pdf/GreaterEvergladesFactsheet.pdf

Environmental Restoration Efforts. The Shakopee Mdewakanton Sioux Community seeks balance in natural habitats.
http://www.shakopeedakota.org/enviro/restoration.html

News Release. Grants awarded to tribes to restore mountain-prairie ecosystems.
http://www.fws.gov/mountain-prairie/pressrel/DC%2014.htm

Restoring a Prairie Icon. Tribes play a role in restoring the bison.
http://www.nwf.org/News-and-Magazines/National-Wildlife/Animals/Archives/2012/Restoring-Bison.aspx

Columbia River Inter-Tribal Fish Commission. CRITFC for Kids. Learn about the salmon and ways the Northwest Coast tribes seek to restore wetlands and watersheds.
http://www.critfc.org/for-kids-home/for-kids/

Welcome to "Manoomin—the Good Berry." Find out all about protecting the harvest of Mahnoomin (wild rice).
http://www.glifwc.org/publications/pdf/Fall2008_Manoomin_Supplement.pdf

Instructor Notes

Safety Note: *When having students do sampling outdoors, be sure to know if they have any plant or insect allergies and take precautions. Also, wearing gloves (garden, regular, or non-latex rubber) is recommended to avoid direct contact with plants and insects. Do not collect known poisonous species. Make sure students clean up properly whenever handling specimens or sampling outside. If students are allowed to collect samples to bring back for identification, they should leave samples in the plastic baggies.*

Activity 4

In choosing the colored fabric, make sure the colors in the pattern are similar to the construction paper dots and that the colored areas are somewhat larger than the size of the paper dots. This way the fabric will act as better camouflage for the dots. If you need to, you can reduce the number of individual colors and/or increase the number of dots of each color. Also, you don't have to have the same pattern for each group; different patterns between groups might lead to interesting discussions of variance between group results.

- If finding fabric with appropriate patterns is difficult, you could have the students paint patterns on white cloth before beginning the activity.

Activity 5

- Have different groups analyze different areas to look at effects of human interaction. For example, a high traffic area, a garden or lawn, or a more remote area distant from human habitation, etc. Looking at a variety of ecosystems allows comparison of areas to demonstrate how human behaviors and peoples' ability to engineer their surroundings affects ecosystems.
- If hula hoops are not available or constructing a square meter out of sticks is not practical, then you can use small sticks and string to mark off a one meter square area.
- If regional plant identification guides are not readily available, the Internet offers excellent resources. Should teachers and students be really stumped about the identity of a sample, the local county extension service or college/university may offer advice.

Science

INVESTIGATION 2
GETTIN' DIRTY—HEALTHY SOILS

Background for Teachers

When Miss Swallow examined Aunt Chick's garden after Coyote had eaten up all the squashes smashed by the bullies, she said it looked like a "moonscape." She couldn't even find a worm casting. Miss Swallow knew that the garden soil growing the squashes would have required four major components: inorganic (non-living) matter, organic (living) matter, water, and air. All she could find was a hard-packed inorganic material that was airless, waterless, and lifeless. Coyote had vacuumed up everything else.

Needless to say, Coyote left the garden in a poor state. For the best growing conditions, inorganic components should make up about 45 percent of soil by volume and contain rocks and minerals in the form of sand, silt, and clay. Organic components will make up about 5% of soil by volume and contain living and dead plants and animals. Air and water will be about 25% each of soil by volume. Soils deficient in any of these components will not be as productive in supporting plant and animal life. Areas with poor soil quality will have sparse plant growth and high competition for resources. Areas with good quality soil can support a high density of plant and animal life.

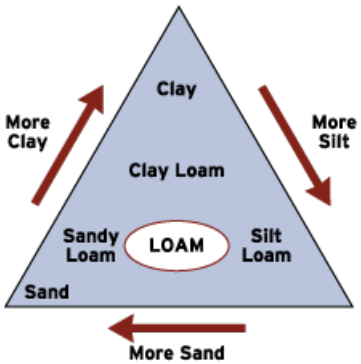
Natural conditions in an ecosystem, such as temperatures and rainfall, will influence the type of soil and soil quality found. But human activities have a big influence, too. In agriculture, we try to improve soil and crop yield by adding air (aeration), adding nutrients (fertilization), and adding water (irrigation). However, these agricultural activities can have negative effects on the soil and other parts of the environment. If not carefully controlled, aeration loosens the soil which can lead to loss of soil and nutrients due to runoff. Over-fertilization can lead to high nutrient loads in our waterways which can cause algae blooms and *eutrophication* (the overgrowth of plant life due to too many nutrients in the water). Over-irrigation can lead to lowering of the water table, excessive runoff into local waterways, and nutrient depletion.

Agriculture is not the only way humans affect soil quality. Heavily trafficked areas will have compacted soils which do not support good plant growth and tend to erode more easily. Also, areas of high human activity tend to be polluted with chemicals that damage the living organisms in the soil and contaminate ground water.

As with most things in nature, keeping soils healthy is a matter of understanding and maintaining the balance of natural components. Respecting the types and quantity of plant life that an area can support is also important. Planting crops too densely depletes soil nutrients and can lead to the use of artificial fertilizers to replace them. Harvesting plants and not returning the non-harvested components to the soil also depletes nutrients. Composting these components and returning them to the soil helps offset the loss of soil nutrients used to fuel plant growth.

Plants grow primarily in the top layer of soil called topsoil. The depth and quality of topsoil is very important to plant biodiversity and agriculture. Topsoil contains the largest amount of organic matter. Topsoil is made stable primarily by plants' root systems and the rock structure. Without stability of the topsoil layer, natural weathering and water runoff can remove the topsoil layer nutrients and mass. Topsoil is naturally replenished by the decomposition of plant and animal materials and the weathering of rocks.

Natural aeration of soils is performed primarily by worms, insects, microbes, and plant roots that live in the soil. In areas of high human activity, soils can become compacted, reducing the air pockets. Lack of oxygen can interfere with microbes which break down mineral and organic components into nutrients. Compacted soil can also make it much more difficult for plant roots to become well established, reducing plant yield and diversity. Lack of porosity (air pockets) in the soil can also reduce water absorption, causing increased water runoff and flooding.



The type of soil is determined by the relative amounts of sand, slit and clay. Sand feels very rough and gritty because of the larger particle sizes. Silt will feel smooth when both wet and dry because of the smaller and smoother particle sizes. Sand and silt do not bind together well. They stay loosely packed and are poor at holding soil together. Clays feel hard when dry but sticky and moldable when wet. Clays are also much more chemically active and have good binding properties due to their very small particle size and stickiness. Clays are very important in their ability to bind soil particles together and retain water.

Sandy soils have high porosity (large holes between particles) and do not hold water efficiently. Excess water drains quickly, often removing nutrients and contaminants from the soil into the ground water. Soils that are mostly silt or clay have low porosity (small holes between particles) and drain poorly. As a result, nutrients and contaminants do not pass readily into the ground water. The lack of drainage in silt and clay soils will cause increased surface runoff of water, moving both nutrients and contaminants to rivers and streams.

The most stable soils are loamy soils. Loamy soils contain a rough balance of sand, silt, and clay. As a result, they have good drainage and absorption of water, so they tend to hold water and nutrients necessary for organisms that live in the soil. Loamy soils are also good at filtering out contaminants before they can get into the ground water or surface water-ways. The diagram to the left shows the relationship between the different types of soils.

Online Resources

Earth's soils.
http://www.kidsgeo.com/geology-for-kids/0002-the-earths-soil.php

Composting Physics.
http://compost.css.cornell.edu/physics.html

S.K. Worm Answers Questions about Soils.
US Geological Survey Water Resources.
http://www.usgs.gov/water/

Just for Kids: Soil Biological Communities.
http://www.blm.gov/nstc/soil/Kids/

ACTIVITY 1
Are All Soils Alike?

Duration: 60-75 minutes

Farmers and gardeners know that all soils are not alike. They want to grow their fruits and vegetables in the best quality soil. Nutrient-rich soil with lots of oxygen produces healthier plants that yield vegetables and fruits with the best nutrition and taste. This activity is well-suited to an after school or weekend project that takes children outside.

Materials

For each group/person:

- Hand trowel or shovel
- Ruler (to measure area and depth of soil sample)
- Plastic bags (quart-size freezer bags work well)
- Permanent markers to label bags
- Newspaper to cover a table
- Rubber or latex gloves, if available (or make sure hands are washed thoroughly after examining soil)
- Toothpicks or tweezers (or suitable clean, pointed sticks)
- Scissors (garden or kitchen types are best)
- Soil test strips (optional)
- Data Table

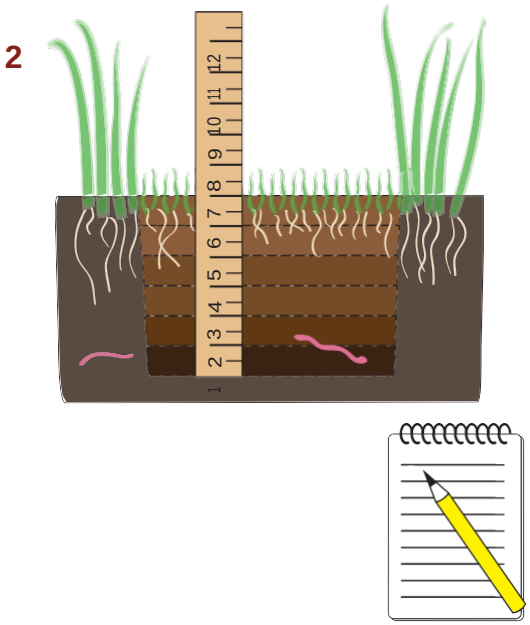
Procedure

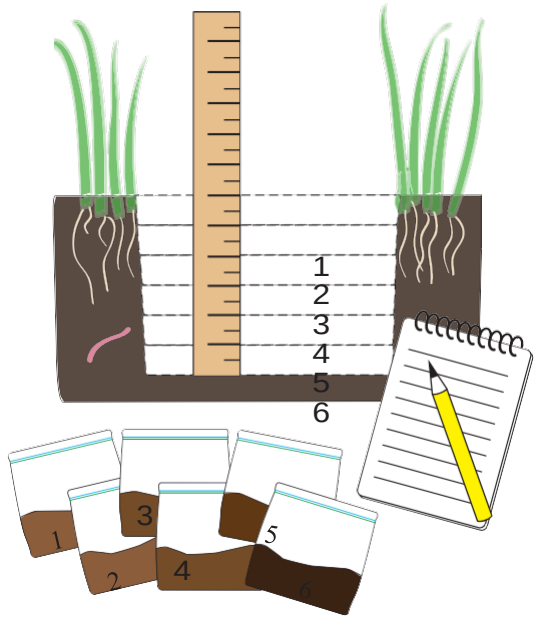
1 Divide students into groups. Each group should obtain a soil sample from a different area. Remind students to obtain permission to take a soil sample from any nonpublic areas. Before removing the sample, they should take notes and draw a sketch that describes the area. Provide as much detail as possible, including nearby features that might influence the soil type and quality. Is there a dripping water fountain nearby? Do tree roots penetrate the area?

2 Dig a circle about 6 to 8 inches in diameter and about 6 to 8 inches deep. Remove the sample 1 inch in depth at a time, keeping the different depth samples in different bags. Label each of the bags by location and depth. Cut off any plant matter that is above the top of the soil in the first layer. Don't pull it out as that will remove the roots which are a part of the soil. Any remaining plant and/or animal matter should be placed in the bag with the soil at the depth where they were located.

3 Cover a table surface with newspaper before emptying bags for examination.

2





4 Examine each layer of your soil separately as follows and record the observation in a data table. (See the Sample Data Table, Appendix 9.)

a Pour out the sample for layer one (soil taken from 1 inch deep) on the paper. Wear thin rubber gloves if available. Take a pinch of the soil between your thumb and forefinger, rub gently. Does it feel gritty, smooth, hard, sticky, or some combination of these? Put a few drops of water on the sample as you rub it. Add the results to your observations. Wash your hands thoroughly when done.

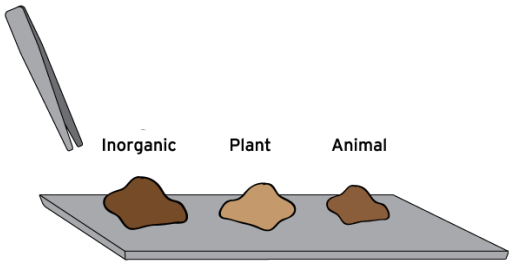
b Have students classify their soil types using the soil pyramid in the Background for Teachers.

c Describe and record the overall color and moistness of the sample.

d Using tweezers or toothpicks, separate the sample into three piles: inorganic material, plant material, and animal material. Students will then place the inorganic sample into a 100-milliliter graduated cylinder and record the volume. Repeat for the plant material and animal material. Add the three volumes together and calculate the percentage of each, based on the total volume.

e Scrape the samples back together and place into the bag, seal it and mix well. Students will use the materials again in Activity 2.

4d



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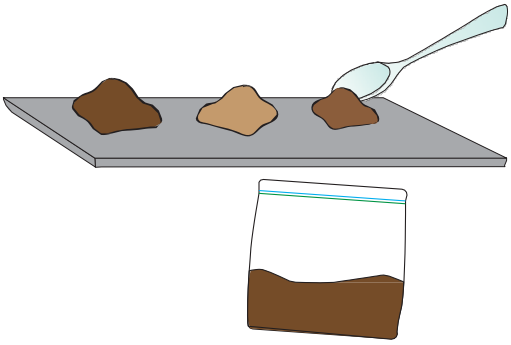
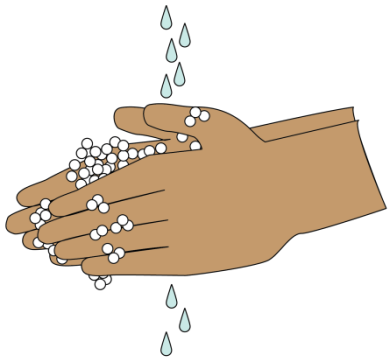


f. Repeat steps a–d for each 1- inch layer collected. Keep careful track of which layer is being analyzed and record it correctly in the data table.

5 Clean up the table and wash hands thoroughly.

Have each group share their data with the class. Discuss similarities and differences between the different areas sampled. Were there differences in soil color, water content, porosity (amount of air between particles)? Suggest reasons for these differences. Where are the healthiest soils to be found? Which areas would students predict would grow the most nutritious fruits and vegetables?

5



Follow-Up Activities

- What natural and human influences contribute to the location of healthy and poor soils in the community?
- What is ground water? What role does it play in the water cycle? Why is clean ground water so important? (Hint: Think about wells that provide water to homes and businesses.) What role do soils play in maintaining clean and drinkable well water? Why is it important to keep pollutants out of soils? What human activities can lead to soil contamination? How can we prevent them?
- Soils are a type of ecosystem. Identify their living and nonliving components. Discuss what balances need to be maintained in order for soils to be healthy and sustain life.

ACTIVITY 2
Improving Soils—Composting

Duration: 60 minutes for set-up
several weeks/months for composting

Background for Teachers

Reservation communities all across the country are becoming involved in composting. Students can build their own miniature compost pile called a "bioreactor." They will observe how composting produces a nutrient-rich natural fertilizer. This would be a great activity to do with help from those in the community who are involved in traditional foods programs that do composting.

Materials

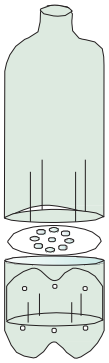
For each group

- Two 2-liter plastic soda bottles for constructing a bioreactor (See Appendix 10, Activity 2 for assembly instructions.)
- A cap from one of the plastic bottles
- A plastic lid from a container similar in diameter to the plastic bottles
- Dead plant material broken up into 1- to 2-inch pieces (leaves, grass, twigs, pine needles, corn husks, saw dust, etc.)
- Live plant material broken up into 1- to 2-inch pieces (leaves, grass, etc.)
- Household garbage materials, broken up into 1- to 2-inch pieces (vegetable and fruit peelings, coffee grounds, tea leaves, egg shells, lettuce, onion, banana peel, etc.)
- Recyclable material broken up into 1- to 2-inch pieces (cardboard, plastic, old fabric, magazine paper, newspaper, Styrofoam, egg cartons, etc.) These ingredients are optional.
- Garden soil or top soil from outside (Students may use soil collected in Activity 1.)
- Local pond, lake, or stream water (Since it is not chlorinated, this water is friendlier to microorganisms like bacteria and fungi that chemically break down compost materials, and more hospitable to the larger organisms like insects and worms that mechanically grind it up.)
- Rubber bands or tape
- Large bowl or bucket
- Thermometer (An electronic kitchen thermometer is best and one can be shared between all groups.)
- Duct tape or clear packing tape
- Utility knife or sharp scissors
- Permanent marker
- Insulating material (bubble wrap, flexible cardboard, small towels, cloth, etc.)
- Twigs that are 3 to 4 inches long

Procedure

1. Assemble the components of the bioreactor according to the instructions in Appendix 10. Label the bottle by group so that it is identifiable.
2. Select and add several handfuls each of dead plant material, live plant material, and garden soil to the bucket. Use roughly equal amounts of each and break up into small pieces. Mix thoroughly. Record observations of each material before they are added. Students will need enough to fill (loosely packed) about 6 to 7 inches of the 2-liter bioreactor.
3. Select three household garbage materials you want to compost and add a small amount of each to the mix. Record observations of the material before adding. Different groups should use different materials to add variety.
4. Select the recyclable materials you want to compost and add several scraps of each to the mix. Record observations of the material before adding. (Optional)
5. Add a few of the twigs to help prevent compacting. Mix all ingredients well by tossing loosely. Add pond water until the mixture is moist, but not saturated with water.

1



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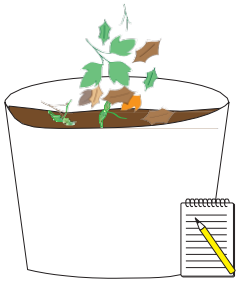

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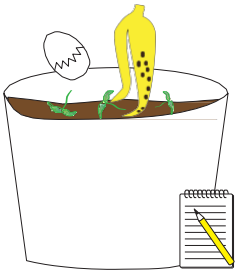

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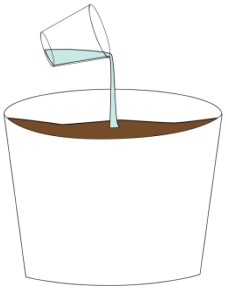


6 Carefully add this mixture on top of the plastic lid inserted into the bottom of the bioreactor. Make sure it's loosely packed so there will be good air circulation through the compost material.

7 Place the top on the bioreactor according to the directions in Appendix 10. Tape the seam together.

8 Insert the thermometer into the top opening of the reactor so that the bulb is centered into the composting material. Record the initial temperature of the mixture as Day Zero. Recap the bottle lid after removing the thermometer.

9 Make general observations of the compost mixture and record on Day Zero.

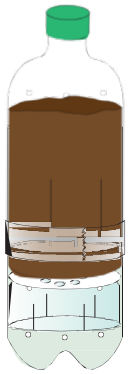
10 Wrap the straight sides of the bottle with insulating material, secure with tape or rubber bands. Be sure the air holes at the bottom are not covered. Place the bioreactors on a table or shelf in a warm place (not under a cold window or in an unheated room).

11 Now let the bioreactors "cook." For each day of composting or as frequently as possible, do the following:

- **a** Record temperature.
- **b** Unwrap the insulation and record observations.
- **c** Carefully rewrap the insulation.

12 Continue recording the observations in Step 6 for several weeks up to 2 months or until the volume is reduced by one-third to one-half.

6–7



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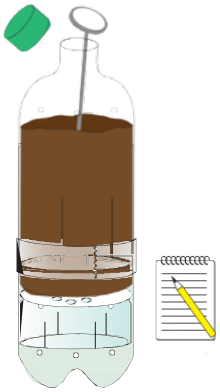

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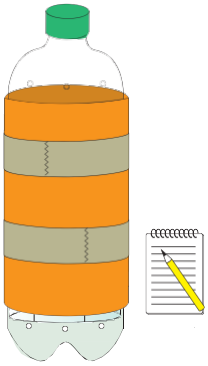
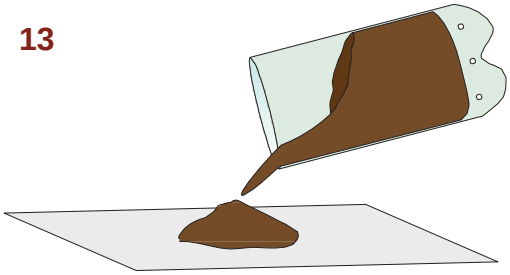


13 On the last day of composting, take the bottle outside and remove the insulation and top part of the bio-reactor. Pour the contents over some newspaper. Using sticks, spread out the mixture. Record observations describing what materials composted completely, partially, or not at all. Compare these observations to those made on Day Zero.

14 Clean up and dispose of materials as the adult supervising the activity directs. Wash hands thoroughly. (Composted material may be added to a local garden.)

15 Have the groups share their findings. Discuss any similarities between substances that composted quickly and those that did not. Use this information to predict the relative amount of time it might take for various trash items to break down.

13



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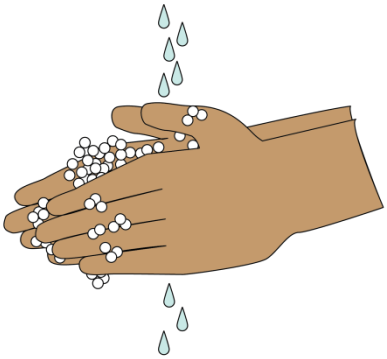

Follow-Up Activities

1. Ask the class to discuss what they have learned about composting.

2. What materials compost easily? Which do not? How can composting reduce trash volume? What are the benefits of composting? What are the drawbacks to composting? (Some drawbacks are that composting takes a long time, it has to be turned to make sure that it is decomposing properly, and compost may smell bad. Compost also doesn't have all the nitrogen that the soil may require.)

INVESTIGATION 3
PRODUCERS AND CONSUMERS

Background for Teachers

Plants harness energy from the sun through photosynthesis. They are *primary producers* because they make energy on their own. During photosynthesis, chlorophyll converts water from the ground and carbon dioxide (CO_2) from the air into glucose (sugar) and oxygen.

$$6H_2O + 6CO_2 \neg C_6H_{12}O_6 + 6O_2$$

Chlorophyll in plants gives them their green color. Plants obtain nutrients — such as nitrogen, phosphorous, potassium, and other trace minerals—from the soil to assemble the thousands of compounds that make up a plant's structure. One important role that plants play in the environment is removing CO_2 from the air. Plants are also the food/energy source for both primary (herbivores) and secondary consumers (carnivores and omnivores).

It is important to maintain an adequate plant supply to support animal life and to prevent excess amounts of CO_2 in the air. Excess amounts of CO_2 could result in increased warming of the atmosphere which could cause changes in ecosystems. Plants also play a role in the water cycle. They absorb water from the ground to use in photosynthesis, and they lose water to the air through transpiration from their leaves. Plants also provide shade which helps to prevent evaporation of water from soils.

Plants and animals are dependent on each other so that all life can survive and flourish. The *carbon cycle* is an important example of this balanced interdependence. Much of the CO_2 used by plants during photosynthesis is produced by animals as they respire (breathe out CO_2). The basic process of *respiration* occurs when animals burn sugar from the food they eat by breathing in glucose-consuming oxygen produced by plants and breathe out CO_2 and water.

$$C_6H_{12}O_6 + 6O_2 \neg 6H_2O + 6CO_2$$

This process is the chemical opposite of what happens during photosynthesis in plants. During photosynthesis sugar and oxygen are produced; during respiration CO_2 and water are produced. This is why plants and animals (including humans) can't get along without each other.

Online Resources

The Importance of Plants in Different Ecosystems.
http://www.blueplanetbiomes.org/plants.htm

Photosynthesis. Ecosystem relationships and the role of producers and consumers.
http://www.sheppardsoftware.com/content/animals/kidscorner/foodchain/photosynthesis.htm

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Photosynthesis Animation. .
http://www.biology.ualberta.ca/facilities/multimedia/uploads/alberta/Photo.html

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Relationship Between Photosynthesis and Respiration.
http://www.science-resources.co.uk/KS3/Biology/Life Processes_and_Cells/relationship_between_photosynthesis_and_respiration.htm

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Photosynthesis and Plant Nutrients.
http://www.ncagr.gov/cyber/kidswrld/plant/nutrient.htm

ACTIVITY

Investigating Natural Fertilizers—Plant Growth

Background for Teachers

Because they wanted to grow giant vegetables, Hummingbird and Arianna had a big interest in fertilizers. A fertilizer is a substance added to soil to supply nutrients essential to plant growth. Aunt Chick donated organic and inorganic fertilizers to the girls so they could pursue their "giant plan." This activity is about testing the capacity of organic fertilizers to promote plant growth. Remember to do a better job of labeling your seeds and fertilizers than Hummingbird did!

Materials: For groups

- Seeds (24-36 per group). Corn, cucumber, lettuce, pumpkin, radish, turnip, or squash seeds can be used.
- Soil (1/2 to 1/3 gallon per group). Use local soils.
- Different natural fertilizers, 1 cup per group. (Natural fertilizers may be compost, coffee/tea grounds, ground-up egg shells, cornmeal, old herbs and spices, alfalfa meal, grass clippings, chicken litter (a mixture of sawdust, bedding, and chicken manure), vegetable juices, or wood ashes.)
- Water from a local stream, pond, or lake
- Gallon-sized plastic bags
- Egg cartons (two per group)
- Plastic spoons
- Plastic wrap
- Medicine dropper
- Rulers
- Plant Growth Data Record

Online Resources

New Hampshire Giant Pumpkin Growers Association. http://www.nhgpga.org/ Great videos of pumpkin weigh-offs.

The Elusive 2,000-Pound Pumpkin. http://www.utne.com/Environment/Atlantic-Giant-Pumpkin-Extreme-Gardeners.aspx

10 Steps to a Giant Pumpkin. http://www.backyardgardener.com/wcgp/tips/10steps/10steps.html.

The World Record Carrot Growers—Heaviest & Longest. http://www.carrotmuseum.co.uk/record.html

Botanical Record Breakers: Amazing Trivia About Plants. http://waynesword.palomar.edu/ww0601.htm

Stinking Buffalo Gourd. http://www.deercanyonfolks.org/flora/buffalo-gourd-june-2011.html

Procedure

1 Divide the class into groups. Have each group choose a different natural fertilizer. Make sure the natural fertilizers are finely ground.

2 Prepare soil by filling a gallon bag 1/4 full with soil and adding 1 cup of the chosen fertilizer. Close the bag and toss ingredients thoroughly.

3 Label each well of two egg cartons with a different number. Use a plastic spoon to fill each well of one egg carton with the fertilized soil until slightly mounded and gently packed down. Label the egg carton containing the fertilized soil (identify the fertilizer used). The second egg carton should be filled with unfertilized soil and labeled appropriately.

4 Each group should select one type of seed to plant in the two egg cartons. Place one seed in each well on top of the soil. Carefully push the seed about 1/4 inch into the soil with a pencil or small stick. Carefully cover the hole with soil. Label each carton with the kinds of seeds that have been planted.

5 Use a medicine dropper to add pond water to each well. The soil should be moist to slightly wet, but not saturated. Loosely cover the egg carton with plastic wrap to help prevent evaporation. Samples should be checked daily for signs of germination and to make sure the soil stays moist. Add pond water in small amounts as needed to keep the soil moist.

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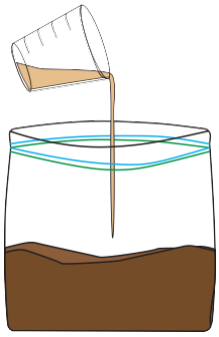

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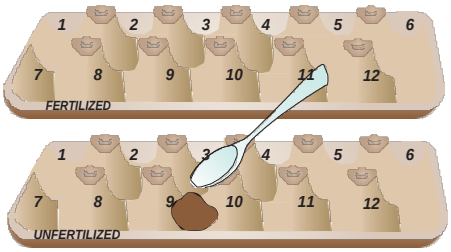

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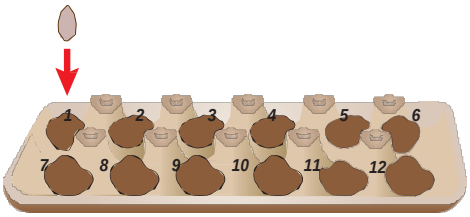

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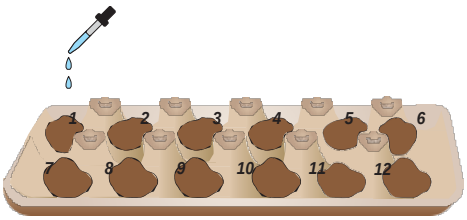


6 Check the egg cartons daily. Re-water if they start to dry out. Keep them moist but not wet. Record the number of days each seed takes to sprout. Once the seeds have all sprouted, calculate the overall percentage that germinated.

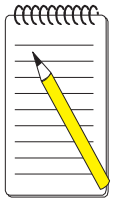
Number of seeds germinated/

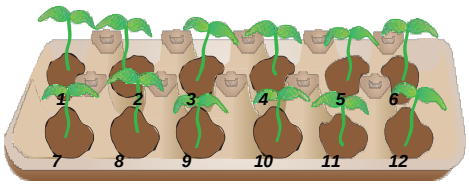
Total number of seeds planted
x 100 = % germination

7 Each day after the seeds sprout, measure the height/length, number of leaves, amount of branching, and color of leaves. Record these measurements daily for 2 weeks. Students will need to create a data table to keep track of these data for the 24 seedlings for at least 2 weeks. (See Plant Growth Sample Data Record in Appendix 11.)

8 At the end of 2 weeks, have the groups use their data tables to compare their growth results. Which seeds have grown the most—fertilized or unfertilized? Was there variation among the different seeds? Was there variation in growth according to the different fertilizers used?

6–7





Follow-Up Activities

- Invite students to research growing giant fruits and vegetables just like Simon and Arianna did. See the Web sites provided. Find out about seed varieties that produce giant fruits and vegetables. What roles do soil quality, fertilizer, and water play in growing the giants? How heavy are the biggest pumpkins ever grown? What are the records for the biggest cabbage, carrot, and radish?
- Coyote grew a giant specimen of the stinking buffalo gourd (or coyote squash as he would prefer it to be called). Check out the actual size of the fruit, flowers, and leaves of *Cucurbita foetissima*. See the Web site provided.

Science

PART 2: FINDING THE BALANCE AND WISDOM IN THE PLANT WORLD AND NATIVE SCIENCE

OBJECTIVES

- Explain why we are encouraged to "eat our colors." Identify the nutritional benefits of colors in plant foods.
- Compare the nutrition of indigenous plant foods with the low-quality processed foods that are a large part of the modern diet.
- Explain how plant colors are used in identifying acids and bases, and how plant-based acid/base indicators are used to protect our health and safety.
- Identify inventions and discoveries of American Indians/Alaska Natives that have contributed to the scientific, technological, and medical knowledge of today.
- Describe Maya rubber-making technology.
- Explain why corn is more nutritious when processed with ash before eating.
- Understand the danger that invasive plants present to the environment and how farm and rangelands can be protected.
- Describe the safety aspects of the Inuit kayak.
- Explain how "Elephant's Toothpaste" can be made with hydrogen peroxide and other materials.
- Define the role of a catalyst in chemical reactions.
- Explain water transport in plants.

Background for Teachers

Students will learn in Part 2 about the many ways that plants provide us not only with healthy nutrients, but also with the resource materials that we use for making the products that we use every day. The activities also highlight the ways that plant colors provide the nutritional value of the foods we eat and help us to balance the soils in which our foods grow. Students will also enjoy learning how Native Americans have applied Native Science in maintaining nutritional balance in the processing of plants foods, ecological balance in the maintenance of indigenous plant communities, and the invention of a new product like rubber from the combination of different plant fluids.

In terms of nutritional balance, it is important for students to understand that our bodies need *macronutrients* (big nutrients) in the form of proteins, carbohydrates, and healthy fats to supply energy and build body tissues. But we also need many *micronutrients* (little nutrients) that are present in fresh foods, such as the vitamins and minerals that help us to build tissues, maintain optimum health, and prevent disease.

The nutrients in fresh fruits and vegetables are related to their colors. Many traditional plant foods that were domesticated in the Americas are characterized by their rich colors. The brilliant yellow and orange hues of squash and pumpkins, the red and black in beans, and the multiple colors of corn come from carotenoids and anthocyanins—the chemicals in plants that give them not only their colors, but also much of their flavor. Carotenoids tend to be red, orange, or yellow, and anthocyanins tend to be red, purple and blue. In plants, these chemicals play a role in resisting disease and pests. In humans, they play a similar role. As important micronutrients in the human diet, they help strengthen the immune system, help repair cells and tissues, and prevent disease. The idea behind "eating your colors" is to make sure we are getting foods high in micronutrients, but lower in calories and fats. Nutrient rich foods make calories count! Moreover, the colors in plants allow us to measure the acidity and alkalinity of foods, beverages, and personal products that assure their safe use and consumption. In Investigation 1, students learn how to use vegetables, fruits, and flowers as indicators of pH.

Of course, unprocessed foods (raw vegetables and fruits and nuts) and less processed food (simply cooked meats, fish, vegetables, and breads made from whole grains) satisfy hunger and best provide the body with the materials needed for important body functions. However, technology has changed the way that much of our food is grown, processed, transported, and consumed. Many processed foods and snacks (cake mixes, cookies, cheese spreads, chips, and luncheon meats) are produced by adding (1) fillers that retard spoilage and bulk up the calories with sugar, fat, and salt; and (2) artificial colors and flavors that increase eye appeal and taste. These low-quality processed foods are easy to transport because they won't go bad, and they are cheap to produce. But, these processed foods have a problem: they are low in nutrients and high in *trickiness*. That's right. They are *Tricky Treats*. Why? Because many people don't realize they are full of salt and empty calories from sugar and fat. Most processed foods are rarely as nutritious as fresh foods and are less satisfying. Not only are they low in nutrients and high in empty calories, but pre-cooking destroys vitamins and flavor. People who eat large amounts of cheap processed foods tend to eat bigger portions, get hungry sooner after eating, and eat more often.

The good news is that some processed foods are high in quality. Frozen vegetables, for instance, preserve much of their vitamin content, and whole-wheat breads and cereals can be fortified with fiber, vitamin D, and calcium. The processed foods featured in the Native Science projects in Investigation 2 are excellent examples of healthy processing, preservation, and prevention of nutritional deficiencies.

Some vitamins in plant foods prevent deficiencies by helping to catalyze (speed up) a wide variety of chemical reactions in our bodies. Vitamin deficiencies lead to many diseases in humans because chemical reactions needed to keep our bodies functioning are too slow. In *Hummingbird's Squash*, Hummingbird demonstrated the role of a catalyst in producing Elephant's Toothpaste. Investigation 3 offers students an opportunity to make their own non-explosive Elephant's Toothpaste and to have some Coyote fun changing the colors of flowers via water transport in plants.

Career Connections

Careers relating to promoting good nutrition, ecological sciences, soil science, environmental engineering, and health education are found in the Career Connections section of the Guide.

Online Resources

Fruits/Vegetables. Great resource on nutrients derived from fruits and vegetables.
http://food.oregonstate.edu/learn/fruitveg.html

FAQs: Phytochemical Info Center. How the colors of foods (phytochemicals) work in the body.
http://www.pbhfoundation.org/about/res/pic/faqs/

Color Me Healthy—Eating for a Rainbow of Benefits.
http://www.todaysdietitian.com/newarchives/110308p34.shtml

Cancer Institute of New Jersey. September Is Fruit and Vegetable Month.
www.cinj.org/fruit-and-vegetable-month-september

The Colors of Fruits and Vegetables. Importance of eating colors.
http://dug.org/storage/school-garden-curriculum/Colors_Fruits_Vegetables.pdf

Micronutrients and Macronutrients
http://diet.ygoy.com/2009/06/19/micronutrients-and-macronutrients/

INVESTIGATION 1
ACIDS AND BASES—USING PLANT WISDOM TO FIND THE "BALANCE"

Background for Teachers

The *Eagle Books* recommend that we eat a "Plate Full of Color." The colored pigments in plants provide many benefits to humans and animals, and to plants themselves. They allow plants to make their own food using chlorophyll (a green color) to trap the energy from sunlight, and they help plants by attracting insects that pollinate flowers and warding off insects that eat plants. They can also act as a plant's sunscreen.

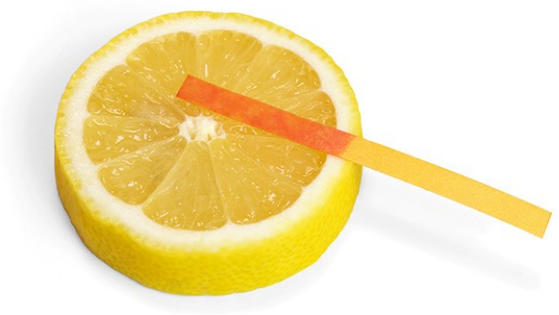
In addition to the health benefits from the colors we eat, plant pigments also provide us with colors for paints and fabric dyes. Another important use of plant pigments is in the identification of acidic and basic substances.

Almost everybody knows what it means when we say something has an "acid taste" (think of lemons). We often describe acidic foods as tasting sour. But rarely would we hear someone say that a substance tasted "basic." However, if anybody asks, just tell them to remember what soap tastes like! Most basic substances, like soap, have a bitter taste. The bitter taste warns us that bases are often poisonous. Labels on cleaning products like ammonia and bleach, which are bases, warn users that they are poisonous.

Understanding acids and bases requires that students understand pH, which is the potential (p) of a solution to have hydrogen (H) in it. When dissolved in water, bases *reduce* the hydrogen concentration in water whereas acids *increase* the concentration of hydrogen in water. The pH scale allows us to rank an acid or base on a scale of 0–14. Zero is most acidic and 14 is most basic. Water is neutral with a pH of 7 (it is neither acidic nor basic). Acids and bases are thought of as opposites. When we combine an acid with a base, we can neutralize them, creating a solution that approaches a pH of 7, like water. We can find out which solutions are acidic or basic by testing for their pH with chemicals called *acid/base indicators*.

Guess where we can find acid/base indicators? We can find them in the colored pigments of fruits, vegetables, and flowers. Plant pigments that have *one color* in acid solutions and a *different color* in basic solutions tell us if a substance (when mixed with water) is acidic or basic. Why is this information important? Ask a farmer or a gardener! He or she will tell you that a healthy soil is necessary for growing healthy food. When soils are too acidic or too basic, plants will not grow properly. A gardener can test the pH of the soil and add an acidic or basic solution to bring it into balance, if needed. Some plants like their soil a little more acidic, and some like it a little more basic. But most plants thrive in a *balanced* soil that has a pH of 7, the pH of water. No wonder we call water the "gift of life."

Indicators from colored pigments are also used in the manufacture of safe cosmetics; personal care products like shampoos, deodorant, and toothpaste; and medicines. We don't want these products to irritate our eyes, skin, or stomachs, or to damage our hair. It is important that their pH be as close as possible to that of water.



Online Resources

The pH Factor. Great middle school activities from the Miami Museum of Science that explain pH.
http://www.miamisci.org/ph/

Approximate pH of Foods and Food Products.
http://foodscience.caes.uga.edu/extension/documents/FDAapproximatepHoffoodslacf-phs.pdf

What is BrainPop? Acids and Bases.
http://www.brainpop.com/science/matter/acidsandbases/preview.weml

ACTIVITY
Veggie Chemistry

Background for Teachers

In order to determine which plant pigments are indicators, we will expose them to an acidic environment (vinegar) and a basic environment (baking soda solution) and compare their colors. If they undergo a distinct color change, then they are acid or base indicators.

Materials

- Vinegar
- Baking soda solution (dissolve one tablespoon of baking soda in 1 cup of water)
- Various flowers, vegetables, fruits or fruit juices (the highly colored ones tend to work better). Try vegetables and fruits such as red cabbage, beets, red radishes, blackberries, carrots, cherries, strawberries, or cranberries. A spice like curry powder works, too. Flower petals that change color in acid and base solutions are geraniums, morning glories, pansies, petunias, violets, and roses.
- Spoons
- Small bowls or cups for testing substances

Procedure

1. Prepare pigments by grinding up fruits, vegetables or flowers with a small amount of water to extract the pigment. Juices can be used directly.
2. Test the pigments by adding five to ten drops of each pigment to a teaspoon of vinegar (an acid) and to a teaspoon of baking soda solution (a base) until the color stops changing.
3. Record the color in each solution.
4. Identify which pigments are good acid or base indicators by noting those that are one color in vinegar, but another color in the baking soda solution.

Which fruits, vegetables or flowers were the best indicators? What colors were they? What color changes occurred?

An Easy Extension Activity

If students would like to do another indicator activity, go to Cabbage Chemistry at http://www.sciencebuddies.org/science-fair-projects/project_ideas/Chem_p013.shtml for instructions. This demonstration uses red cabbage as an indicator. Students have a lot of fun pouring acidic and basic solutions into the red cabbage indicator, making it change color instantly from basic (green/yellow) to acid (red) and other colors that indicate various pH values. Referring to the chart given in the activity, which color is closest to neutral, a pH of 7?

INVESTIGATION 2
NATIVE SCIENCE: YESTERDAY, TODAY AND TOMORROW

Background for Teachers

Science Fairs are an excellent opportunity for students to undertake and present their own research. Independent research allows students to learn about designing an experiment, recording their observations as data, analyzing it, and drawing conclusions about what happened. Science Fairs can be as simple as presenting projects in front of a class or community group or a formal competition with awards. In addition, students learn that real experiments may not work out the way they expected. Students can appreciate that important learning comes from the mistakes they make and the ways they figure out a problem. In real science, if everything worked the first time, there wouldn't be much need for experimentation.

The best projects are those that really grab the interest of the students. The *Eagle Books* project has developed a series of Science and Technology Cards that we hope "grab the interest" of students. They describe and illustrate Native peoples' scientific contributions to the world. In *Hummingbird's Squash*, Chris investigated one of these contributions: the making of rubber. Even though Chris was pretty cranky most of the time, he really enjoyed the time and hard work that went into doing an award-winning project.

Chris used natural materials (the sap of the rubber tree and morning glory juice) just as the first rubber-makers, the Olmecs, did. Latex is the ingredient in the plant sap or "milk" that makes rubber. When exposed to an acid or when dried, the molecules of latex bond together in long chains called *polymers*. The long strands of polymer get tangled together like wet spaghetti. Polymer molecules are the basis for most plastics, glues, and rubber. Natural polymers can be made from plant saps or "milks" and animal proteins or plants juices containing sulfur. The Olmecs, and later the Mayas and Aztecs, made rubber that was very stable. We still have some of the rubber balls that the Olmecs made 3,500 years ago to play their ball game. To see one of these ancient balls, go to the National Geographic Web site in the online resources provided in this section.

Today, we use synthetic polymers (they are not made from plants) to make products we use every day—like plastics. In Activity 1 we will make a "rubber" polymer using synthetic, not natural products. For a classroom activity, it would be difficult to obtain the sap of the rubber plant and the morning glory juice that Chris used. However, the process of breaking down synthetic glue into polymer chains is very similar to breaking down the rubber sap into polymer. In Activity 2, students are invited to research the other science projects, including Hummingbird's, that were described in *Hummingbird's Squash*.

ACTIVITY 1
Chris's Science Fair Project—Making Rubber

Materials

- A bottle of Elmer's white liquid glue (to act as plant "milk")
- Borax (an acid that can be bought in grocery or hardware stores)
- Corn starch (a plant-based carbohydrate polymer)
- Food color (optional)
- Measuring spoons
- Meter stick or measuring tape
- Pint-size plastic bags with a zip closure

Online Resources

Aztec, Maya Were Rubber-Making Masters?
http://news.nationalgeographic.com/news/2010/06/100628-science-ancient-maya-aztec-rubber-balls-beheaded/

The Game: Watch how the Mesoamerican ball game is played today. It's called "ulama!"
http://www.ulama.freehomepage.com/about.html

The Sport of Life and Death: The Mesoamerican Ballgame.
http://www.ballgame.org

How to Make Rubber at Home. Making rubber from the rubber tree and morning glories.
http://hassam.hubpages.com/hub/How-To-Make-Rubber-At-Home

4

Procedure

1. Make a borax solution by dissolving 1 teaspoon of borax in 1/4 cup of warm water. Stir to dissolve completely.
2. Place 2 tablespoons of glue into the baggie.
3. Add 2 tablespoons of corn starch to the glue in the baggie. Add one to four drops of food color (optional).
4. Mix the glue and starch mixture by squeezing the outside of the bag.
5. Add 1 teaspoon of the borax solution to the ingredients in the baggie and seal the bag. Let sit for 15 to 20 seconds.
6. Then knead the ingredients in the bag until it starts to form a semi-solid mass.
   - Remove the mass from the bag and continue to knead it. Then roll the mass into a ball. Use paper towels to dry off any excess water. Wash hands.
7. Try to bounce the ball in the table or floor. Record observations.
8. Using the meter stick as a guide, drop the ball from a height of 24 inches to a flat surface. Measure how high it rebounds.
9. Repeat Step 8 five times and calculate the average result.
10. Compare the rebound results to others in the class.

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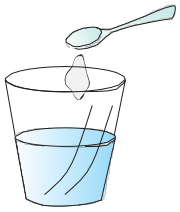

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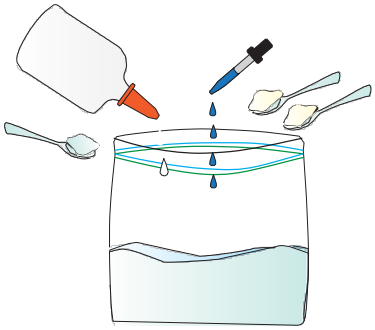

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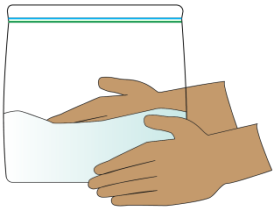

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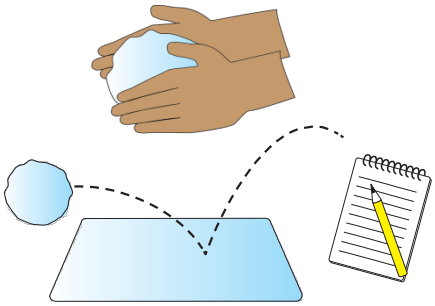

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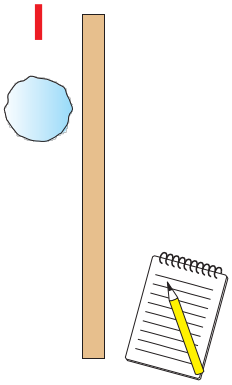


ACTIVITY 2
Other Native Science Activities

Students may be interested in researching or reading about other projects that won awards at the Thunder Rock Middle School science fair:

- **Little Deb's Project**
  Ash and Corn—Releasing the Nutrition
  Students can read about "nixtamalization." This process is named after two Nahuatl (Aztec) words: nextli, meaning "ashes," and tamalli, meaning "unformed corn dough." Many tribes boiled corn with ashes to release niacin, an important nutrient. On the Web sites below, students will learn about pellagra, a terrible disease that affected poor Americans in the southern United States that lived mainly on a diet of pork and corn. They did not boil their corn with ashes (or other alkalines) to release niacin like American Indians had done for thousands of years. The result was mental illness and skin disease due to nutritional deficiency.

  The History of Pellagra in Alabama.
  http://www.uab.edu/reynolds/pellagra/history

  Dr. Joseph Goldberger and the War on Alabama.
  http://history.nih.gov/exhibits/goldberger/index.html

  Preparation of Corn. Recipe for releasing niacin using ash.
  http://ancestral.nativeaccess.com/corn/winter.html

- **Hank's Project**
  The Kayak—From Hunting Boat to Modern Sport

  The History of Kayaking. Traditional kayak designs and functions.
  http://www.kayak.spirithawk.net/history.html

  Outline of Canoeing and Kayaking. Modern kayaks and canoes.
  http://en.wikipedia.org/wiki/Outline_of_canoeing_and_kayaking

- **Mindy's Project**
  Freeze Drying Potatoes—The Inca Way

  Food of the Incas.
  http://library.thinkquest.org/C005446/Food/English/inca.html

  Andean Native Potatoes. Learn about the thousands of potato varieties grown in the Andes Mountains (talk about diversity!) and how to make chuño (pronounced choon-yo). http://www.underutilized-species.org/species/brochures/Andean%20potatoes.pdf

- **Hummingbird's Project**
  Invasive Plants on Tribal Rangelands

  Hummingbird's project is about protecting native prairie grasses that bison eat and the greater nutrient value of meat from bison that range free. The following Web sites provide information about bison and controlling invasive plants that crowd out native plant species.

  Intertribal Buffalo Council (Miss Swallow would probably be a member).
  http://itbcbuffalo.com/

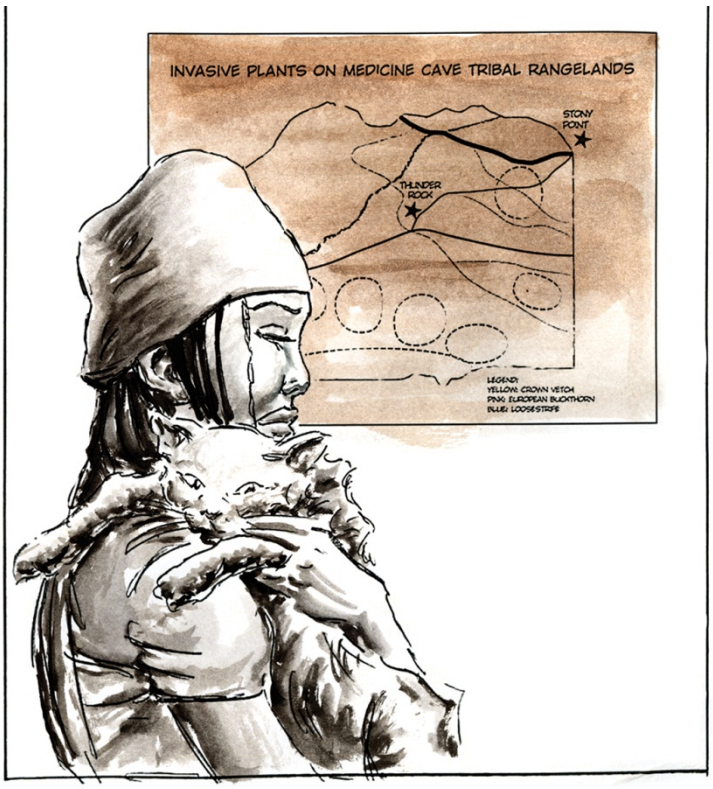
  The Ecological Importance of Bison in Mixed-grass Prairie Ecosystems. Download a free 4-page ebook at http://ebookbrowse.com/fallon-the-ecological-importance-of-bison-doc-d16333666

  Where's Weedo? Students can try to spot invasive plants.
  http://www.blm.gov/pgdata/etc/medialib/blm/wo/Communications_Directorate.Par.0136.File.dat/WildSide%2013.pdf

  Invasive Plants of Nebraska. See how the State of Nebraska invites people to recognize and help control invasive plants.
  http://snr.unl.edu/invasives/invasiveplants.htm

Silent Invaders. Middle School curriculum about invasive plants in the Florida ecosystem. Provides key concepts for protecting native ecosystems. http://plants.ifas.ufl.edu/education/module1/web/silent_invaders.html

Alien Invasion. Great site for activities about invasion of alien species, for grades 5-8. http://www.pbs.org/saf/1204/teaching/menu.htm



Cross-Curricular Connections

See other Native Science activities in the *Hummingbird's Squash*, Art and Music section of the Guide. These activities offer a variety of ways to utilize the Native Science and Technology Cards.

Instructor Notes

Safety Note: *It may be better to for teachers to prepare the original borax solution in Activity 1 so that students are not handling it directly. Make sure students are careful not to touch their eyes without washing their hands.*

The "rubber" balls will hold up quite well if stored in the baggies between use.

Science

INVESTIGATION 3
FUN SCIENCE THE COYOTE WAY

Background for Teachers

Science is a fascinating subject filled with wonder. It can also be fun! One way to make science entertaining is to include laboratory experiments and demonstrations that are colorful or fizzy and have the ability to surprise. In *Hummingbird's Squash*, Coyote certainly surprised Mr. Pence's class when he instigated the spectacular explosion of Elephant's Toothpaste. For safety's sake, a demonstration of Elephant's Toothpaste made with 35% hydrogen peroxide is best watched online. However, we can make foamy "toothpaste" in class with simple household products.

We can also create some amazement by making flowers or celery change their colors. Coyote might want students to think it is magic, but, of course, the transformation is all scientifically explainable.

Hopefully, students won't end up looking like Mr. Pence after making their Elephant's Toothpaste!

ACTIVITY 1
Elephant's Toothpaste

Duration: 30-45 minutes

The Elephant's Toothpaste that erupted in Mr. Pence's class probably involved 35 percent hydrogen peroxide which is dangerous and should only be used in a proper lab setting. (Of course, since Coyote was involved in creating the explosion we can't be sure how he did it.) In this activity we will be using 3 percent hydrogen peroxide that is sold in stores and is used as a disinfectant for cuts in the skin. Hydrogen peroxide is unstable and naturally decomposes into water and oxygen gas. That is why hydrogen peroxide is good only if it has been purchased recently. The bottle should be stored in the refrigerator and the cap twisted on tightly to keep the oxygen from escaping. After the cap has been removed even once, the hydrogen peroxide will degrade rather quickly. An open bottle of hydrogen peroxide will give off all its oxygen in a very short time and only water will be left in the bottle.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

Reaction 1
Speeding up the breakdown of hydrogen peroxide.

The rate at which H_2O_2 breaks down into water and oxygen can be significantly increased by adding a catalyst, a substance that speeds up a chemical reaction. Students will remember the explosion that occurred when Hummingbird added a catalyst to the 35 percent hydrogen peroxide. But don't worry, our demonstration won't explode—just fizz and foam. Our catalyst will come from minerals like oxides of manganese and iron that are in dirt.

By mixing dish detergent in with the vinegar, the carbon dioxide bubbles will get trapped in the soap and produce lots of foam. Food coloring can be added to make it a little more fun.

Reaction 2
Making Elephant's Toothpaste.

An easy way to make foamy "toothpaste" is to create an acid/base reaction between vinegar (an acid) and baking soda (a base) that produces a salt, water, and carbon dioxide gas. This "recipe" doesn't use hydrogen peroxide or a catalyst, but it does make a show.

Materials

Reaction 1

- Hydrogen peroxide (a new bottle of 3 % solution)
- Dirt
- Cup

Reaction 2

- Vinegar
- Baking soda
- Liquid dish detergent
- Food coloring
- 100-milliliter graduated cylinder, or tall narrow glass or tube about 1 inch in diameter
- Small cup
- Shallow pan

Procedure

Reaction 1

1 Place 2 to 3 milliliters of hydrogen peroxide in a small cup. Describe what is happening.

2 Sprinkle some dirt into the cup. Describe what is happening now. Is the dirt acting as a catalyst?

Show students other common substances that will make hydrogen peroxide bubble. Try a slice of potato or celery, or a pinch of powdered detergent. They contain an enzyme called catalase that is a catalyst. Ask students if they have seen 3% hydrogen peroxide poured on a cut in the skin. What happens? It bubbles because blood and damaged cells also release the same enzyme—catalase.

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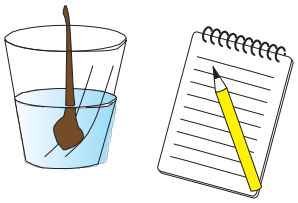

Reaction 2

1. Place about 40 milliliters of vinegar into the graduated cylinder. Add about 1 milliliter of dish detergent and mix thoroughly.
2. Add three to five drops of food coloring. Place the graduated cylinder upright in a shallow baking ban.
3. Quickly add 1 heaping tablespoon of baking soda. The easiest way to do this is to measure the baking soda, place it onto a piece of paper, fold the paper in half, and add the baking soda by placing the crease above the opening and letting the powder slide into the cylinder. Have students record their observations and compare them to what happened in Mr. Pence's classroom.
4. Pour the Elephant's Toothpaste ingredients into the sink and rinse. Clean up sink area.

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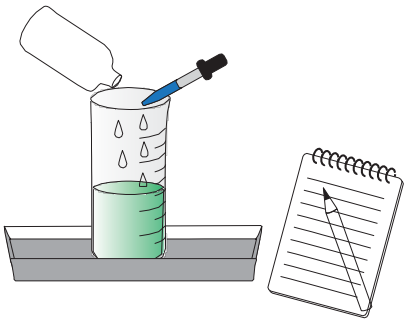

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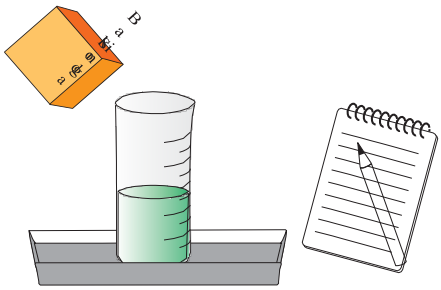

Online Resources

Watch a demonstration almost as big as Hummingbird's.
http://www.youtube.com/watch?v=ezsur0L0L1c

Elephant Toothpaste demonstrations using concentrated hydrogen peroxide and a catalyst. One of these, a Fourth of July celebration is as big as Hummingbird's.
http://www.stevespanglerscience.com/experiment/hydrogen-peroxide-eruption

ACTIVITY 2
Roses Are Red, Carnations Are…Blue?

Background for Teachers

Hummingbird and Arianna didn't know that Coyote had changed their turnip, cabbage, and carrot seeds into coyote squash—squash that would sprout and grow two feet tall in one day! The secret to the rapid growth was the xylem tubes that go up from the roots into the rest of the plant. Water and nutrients were going up these tubes "like crazy," making the plants grow faster and faster. Just how did this magic take place?

Coyote knew that plants absorb water from the soil through their roots. The water travels by capillary action up through the xylem. *Capillary action* is the way water travels upward though *adhesion*. Adhesion is the force that attracts water to other surfaces, in this case the xylem tubes. Water goes up these tubes and is lost through transpiration. *Transpiration* occurs when water is carried from the roots to tiny pores on the underside of leaves, where it changes to water vapor and is released into the air. The loss of water from the leaves creates a negative pressure which pulls more water up the xylem tubes—similar to the way you drink out of a straw. The water brings along dissolved nutrients which are used by the plant to grow its many structures. In the following activity we can do our own magic using a plant's ability to draw water upward through the xylem.

Materials

- Blue food coloring
- Water
- Fresh cut flowers or fresh cut celery stalks (colored flowers like white carnations or Queen Anne's Lace work well.)
- Magnifying glass or microscope (optional)
- Cup, tall glass, or graduated cylinder (to hold flower stems)
- Knife or box cutter

Online Resources

National Science Teachers Association. Up Goes the Water.
http://www.nsta.org/publications/news/story.aspx?id=49197

Color Changing Carnations.
http://www.stevespanglerscience.com/experiment/colorful-carnations

Procedure

1. Fill a cup with about 6 to 8 ounces of water. Add food coloring until the water is a darker color.
2. With a sharp knife, cut a very thin cross section off the bottom of the flower stem or celery stalk. Observe the cross section with a magnifying glass or microscope. Draw the structures that you see and label them.
3. Place the freshly cut flower stem or celery stalk into the cup of water with food coloring. Record observations of any changes every 20 minutes during the class period.

   Check out the flower or celery stalk the next day. What happened? What role did the xylem play?

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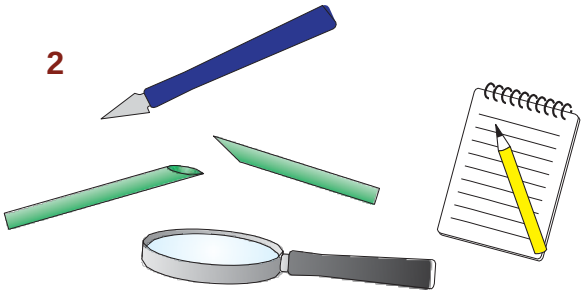

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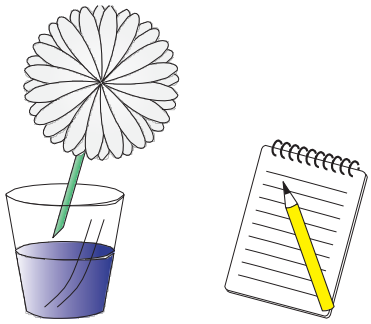

Follow-Up Activity

Split the stem of a white or very light-colored flower in half, starting beneath the flower and slicing downward. Place half of the stem in a cup containing blue food coloring and the other half of the stem in a cup containing red food coloring. Check out the flower after 30 minutes. What is happening?