HOW PLANTS WORK EXHIBIT
POST-VISIT ACTIVITIES

Each of the Pre-Visit Activities and the Student Discovery Journal leave a door open for a Post-Visit wrap-up. This includes updating charts, concept maps, and stories. By revisiting their earlier ideas and theories, and revising or extending them on the basis of new discoveries from the field trip, students should develop a deeper understanding of concepts. Your students will be able to use these Pre-Visit and Post-Visit products to assess what they've learned.

In addition, this section features new activities that enable students to extend, share, and apply what they've uncovered about the green denizens of our planet.

The following chart provides an overview of the Pre-Visit Activities. Please click on an activity link to gain access to the lesson plan.

ACTIVITY	OVERVIEW	TIME FRAME	BIG IDEAS	NATIONAL STANDARDS
Pitching Plants	Students reflect on and reveal their enriched understanding of plants by creating advertisements to "pitch" their virtues.	2 class sessions	General Review: Be a Plant Ambassador!	NS.K-4.1 (SCIENCE AS INQUIRY) NS.5-8.1 (SCIENCE AS INQUIRY) NL-ENG.K-12.4 (COMMUNICATION SKILLS) NL-ENG.K-12.5 (COMMUNICATION STRATEGIES) NL-ENG.K-12.6 (APPLYING KNOWLEDGE)
Rewards of a Green Scene	Students draw favorite places and reflect on what plants and green spaces mean to them, classmates, and communities.	1 class session	General Review: Be a Plant Ambassador!	NS.K-4.1 (SCIENCE AS INQUIRY) NS.5-8.1 (SCIENCE AS INQUIRY) NS.K-4.3 (LIFE SCIENCE) NS.5-8.3 (LIFE SCIENCE) NA-VA.K-4.1 (UNDERSTANDING & APPLYING MEDIA, TECHNIQUES, & PROCESSES) NA-VA.5-8.1 (UNDERSTANDING & APPLYING MEDIA, TECHNIQUES, & PROCESSES) NM-PROB.REP.PK-12.3 (MATH REPRESENTATION) NSS-G.K-12.2 (PLACES & REGIONS)
Plant Parts Feast	Students try to figure out which foods represent different plant parts. As they later examine, taste, and describe a variety of foods, they try to explain the similarities and differences within and between categories.	1-2 class session(s)	A Puzzle of Plant Parts	NS.K-4.1 (SCIENCE AS INQUIRY) NS.5-8.1 (SCIENCE AS INQUIRY) NS.K-4.3 (LIFE SCIENCE) NS.5-8.3 (LIFE SCIENCE)
Invent a Plant	Students draw on their exposure to a variety of plant adaptations to "invent" unique plants capable of surviving in specific environments or circumstances.	2 class sessions	A Puzzle of Plant Parts, Surviving Against the Odds	NS.K-4.1 (SCIENCE AS INQUIRY) NS.5-8.1 (SCIENCE AS INQUIRY) NS.K-4.3 (LIFE SCIENCE) NS.5-8.3 (LIFE SCIENCE) NA-VA.K-4.1 (UNDERSTANDING & APPLYING MEDIA, TECHNIQUES, & PROCESSES) NA-VA.5-8.1 (UNDERSTANDING &

				APPLYING MEDIA, TECHNIQUES, & PROCESSES) NA-VA.K-4.6 (MAKING CONNECTIONS BETWEEN VISUAL ARTS & OTHER DISCIPLINES)
Tread on Me! Grasses Measure Up	Students set up investigations that reveal how humble grasses are designed to withstand a host of insults.	1 class session; 2+ weeks occasional observation	Surviving Against the Odds, Green Machine, A Puzzle of Plant Parts	NS.K-4.1 (SCIENCE AS INQUIRY) NS.5-8.1 (SCIENCE AS INQUIRY) NS.K-4.3 (LIFE SCIENCE) NS.5-8.3 (LIFE SCIENCE) NM-MEA.3-5.2 (APPLY APPROPRIATE TECHNIQUES, TOOLS, & FORMULAS TO DETERMINE MEASUREMENTS) NM-DATA.3-5.1 (FORMULATE QUESTIONS THAT CAN BE ADDRESSED WITH DATA & COLLECT, ORGANIZE, & DISPLAY RELEVANT DATA TO ANSWER) NM-DATA.3-5.3 (DEVELOP & EVALUATE INFERENCES & PREDICTIONS THAT ARE BASED ON DATA)
Catch Them in the Act! How Neighborhood Plants Get By	Students walk through their schoolyard or neighborhood seeking evidence of how plants survive in different environments.	1 or more outdoor sessions; 2 class sessions	Surviving Against the Odds, A Puzzle of Plant Parts	NS.K-4.1 (SCIENCE AS INQUIRY) NS.5-8.1 (SCIENCE AS INQUIRY) NS.K-4.3 (LIFE SCIENCE) NS.5-8.3 (LIFE SCIENCE) NA-VA.K-4.1 (UNDERSTANDING & APPLYING MEDIA, TECHNIQUES, & PROCESSES) NA-VA.5-8.1 (UNDERSTANDING & APPLYING MEDIA, TECHNIQUES, & PROCESSES) NSS-G.K-12.2 (PLACES & REGIONS)
Pursuing Pollination Partners	By observing flowers and their pollination partners outdoors, students begin to explore this relationship and the adaptations that make it work.	2 class sessions; 1 or more outdoor sessions	A Puzzle of Plant Parts, Plant Multiplication, Surviving Against the Odds	NS.K-4.1 (SCIENCE AS INQUIRY) NS.5-8.1 (SCIENCE AS INQUIRY) NS.K-4.3 (LIFE SCIENCE) NS.5-8.3 (LIFE SCIENCE) NA-VA.K-4.1 (UNDERSTANDING & APPLYING MEDIA, TECHNIQUES, & PROCESSES) NA-VA.5-8.1 (UNDERSTANDING & APPLYING MEDIA, TECHNIQUES, & PROCESSES) NSS-G.K-12.2 (PLACES & REGIONS)
Growing Tips	Students explore bare twigs in the classroom and try to figure out their ages and how they grow.	1-2 class session(s)	Green Machine, A Puzzle of Plant Parts	NS.K-4.1 (SCIENCE AS INQUIRY) NS.5-8.1 (SCIENCE AS INQUIRY) NS.K-4.3 (LIFE SCIENCE) NS.5-8.3 (LIFE SCIENCE) NA-VA.K-4.1 (UNDERSTANDING & APPLYING MEDIA, TECHNIQUES, & PROCESSES) NA-VA.5-8.1 (UNDERSTANDING & APPLYING MEDIA, TECHNIQUES,

				& PROCESSES) NL-ENG.K-12.5 (COMMUNICATION STRATEGIES)
Flowers Up Close	Students explore flowers from the outside in, and connect what they see to what they have already learned.	1-2 class session(s)	Plant Multiplication, A Puzzle of Plant Parts	NS.K-4.1 (SCIENCE AS INQUIRY) NS.5-8.1 (SCIENCE AS INQUIRY) NS.K-4.3 (LIFE SCIENCE) NS.5-8.3 (LIFE SCIENCE) NA-VA.K-4.1 (UNDERSTANDING & APPLYING MEDIA, TECHNIQUES, & PROCESSES) NA-VA.5-8.1 (UNDERSTANDING & APPLYING MEDIA, TECHNIQUES, & PROCESSES)
Fruit for Thought I: Getting to the Core	Students observe apples, predict what they'll find inside them, and try to explain how they came to be.	1-2 class sessions	Plant Multiplication, A Puzzle of Plant Parts	NS.K-4.1 (SCIENCE AS INQUIRY) NS.5-8.1 (SCIENCE AS INQUIRY) NS.K-4.3 (LIFE SCIENCE) NS.5-8.3 (LIFE SCIENCE) NA-VA.K-4.1 (UNDERSTANDING & APPLYING MEDIA, TECHNIQUES, & PROCESSES) NA-VA.5-8.1 (UNDERSTANDING & APPLYING MEDIA, TECHNIQUES, & PROCESSES)
Fruit for Thought II: Flower to Fruit	Students ponder what life cycle stage follows flowers and then observe the progression over time from flower to fruit.	Long-term indoor or outdoor observation	Plant Multiplication, A Puzzle of Plant Parts	NS.K-4.1 (SCIENCE AS INQUIRY) NS.5-8.1 (SCIENCE AS INQUIRY) NS.K-4.3 (LIFE SCIENCE) NS.5-8.3 (LIFE SCIENCE) NA-VA.K-4.1 (UNDERSTANDING & APPLYING MEDIA, TECHNIQUES, & PROCESSES) NA-VA.5-8.1 (UNDERSTANDING & APPLYING MEDIA, TECHNIQUES, & PROCESSES)
Plant Elders: Seedless But Savvy	Students collect, observe, and compare seedless plants in different stages of their reproductive cycles.	2 class or outdoor sessions	Plant Multiplication	NS.K-4.1 (SCIENCE AS INQUIRY) NS.5-8.1 (SCIENCE AS INQUIRY) NS.K-4.3 (LIFE SCIENCE) NS.5-8.3 (LIFE SCIENCE) NA-VA.K-4.1 (UNDERSTANDING & APPLYING MEDIA, TECHNIQUES, & PROCESSES) NA-VA.5-8.1 (UNDERSTANDING & APPLYING MEDIA, TECHNIQUES, & PROCESSES) NSS-G.K-12.2 (PLACES & REGIONS)
Crossword Puzzle	Challenge your students to "show what they know" by completing this puzzle about how plants work!	1+ class session(s)	All	

PITCHING PLANTS

This activity corresponds to the following Big Idea section(s):
General Review: Be a Plant Ambassador!

Overview
Students reflect on and reveal their enriched understanding of plants by creating advertisements to "pitch" their virtues.

Review the activity and decide whether you want students to create magazine ads, as detailed below, or to have the option of creating radio or television ads.

Time Allotted
2 class sessions

Student Objectives

After completing this lesson, the student will be able to:

1. Identify elements of successful advertising.
2. Create an advertisement to promote plants.
3. Present a promotional product to the rest of the class.
4. Critique and discuss classmates' advertisements.

Materials

Large sheets of construction paper or newsprint

Markers and other writing or art materials

Optional: old seed or plant catalogs, advertising-rich magazines or public service announcements, videotaped television ads

What to Do

1. Divide students into small groups and read the following or create and print a copy of it for students:

Dear __-Grade Plant Promoters:

The U.S. Botanic Garden has heard that you've learned a lot about the green partners that share our planet. We'd like to commission you to use your newfound wisdom to help "pitch" plants to the public. Here's why: We're concerned that people don't fully appreciate these amazing organisms that we depend on for our survival. After all, plants don't bark, swim, or snuggle. Because they don't seem to do much of interest, many people simply take them for granted.

Your assignment is to work with your group to create poster-size ads, using both words and pictures that "sell" the idea that plants are awesome. You can use writing and drawing materials, photos cut out from catalogs or magazines, or even pressed or whole plant parts to bring your ad to life.

2. Give student groups at least 30 minutes to plan their ad campaigns and another 30+ minutes on the following day to execute them. Tell them you'll be looking for evidence of things they learned at the How Plants Work exhibit. Prompt their thinking with the following types of questions: *What messages about*

plants do you think are important to share with the world? What characteristics make plants unique and impressive? How do they enrich our lives? Where would we and other animals be without them?

3. On the second day, invite each group to showcase its completed ad for the rest of the class. Ask the "viewers" to give feedback to the ad creators: *How powerful was the "pitch?" Which words or images were most effective? What new information did you learn? What questions do you have for the creators?*

Making Connections

4. Ask students to consider which other audiences might be interested in their persuasive messages. These might include younger students, parents, a librarian, community members, or a nursery owner. Give them a chance to brainstorm how and with whom they'd like to share their ad posters and what steps they'd need to take to bring their ideas to life.

Digging Deeper

- ❖ To get students thinking about creating effective messages, bring in a variety of ad-rich magazines or public service announcements. Ask students to identify some of the visual and verbal "tricks" used to grab readers' attention and sell an idea or product (e.g., choosing inviting colors, appealing to people's needs or fears, using celebrity endorsements, associating the "product" with desirable images or outcomes). How might they use these 'tricks' of the trade to enhance or alter their plant promotions?

National Science Education Standards

- NS.K-4.1 – SCIENCE AS INQUIRY:

  As a result of activities in grades K-4, all students should develop an understanding about scientific inquiry.
- NS.5-8.1 – SCIENCE AS INQUIRY:

  As a result of activities in grades 5-8, all students should develop an understanding about scientific inquiry.

Standards for the English Language Arts

- NL-ENG.K-12.4 – COMMUNICATION SKILLS

  Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.
- NL-ENG.K-12.5 – COMMUNICATION STRATEGIES

  Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences for a variety of purposes.
- NL-ENG.K-12.6 – APPLYING KNOWLEDGE

  Students apply knowledge of language structure, language conventions (e.g. spelling and punctuation), media techniques, figurative language, and genre to create, critique, and discuss print and non-print texts.

REWARDS OF A GREEN SCENE

This activity corresponds to the following Big Idea section(s):

General Review: Be a Plant Ambassador!

Overview:

Students draw favorite places and reflect on what plants and green spaces mean to them, classmates, and communities.

Time Allotted

1 class session

Student Objectives

After completing this lesson, the student will be able to:

1. Draw a favorite outdoor location.
2. Explain his or her choice of location and the elements depicted in the drawing.
3. Analyze the role of plants in his or her favorite outdoor location.

Materials

Drawing paper

Colored pencils or crayons

Copies of the Green Relief sheet (1 for you to read it or several if you'd like the student to read it)

What to Do

1. Ask students to think of an outside place where they like to be. (These can be current favorites or places they recall from the past.) Give students time to draw their spots in detail using colored pencils or crayons.

2. Drawings in hand, have students pair up and take turns showing their creations and describing the places they represent. You might use these prompts: *What do the places look like? When would you go there? What's special about them? How do (or did) they make you feel?*

Making Connections

3. As a class, discuss the types of places that came up and students' reasons for choosing them. Ask, *how many have green in their pictures — that is, trees, gardens, or other plants?* Ask students who included them to explain why they did.

4. Next, read aloud or hand out copies of Green Relief and have students read the research findings. Ask, *what do you think of the conclusions? Did any of this surprise you? Explain why. Have you noticed anything similar in your own community? What questions do you have about how green scenes affect people? How could we find out?*

Digging Deeper

- Use to post-drawing class discussion as a prompt to create poetry and/or prose about the student's favorite outdoor spot.
- Students might interview family members or other people in the community concerning how they feel

about green environments. For instance, they might ask, *do you think it's important to have plants around? Why or why not?* Once they've conducted surveys, they should graph or otherwise summarize and present their data. Ask, *did anything surprise you? What patterns did you notice? What do your surveys tell you about people/plant connections? What new questions do you have?*

National Science Education Standards

- NS.K-4.1 – SCIENCE AS INQUIRY:

  As a result of activities in grades K-4, all students should develop an understanding about scientific inquiry.
- NS.5-8.1 – SCIENCE AS INQUIRY:

  As a result of activities in grades 5-8, all students should develop an understanding about scientific inquiry.
- NS.K-4.3 – LIFE SCIENCE:

  As a result of activities in grades K-4, all students should develop an understanding of characteristics of organisms.

  As a result of activities in grades K-4, all students should develop an understanding of the life cycles of organisms.
- NS.5-8.3 – LIFE SCIENCE:

  As a result of activities in grades 5-8, all students should develop an understanding of structure and function in living systems.

  As a result of activities in grades 5-8, all students should develop an understanding of reproduction and heredity.

National Standards for Arts Education

- NA-VA.K-4.1 – UNDERSTANDING & APPLYING MEDIA, TECHNIQUES & PROCESSES

  Students use different media, techniques, and processes to communicate ideas, experiences, and stories.
- NA-VA.5-8.1 – UNDERSTANDING & APPLYING MEDIA, TECHNIQUES & PROCESSES

  Students intentionally take advantage of the qualities and characteristics of art media, techniques, and processes to enhance communication of their experiences and ideas.

Principles and Standards for School Mathematics

- NM-PROB.REP.PK-12.3 – MATH REPRESENTATION (Digging Deeper Activity)

  Instructional programs from prekindergarten through grade 12 should enable all students to use representations to model and interpret physical, social, and mathematical phenomena.

The National Geography Standards

- NSS-G.K-12.2 – PLACES & REGIONS

  Understand the physical and human characteristics of places.

GREEN RELIEF

Do plants create peace, hope, and all-around good feelings? Here are some study findings to ponder:

- **Short or long encounters with nature help city dwellers re-focus their attention and relieve stress.**

- **Office workers with windows that overlooked a natural scene reported more satisfaction with their job and better health than office workers without windows that overlooked a natural scene.**

- **People who live in apartments in urban environments are less likely to resort to anger and violence when dealing with conflict if their buildings are surrounded by trees and other greenery.**

- **People who looked at city scenery with trees seemed happier and friendlier (and less sad and fearful) than when they saw a city scene with no trees.**

Another topic for discussion:

- **Do you think as people spend more time inside there will be consequences felt outdoors? Why?**

Study information taken from http://www.cfr.washington.edu/research.envmind/UF/PsychBens-FS1.pdf on 3/10/08.

PLANT PARTS FEAST

This activity corresponds to the following Big Idea section(s):

A Puzzle of Plant Parts

Overview

Students try to figure out which foods represent different plant parts. As they later examine, taste, and describe a variety of foods, they try to explain the similarities and differences within and between categories.

Time Allotted

1-2 class session(s)

Student Objectives

After completing this lesson, the student will be able to:

1. Analyze foods to determine their plant part origin.
2. Conduct a taste test to better identify a food's plant part origin.
3. Separate food items into plant part categories and defend choices to classmates.
4. Compare and contrast different plant part categories based on observations.
5. Summarize observations of plant part categories.

Sugar comes from the stem of the sugarcane plant.

Materials

A collection of plant foods that represent different parts. Here are some examples:

Roots – carrot, beet, radish, sweet potato, turnip, parsnip, rutabaga

Stems – asparagus, sugarcane, bamboo shoot, broccoli stalk, potato *(modified stems called tubers)*

Flowers – cauliflower, broccoli floret, artichoke (all are immature buds); nasturtium, cloves (spice from ground flower buds); squash flower

Leaves – lettuce, cabbage, spinach, tea, basil and other green herbs

Fruit – apple, pear, peach, banana, tomato, eggplant, raisin (dried grape), okra, squash, cucumber

Seeds – bean, corn, wheat, rice, coffee, chocolate, almond, whole nutmeg, peanut, cola nut (for cola drinks), corn or safflower oil, spices such as caraway and dill seed. (See number 2 below.)

A knife or other utensil to cut the plant parts

Paper plates

Any other food preparation tools you find necessary for the activity *[You may want to prepare some at home (e.g., cook beans) or bring in accoutrements (dip) or prepared seed-based items (bread).]*

Menu of Plant Parts page (on computer or printed copies)

Parts of Plants We Eat web page

http://www.jmu.edu/biology/k12/garden/parts.htm

What to Do

1. Bring up the Menu of Plant Parts page (and perhaps the Parts of Plants We Eat Web page) on one or more computer screens, project it onto a screen, or print copies for student groups. Plan a grocery store trip if you want students to help pick out plant foods.

2. Your students should already have had a chance to explore plant parts and consider their functions at the *How Plants Work* Exhibit at the United States Botanic Garden. Have them recall their trip and what they learned about the Puzzle of Plant Parts. Relate the discussion to different ways humans consume plant parts. Ask, *have you ever tried eating leaves? Describe your experiences. What other plant parts have you eaten? How did they taste?* Have students discuss specific examples and list them on a chart. If students are unsure of some items, tell them they will examine some up close (and perhaps taste them) too!

3. Label a different desk or other location with the name of each major plant part. Next, challenge the class to sort the items they gathered by the plant part they think each represents. As they send each item to its appropriate area, encourage discussion. In each case, ask, *what's the reason behind your choice?*

Students can compare their choices with photos on the students' Menu of Plant Parts page or on the Parts of Plants We Eat Web page. Ask, *did anything surprise you?* If they are still unsure of some of the items, have them brainstorm how they could find answers.

4. Invite students to set up a taste test of the different divided plant parts. [You can gather the fare yourself, have students bring in some favorite plant foods, or take a class field trip to a grocery store. (Make sure to add in some of the more unusual items from the materials list.)]

5. Assign small student groups to each of the plant part categories. With help from an adult, have them cut or otherwise prepare items for tasting. (If you have access to a hotplate, stove, or microwave, you may want to steam or otherwise cook certain items, such as potatoes.)

6. As groups sample the fare in each plant part group, have them discuss and describe the textures and flavors. Ask, *How are the tastes alike? How are they different?* Leave a sheet of paper at each station so students can write down some descriptive words and phrases.

Making Connections

7. Once students have tasted items at each station, the class should review the written descriptive phrases and respond to some questions.

- *Do some words or descriptions show up many times for a particular plant group? How would you summarize the flavors of fruits (or roots, leaves, and so on)? What exceptions exist?* (Students might note that, for example, an avocado isn't sweet.)
- Help students think about why some of the flavor differences exist. For instance, ask, *How are the flavors and textures of edible roots different from those of edible leaves? Why do you think that's so?* (Edible roots *tend* to be sweeter than leafy vegetables because they store extra sugars and starches. In contrast, many fruits taste sweet because they are designed to attract animals to eat them and, inadvertently, help disperse seeds.*)*
- *What questions do you have about edible plant parts? How could we try to answer them?*

Digging Deeper

❖ Challenge students to create a plant parts feast for another classroom. Once they decide on foods and recipes to feature, they can create a menu highlighting the plant parts in each food *or* create a game that inspires diners to try to figure it out themselves! They can also research the nutritional values of specific plant foods to include on the menu.

National Science Education Standards

- NS.K-4.1 – SCIENCE AS INQUIRY:

  As a result of activities in grades K-4, all students should develop an understanding about scientific inquiry.

- NS.5-8.1 – SCIENCE AS INQUIRY:

  As a result of activities in grades 5-8, all students should develop an understanding about scientific inquiry.

- NS.K-4.3 – LIFE SCIENCE:

  As a result of activities in grades K-4, all students should develop an understanding of characteristics of organisms.

  As a result of activities in grades K-4, all students should develop an understanding of lifecycles of organisms.

- NS.5-8.3 – LIFE SCIENCE:

  As a result of activities in grades K-4, all students should develop an understanding of structure and function in living systems.

MENU OF PLANT PARTS

Where would you put each of the edible plant parts you explored?

Flowers (Flower Buds)


Broccoli


Artichoke


Cauliflower

Stems


Asparagus


Rhubarb


Sugarcane

Fruits


Peppers


Green Beans


Tomatoes

Leaves


Sage


Lettuce


Cabbage

Seeds


Corn


Peas


Beans

Roots


Carrots


Parsnips


Radishes

INVENT A PLANT

This activity corresponds to the following Big Idea section(s):

A Puzzle of Plant Parts, Surviving Against the Odds

Overview

Students draw on their exposure to a variety of plant adaptations to “invent” unique plants capable of surviving in specific environments or circumstances.

Time Allotted

2 class sessions

Student Objectives

After completing this lesson, the student will be able to:

1. Use prior and/or newly acquired knowledge of plant structures and adaptations to invent a new plant.
2. Create a 2- or 3-dimensional model of a self-invented plant.
3. Share and defend self-invented plant design.

Materials

Decide in advance whether you want students to make 2- or 3-dimensional plant models

Suggested supplies for plant models:

Construction paper

Markers

Glue

Pipe cleaners

Scissors

Tape

Cotton balls

Craft sticks

Yarn and string (they make great roots)

Colored tissue paper or cellophane

Molding clay

Natural materials such as twigs or shells

Samples of Cabbage, Kale, Broccoli, and Brussel Sprouts (for Digging Deeper Activity)

What to Do

1. Pair up students and challenge them to use their newfound plant savvy to invent fictitious plants “designed” to survive in specific environments or circumstances. You can assign one or more of the ideas below, let pairs choose one to tackle, or come up with new choices.

Invent a plant that . . .

* could live inside a cave
* could survive in rock-hard soil
* is adapted to survive for many years (a perennial)
* has its seeds transported by birds
* could entice a flying pollinator
* could meet its needs in the arctic
* could survive next to a busy, polluted highway

Set some criteria for the models. For instance, each "plant" must include and label all the main parts, be made with art supplies and recycled classroom or natural materials, and be at least 6 inches (but not more than 4 feet) tall!

2. While students plan, you should circulate and, if necessary, ask questions to prompt their thinking. For example, *what can you assume about the environment (for example, what is the average temperature)? Which part(s) of the plant might be adapted to help the plant meet its needs?*

Making Connections

3. On the following day, once your young artists' creations are complete, set up a classroom gallery to showcase them. Ask each pair of designers to write their names next to their exhibits, but not to reveal their plants' special characteristics. Have gallery-goers (all students) rotate through the exhibits, paper in hand, and jot down observations, ideas about the adaptations, and questions about each plant.

4. Get back together and focus on each creation in turn. Ask students to share their thoughts and try to guess how each plant is uniquely suited to a particular situation or environment. Creators can then explain what they'd had in mind. Consider inviting other classes in to see your gallery!

5. If working with older students, ask, *In the natural world, how do you think a plant becomes adapted to a specific environment?* Students sometimes assume incorrectly that a plant can deliberately change so it's better suited to an environment. Explain that when a plant happens to have a slight edge over others (for instance, a jungle plant with bigger leaves), it has a better chance of surviving and passing on the characteristic to its offspring. Over time (hundreds or even millions of years), that characteristic is passed down through the generations. The great diversity of plants on the planet results from this process occurring constantly in every environment on earth.

Digging Deeper

- Discuss breeding plants for genetic variation. Show students cabbage, kale, broccoli, and brussel sprouts. Compare and contrast the different plants. Explain and discuss how each plant is a member of the same species, but bred by humans for different purposes. Theorize how that might be accomplished and how the human interaction with the plant's development altered the energy consumption of the plant.
- Inspire your students' creations and thinking about how plants work by viewing some of these fantastic web sites:

  Plants in Motion: time-lapse movies on this site. Try to view some of the clips in these categories: *flowers*, *plant growth* (especially root growth), and *nastic movements*.
  plantsinmotion.bio.indiana.edu/plantmotion/starthere.html

  Missouri Botanic Garden's Biomes of the World Web site (it's kid-friendly and packed with great information on how plants survive in all kinds of circumstances.)
  http://mbgnet.mobot.org/

- Read this book to students to inspire further creations and thoughts about plants: *Seeds, Stems, and Stamens: The Ways Plants Fit into Their World* by Susan E. Goodman

- ❖ If you have the time and/or resources, have students create their own time-lapse videos and/or flip-books using their invented plant designs.

National Science Education Standards

- NS.K-4.1 – SCIENCE AS INQUIRY:

  As a result of activities in grades K-4, all students should develop an understanding about scientific inquiry.

- NS.5-8.1 – SCIENCE AS INQUIRY:

  As a result of activities in grades 5-8, all students should develop an understanding about scientific inquiry.

- NS.K-4.3 – LIFE SCIENCE:

  As a result of activities in grades K-4, all students should develop an understanding of characteristics of organisms.

  As a result of activities in grades K-4, all students should develop an understanding of lifecycles of organisms.

  As a result of activities in grades K-4, all students should develop an understanding of organisms and environments.

- NS.5-8.3 – LIFE SCIENCE:

  As a result of activities in grades K-4, all students should develop an understanding of structure and function in living systems.

  As a result of activities in grades K-4, all students should develop an understanding of diversity and adaptations of organisms.

National Standards for the Arts

- NA-VA.K-4.1 – UNDERSTANDING & APPLYING MEDIA, TECHNIQUES, & PROCESSES

  Students use different media, techniques, and processes to communicate ideas, experiences, and stories.

- NA-VA.5-8.1 – UNDERSTANDING & APPLYING MEDIA, TECHNIQUES, & PROCESSES

  Students intentionally take advantage of the qualities and characteristics of art media, techniques, and processes to enhance communication of their experiences and ideas.

- NA-VA.K-4.6 – MAKING CONNECTIONS BETWEEN VISUAL ARTS & OTHER DISCIPLINES

  Students identify connections between the visual arts and other disciplines in the curriculum.

TREAD ON ME! GRASSES MEASURE UP

This activity corresponds to the following Big Idea section(s):

Surviving Against the Odds, Green Machine, A Puzzle of Plant Parts

Overview

Students set up investigations that reveal how humble grasses are designed to withstand a host of insults.

Time Allotted

1 class session; 2+ weeks occasional observations

Student Objectives

After completing this lesson, the student will be able to:

1. Investigate how grasses are designed to withstand various conditions.
2. Predict investigation outcomes.
3. Create a chart (Option 1) or graph (Option 2) to record investigation outcomes.
4. Utilize measurement tools to track grass growth. (Option 2)
5. Analyze and compare investigation results with predictions.

Materials

Grass seed

Bean seeds (optional)

Light potting mix

3-inch containers

Scissors

Chart Paper

Measuring Tool (ruler or measuring tape)

Graph Paper (Option 2)

What to Do

For Your Information: Grasses are tough. What other plants could endure mowing, baseball games, grazing zebras and cows, even burning, with such resiliency? Here's why they can: The long, slender grass leaves are attached around the green stems at round, hollow joints called nodes. (You can feel these if you run your fingers down a tall grass plant.) While most other plants grow from the topmost point, grass stems grow from the lower nodes. So, when they're cut or trampled, they don't lose their ability to grow. Their roots are dense and extensive, containing lots of fine rootlets that spread throughout the soil, holding on to particles and searching for water. It's been estimated, in fact, that the roots of one grass plant of a certain species, if laid end to end, could extend 387 miles!

1. Ask your students, *if you were a grass plant, what survival challenges would you face*? If they struggle

to think of hazards, ask, *how do you think grass plants manage to keep growing after we mow, picnic, or play soccer on them, or after cows graze on them? How do you think other plants — beans or tomatoes, for instance — would respond to the same treatment?* To start students thinking about the grass experiment, ask, *how might we set up an investigation to explore how grass responds to trampling, mowing, or grazing? What would we observe or measure?* Allow students to test their questions, or use one of the options described below.

Option 1

2. Plant grass seed in a container of moist potting mix. When the grass is about 2 inches high, cut it off evenly at about 1/2 inch above the soil (simulating mowing or grazing). Pull out one of the cut-off grass plants and attach it to a chart for later comparison. Ask students to predict what will happen in a week to the plants in the container. If they suggest that they'll grow, ask, *from what part of the plant do you think the growth will take place? Explain your prediction.*

3. A week later, pull out another "mown" plant and compare it with the previous uprooted one. Ask, *where do you think the growth took place? What's your evidence?*

Option 2

3. Plant grass seed in a container of moist potting mix. When grass measured at 2 inches above the soil, trim ½ of the grass so that it measures ½ inch above the soil (see above photo). Ask students to predict what will happen to the plants in the container after a week's time. To prompt discussion of growth options, ask, *will the grass grow? Why or why not? Will the 2" grass and the ½" grass grow at the same rate? Why or why not? What will affect the growth of the grass?* Create a graph to chart the progress of the grass experiment.

4. After 1 week, have students measure the grass in the container and chart their results on their graph. Ask, *what has happened? Did the grass grow? From what part of the plant did the grass grow? How do you know? Did the two sections of grass grow equally or at different rates?* Repeat the process from the week prior, cutting half of the formerly ½" section to measure ½ inch above the soil. Now students will be tracking three segments of grass: the grass originally measured at 2", the grass originally measured at ½" and the grass currently measured at ½". Have students repeat their predictions from the previous week.

5. One week later, have take another set of measurements. Ask, *what has happened? Are the segments growing at equal rates?* See if students can theorize a growth pattern for the grass plant.

Making Connections

6. Prompt students with the following question: *How do you think the way grass grows helps it survive in different circumstances?* Ask, *based on your experiment, what do you think affects grass growth and development?*

Digging Deeper

- ❖ Pose the question, *which is tougher: beans or grass?* Consider doing a similar investigation; this time raise grass in one container and a bean plant in the other. (You may have to start it a week earlier than the grass seed.) If you cut off half the grass, cut off half the bean plant. Ask students to predict how each plant will look in a week. After the students have observed and measured both plant types, ask, *do you think grasses or beans are better adapted for mowing and grazing? What have you observed here and in the natural world that supports your answer?*
- ❖ Have students predict and then set up an experiment to determine whether the height of mowing or grazing will affect the growth rate of grass. They might, for instance, plant six containers. In two, they'd cut three-quarters of the grass height each time they clip it; in another two, they'd cut half the grass on each clipping; in the remaining two, they'd cut one-quarter of the grass each time. Also have them pull out a plant from each treatment and examine its roots.

  Students should continue to observe changes and graph growth rates over time. How can they explain their findings? (When grass tops are chewed or mowed, they quickly re-grow from below, but there is a limit to this. When grass blades are cut very low, little leaf and stem area is left to capture sunlight and make food, the roots are too small to take in enough water and nutrients, and the plant uses up its stored energy.)

National Science Education Standards

- NS.K-4.1 – SCIENCE AS INQUIRY:

  As a result of activities in grades K-4, all students should develop an understanding about scientific inquiry.
- NS.5-8.1 – SCIENCE AS INQUIRY:

  As a result of activities in grades 5-8, all students should develop an understanding about scientific inquiry.
- NS.K-4.3 – LIFE SCIENCE:

  As a result of activities in grades K-4, all students should develop an understanding of characteristics of organisms.

  As a result of activities in grades K-4, all students should develop an understanding of lifecycles of organisms.

  As a result of activities in grades K-4, all students should develop an understanding of organisms and environments.
- NS.5-8.3 – LIFE SCIENCE:

  As a result of activities in grades K-4, all students should develop an understanding of structure and function in living systems.

  As a result of activities in grades K-4, all students should develop an understanding of regulation and behavior.

  As a result of activities in grades K-4, all students should develop an understanding of diversity and adaptations of organisms.

Principles and Standards for School Mathematics

- NM-MEA.3-5.2 – APPLY APPROPRIATE TECHNIQUES, TOOLS, & FORMULAS TO DETERMINE MEASUREMENTS

  In grades 3-5 all students should select and use benchmarks to estimate measurements.

- NM-DATA.3-5.1 – FORMULATE QUESTIONS THAT CAN BE ADDRESSED WITH DATA & COLLECT, ORGANIZE, & DISPLAY RELEVANT DATA TO ANSWER

  In grades 3-5 all students should collect data using observations, surveys, and experiments.

- NM-DATA.3-5.3 – DEVELOP & EVALUATE INFERENCES & PREDICTIONS BASED ON DATA

  In grades 3-5 all students should propose and justify conclusions and predictions that are based on data and design studies to further investigate the conclusions or predictions.

CATCH THEM IN THE ACT! HOW NEIGHBORHOOD PLANTS GET BY

This activity corresponds to the following Big Idea section(s):
Surviving Against the Odds, A Puzzle of Plant Parts

Overview
Students walk through their schoolyard or neighborhood seeking evidence of how plants survive in different environments.

Time Allotted
1+ outdoor session(s); 2 class sessions

Student Objectives

After completing this activity, the student will be able to:

1. Investigate an outdoor area for plant adaptations.
2. Identify survival adaptations of plants.
3. Discuss findings from outdoor area investigation.
4. Hypothesize reasons for particular plant adaptations (Option 2)

Materials

Writing utensils

Option 1:

Scavenger hunt sheet (teacher produced)

Pencil

Digital camera (optional)

Option 2:

Journals

Notebooks

Clipboards with paper (so students can record what they find)

What to Do

1. Find an area of the schoolyard or neighborhood (a park, botanic garden, weedy lot, or other location) where there is an abundance of plants.

2. Tell students that you hope the *How Plants Work* Exhibit at the United States Botanic Garden sparked some new discoveries about how plants meet their basic needs, protect themselves, and reproduce. Ask them to generate a list of ways in which plants survive. (This could include structures, ways of growing, and partnerships with other organisms.) They should draw on what they observed in the exhibit and in the classroom or natural world. You may need to ask questions to prompt their thinking: *How do certain plants manage to get the light they need? Disperse seeds? Compete for nutrients? Keep predators away? Survive cold winters or droughts?*

3. While this discussion is fresh in their minds, take the class on a walk in the plant-rich location you selected. Challenge your nature detectives to try to catch plants in the act of meeting their needs and otherwise getting by! Here are a couple of options for proceeding:

Option 1

Create a scavenger hunt sheet to focus students' attention during the walk (or simply call out directions). Have students sketch or take digital photos of the plants that match each description. Students can compare findings when they return to the classroom.

Here are some sample items:

Find a plant or plant characteristic that . . .

- *might discourage insects from eating it*
- *helps a seed travel*
- *helps a plant cope with cold (or hot) weather*
- *helps a plant stay upright*
- *helps the plant reach for sunlight*
- *helps the plant compete with other plants for water and nutrients*
- *looks like it could attract a tiny pollinator*
- *probably depends on wind to spread pollen*
- *could help a plant survive in shade*
- *could help a plant survive from year to year*



Seeds with hooked barbs can travel great distances on animals' fur. These burdock seeds hitched a ride on a dog's tail.

Option 2

Challenge students to find five (or more) different forms of plants. Have students observe plant adaptations they think help a plant to survive. Students can do this as a class or work in pairs. Direct students to sketch each example and describe the environment in which the plant is growing (e.g., *the shade of a tree by the road*). If students focus on a particular plant trait (e.g. a mass of thorns on a stem), they should note that in their drawings by using arrows and labels if appropriate.

Being as specific as possible, ask students to share or write an explanation of how they think each trait helps the plant survive (e.g. *Having wind dispersed seeds helps the plant find new places to grow*). Don't be concerned about "right" answers. It's more important that students' explanations are based on observations and what they know about plants. (Even botanists haven't figured out *all* the connections!)

Making Connections

3. On the following day back in class, have small groups of students discuss their findings and list new questions sparked by their exploration. These can fuel future research and investigations. They should add their findings, as well as new questions, to the original list of ideas about how plants survive.

Digging Deeper

- If you have time, and students can handle such a project, challenge each group to prepare and present a 2-minute mock TV news story to highlight its findings! You can suggest a headline for this breaking news item (for instance, *Plants Found to Be Masters of Survival!*) or let students create their own titles.
- If you're in an urban area, students may have questions about how city trees and other plants manage. Consider raising the issue by asking them what special challenges might exist for city plants (e.g., pollution, poor soil, low-light conditions). This could lead to observations of urban plants and discussions with city planners and landscapers. What can they learn about which plants are likely to survive in such conditions and why they do so? Here is some background reading for you: Tree Street City. http://www.thebrooklynrail.org/streets/april03/treestreet.html
- Check out these interesting sites to spark further inquiry and discussion:

  Virtual Jungle: On this interactive Web site from the BBC, students can tour all levels in a jungle for images and details on the amazing adaptations that jungle dwellers (plants and animals) have developed for survival.

  http://www.bbc.co.uk/nature/programmes/tv/jungle/vjungle.shtml

  Biomes of the World: Rainforests, deserts, grasslands, and other ecosystems in full color are featured on this Web site for kids from the Missouri Botanic Garden. Each biome has a section on plants and the adaptations that help them survive there. Have students use it to research plant adaptations before or after their neighborhood investigation.

  http://mbgnet.mobot.org/

  Plants in Motion: This site features stunning time-lapse movies of plants. This link will take you to the section on tropisms. Have students view the *sunflower* clip and try to explain how the response they see helps plants survive.

  http://plantsinmotion.bio.indiana.edu/plantmotion/movement/tropism/tropisms.html

National Science Education Standards

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  As a result of activities in grades K-4, all students should develop an understanding about scientific inquiry.
- NS.5-8.1 – SCIENCE AS INQUIRY:

  As a result of activities in grades 5-8, all students should develop an understanding about scientific inquiry.
- NS.K-4.3 – LIFE SCIENCE:

  As a result of activities in grades K-4, all students should develop an understanding of characteristics of organisms.

  As a result of activities in grades K-4, all students should develop an understanding the life cycles of organisms.

- NS.5-8.3 – LIFE SCIENCE:

  As a result of activities in grades 5-8, all students should develop an understanding of structure and function in living systems.

  As a result of activities in grades 5-8, all students should develop an understanding of reproduction and heredity.

National Standards for Arts Education

- NA-VA.K-4.1 – UNDERSTANDING & APPLYING MEDIA, TECHNIQUES & PROCESSES

  Students use different media, techniques, and processes to communicate ideas, experiences, and stories.

- NA-VA.5-8.1 – UNDERSTANDING & APPLYING MEDIA, TECHNIQUES & PROCESSES

  Students intentionally take advantage of the qualities and characteristics of art media, techniques, and processes to enhance communication of their experiences and ideas.

The National Geography Standards

- NSS-G.K-12.2 – PLACES & REGIONS

  Understand the physical and human characteristics of places.

PURSUING POLLINATION PARTNERS

This activity corresponds to the following Big Idea section(s):

A Puzzle of Plant Parts, Plant Multiplication, Surviving Against the Odds

Overview

By observing flowers and their pollination partners outdoors, students begin to explore this relationship and the adaptations that make it work.

Time Allotted

2 class sessions; 1+ outdoor session(s)

Student Objectives

After completing this lesson, the student will be able to:

1. Describe the relationship between flowers and pollination partners.
2. Observe flowers and pollination partners in their natural habitats.
3. Create a chart to track investigation findings and questions.
4. Theorize pollinator strategies based on observations and discussion.

Materials

Copies of Flowers and Their Visitors worksheet (several per pair of students)

Writing utensils

Chart paper (or dry erase board or transparency sheet)

What to Do

For Your Information: Every aspect of flowers is vital to their mission: to ensure that plants produce offspring. Animals can roam about and seek mates with whom to reproduce, but imagine the challenge for a plant, rooted firmly to the ground, to achieve the same end. Some plants rely on wind to transport male pollen grains to the flower's female part (pistil). Most flowering plants, however, have evolved remarkable adaptations to lure unsuspecting insects and other animal partners to make the transfer as they search for food.

A bee wiggles its way into a snapdragon flower.

Here's how they do it: Nutritious nectar lies deep within the blossom, which advertises the sweet stuff's presence with colors, designs, aromas, shapes, and other lures. A hungry insect or other visitor poking around gets dusted with pollen (you can often see this on the bristly legs of a bee). As the creature moves on to other flowers, it inadvertently drops pollen grains, some of which stick to the female stigma. The pollen will grow within the pistil into the egg-filled ovary. There, it fertilizes an egg, which eventually forms a seed. Learn more about this fascinating courtship in the article Flower Courtship: Alluring Advertisers.
http://www.kidsgardening.com/Dig/DigDetail.taf?ID=1115&Type=Art

1. Before launching this activity, you'll need to find a school, community, or backyard garden, weedy lot, wildflower meadow, botanic garden, or other location where flowers are blooming. Try to set aside at least

two 30-minute sessions to visit the area over the course of a week or two.

2. On the basis of students' visit to the United States Botanic Garden's *How Plants Work* Exhibit or their past experiences, your students likely have some theories about flowers and the animals that visit them. They may know that bees, other insects, and some other animals, like hummingbirds, interact with or pollinate flowers. But they may *not* understand that the animals, too, reap rewards, nor may they have considered the amazing flower characteristics that entice the right pollinators.

To find out what students know and prime them for outdoor observations, generate a class chart titled *Flowers and Their Visitors*. Use these headings: *Things We Know*, *How We Know* (for instance, students may respond by saying that they observed something, read about it, or learned about it from someone else), *Questions We Have*. Tell them they'll have a chance to be field scientists who explore these remarkable partnerships.

3. Hand out copies of the Flowers and Their Visitors worksheet. Have students work in pairs to observe flowers and their visitors in the location you selected. You can simplify their task by having each pair focus on just one flower or on a small group of blooms. (*Caution*: Be sure to check first for bee allergies. Assure students that unless bees feel threatened, they are much more interested in flowers than people. Nonetheless, youngsters should move slowly and keep their distance.)

4. Once students have spent at least a few minutes making observations, ask the following questions:

- *How are the flowers' visitors behaving*? (Students might note that they are flying, landing, hovering, or crawling inside.)
- *What do you think the flowers' visitors are doing?*
- *Is the visitor taking anything from the flower? If so, where do the visitors put what they have taken?*

5. Choose one or more of these focus questions for a second period of observation:

- *Are some flowers visited more often or visited only by certain creatures?* Have students record what they observe.
- *What kinds of paths do the visitors take as they move among flowers?* (Prompt students track the paths of one particular flower visitor. *Does the visitor go to the same flowers or different flowers? What are some differences in the flower visitor's choices? What are some similarities?*)
- *Do bees (or another type of pollinator) seem to prefer certain flower colors, shapes, or petal designs?* Have students develop a theory based on their observations.
- *Which characteristics of a flower do you think cause visitors to drop by?* Have students develop a theory based on their observations.

Making Connections

6. Back in class, use students' observations and discoveries to revise the earlier chart. Here are some new column options: *Things We Noticed, Theories We Have*. As students discuss their observations and related thoughts, they should also update the earlier columns.

7. As students discuss and review the chart, put a star by ideas and questions they can explore through firsthand observations or experiments. (For instance, *Do bees go to any color flower? Do some flower colors attract more visitors? Are visitors/pollinators more active at certain times of day?*) Put a B next to questions they can answer by reading information in books or articles. Put a checkmark next to those they can answer by interviewing a botanist or other scientist.

8. Introduce the idea of the plant-pollinator 'contract'. (For a more in-depth discussion, see the Digging Deeper Activity below.)

9. Allow students to work in small groups to explore some of their theories and questions.

Digging Deeper

- Compare reproductive strategies between flowering and non-flowering plants. Put students in the role of evolving non-flowering plants and consider the questions: *How can I disperse my pollen more efficiently with less waste? How can I get insects to take pollen only to other plants like me?* Discuss the contract that developed between plants and their pollinating partner insects when flowers were included in plant life cycles.
- Investigate the concepts of "nectar robbery" and "floral deception".

  The Nature of Nectar: An article all about nectar from the Brooklyn Botanic Garden.

  http://www.bbg.org/gar2/topics/essays/2005su_naturenectar.html

  Mimicry: The Orchid and the Bee: This web site details the 'pseudo-copulation strategy' of some orchids to attract pollinators.

  http://www.pbs.org/wgbh/evolution/library/01/1/l_011_02.html

  Ask, *how do each of these activities represent a break in the plant-pollinator contract?*
- Consider the question, *Why are there so many flowers?* Follow up with the Flowers Up Close Post-Visit Activity.
- Use these websites for further discussion and inquiry:

  The Other Pollinators: An article from a gardener with the National Gardening Association. The article records the author's observations of the pollinators in her garden after a local honeybee population was devastated by mites and gives photos and examples of other types of pollinators.

  http://www.garden.org/articles/articles.php?q=show&id=73

  Plants in Motion: This site features short time-lapse movies. The stunning clips in the *flowers* category show a variety of blooms unfurling and closing. Invite students to view them before or after completing this activity.
  http://plantsinmotion.bio.indiana.edu/plantmotion/movement/tropism/tropisms.html

  Alluring Pollinators: Inspire a schoolyard pollinator garden by sharing details of this online article with students.

  http://www.kidsgardening.com/Dig/DigDetail.taf?ID=1115&Type=Art

  Photographic Plant/Pollinator Database: Click on Latin name links on this Web site to view dozens of wonderful close-up photos of pollinators engaging with flowers. Select a batch to share with students.

  http://www.pollinator.com/plant_pol/databaseindex.htm

  Flower Courtship: An article written by a gardener with the National Gardening Association. The author describes different characteristics that make flowers appealing to pollinators and lists which characteristics specific pollinators enjoy.

  http://www.garden.org/articles/articles.php?q=show&id=1115&page=1

National Science Education Standards

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- NS.5-8.1 – SCIENCE AS INQUIRY:

  As a result of activities in grades 5-8, all students should develop an understanding about scientific

inquiry.

- NS.K-4.3 – LIFE SCIENCE:

  As a result of activities in grades K-4, all students should develop an understanding of characteristics of organisms.

  As a result of activities in grades K-4, all students should develop an understanding of the life cycles of organisms.

  As a result of activities in grades K-4, all students should develop an understanding of organisms and environments.

- NS.5-8.3 – LIFE SCIENCE:

  As a result of activities in grades 5-8, all students should develop an understanding of structure and function in living systems.

  As a result of activities in grades 5-8, all students should develop an understanding of reproduction and heredity.

  As a result of activities in grades 5-8, all students should develop an understanding of populations and ecosystems.

National Standards for Arts Education

- NA-VA.K-4.1 – UNDERSTANDING & APPLYING MEDIA, TECHNIQUES & PROCESSES

  Students use different media, techniques, and processes to communicate ideas, experiences, and stories.

- NA-VA.5-8.1 – UNDERSTANDING & APPLYING MEDIA, TECHNIQUES & PROCESSES

  Students intentionally take advantage of the qualities and characteristics of art media, techniques, and processes to enhance communication of their experiences and ideas.

The National Geography Standards

- NSS-G.K-12.2 – PLACES & REGIONS

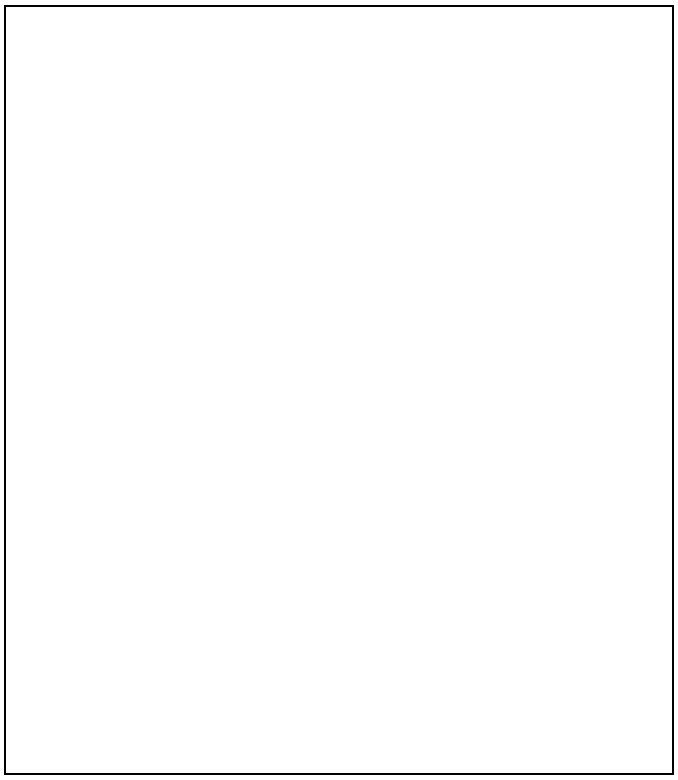
  Understand the physical and human characteristics of places.

FLOWERS AND THEIR VISITORS

Names _____

Draw your flower.

Describe it.



What do you notice about the flower's visitors? (You can draw some on the back of this page.)

What do you wonder about the flower and its visitors?

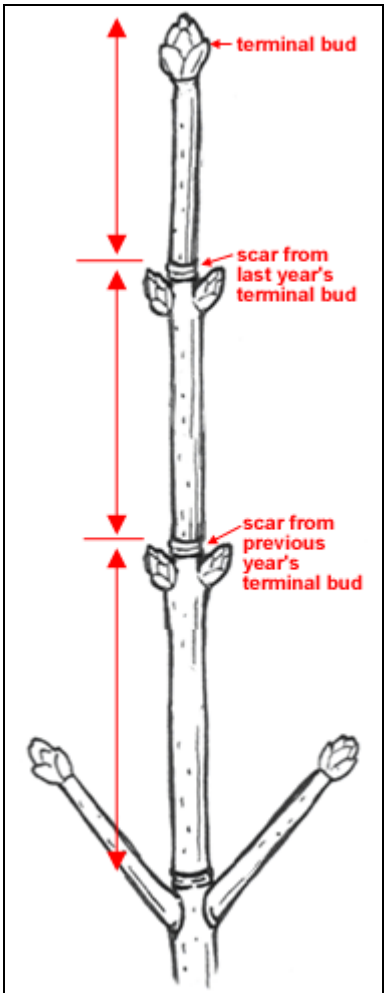
GROWING TIPS

This activity corresponds to the following Big Idea section(s):

Green Machine, A Puzzle of Plant Parts

Overview

Students explore bare twigs in the classroom and try to figure out their ages and how they grow.



Each red arrow represents one season's growth.

Time Allotted

1-2 class session(s)

Student Objectives

After completing this lesson, the student will be able to:

1. Compare and contrast tree branches.
2. Theorize strategies for tree branch growth.
3. List factors that affect tree branch growth.

Materials

1- or 2-foot sections of small branches or twigs from different types of deciduous (not evergreen) trees *(If appropriate, get permission from property owners or managers before cutting twigs)*.

Paper

Pencils

Chart Paper (1 sheet per group)

What to Do

For Your Information: The twig wood at the ends of branches on most trees offers clues about their growth rate. Trees and other woody plants add length every year at the tips of twigs and roots. (These are called apical meristems and the elongation is called primary growth.) They add width more slowly as new xylem and phloem cells, which transport water, minerals, and food, form between the wood and bark (cambium). In this activity, students will uncover evidence of primary growth.

1. Give each small group of students at least two branches to examine. Ask them to carefully observe and sketch each twig and then add labels pointing out things they noticed (e.g., lines, repeating patterns, color changes, buds). Encourage each group to discuss its findings, prompting them with these questions: *How are your twigs alike? How are they different? What do your observations tell you about the life and growth of tree branches? What questions do you have?*

2. Ask each group to report its observations and theories about twig growth to the class and document these on a chart. Your keen observers may have noticed that the tips of twigs have a bump (a *terminal bud*); relatively smooth bark is usually beneath that. (Each spring, buds become new leaves, flowers, or

stems. The scales that cover the terminal bud during the winter drop off each spring, leaving a scar where they attached.) Consider dissecting a bud or scraping the branch bark to reveal the green "living" layer inside.

Making Connections

3. If they haven't made these observations, have students look again at the tip of the twig. Direct them to move their eyes down the twig until they notice a change in the bark. They will likely see a few lines encircling the twig, followed by a change in color, texture, or both. Ask, *how would you explain that change?* (It marks the end of the last year's growth where the terminal bud once was. As they continue looking down the branch, if it's long enough, they'll find a similar pattern repeating itself. Ask, *what can we tell by counting the number of sections? Explain your answer.* (They reveal the age of the branch.)

Students may have noticed that these sections, each representing a year's growth, are different lengths. If not, have them measure and compare them. *Ask, what factors do you think might affect how much a twig grows in a year?* (Factors that can affect plant growth include the amount of water or sunlight it receives, temperature, or presence of disease.) *What new questions do you have about how twigs grow?* Some of these may lead to further investigations (see below).

Digging Deeper

- ❖ Give students a chance to set up investigations to explore their questions. Here's an example: *Do different branches on the same tree grow the same amount each year?* In this case, students might compare the past year's growth of a branch in the sun with that of one in the shade. They will likely find that the sun-bathed branch grows faster.
- ❖ Students can also set up this or other investigations outside using live branches. They might decide to tie yarn on two branches so they can track them over time and measure growth each month. Ask questions to get students thinking about the "fairness" of their study. For instance, *How can we be sure to measure the same way each time we visit?* (For instance, the class might decide to always measure from the top of the bud scale.)
- ❖ If the twigs students observed are thick enough, cut them into four sections, mix them up, and see if students can reassemble them on the basis of their previous observations.
- ❖ After becoming familiar with twig features, leaf shapes (from earlier investigations), and other plant characteristics, have your sleuths use a tree and shrub key to figure out which trees their twigs came from.
- ❖ Use this prompt for a creative writing exercise based on this activity and the Green Machine section of the *How Plants Work* Exhibit at the United States Botanic Garden: *If plants grew like humans and humans grew like plants . . .*

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- NS.5-8.1 – SCIENCE AS INQUIRY:

  As a result of activities in grades 5-8, all students should develop an understanding about scientific inquiry.
- NS.K-4.3 – LIFE SCIENCE:

As a result of activities in grades K-4, all students should develop an understanding of characteristics of organisms.

As a result of activities in grades K-4, all students should develop an understanding of the life cycles of organisms.

- NS.5-8.3 – LIFE SCIENCE:

  As a result of activities in grades 5-8, all students should develop an understanding of structure and function in living systems.

National Standards for Arts Education

- NA-VA.K-4.1 – UNDERSTANDING & APPLYING MEDIA, TECHNIQUES & PROCESSES

  Students use different media, techniques, and processes to communicate ideas, experiences, and stories.

- NA-VA.5-8.1 – UNDERSTANDING & APPLYING MEDIA, TECHNIQUES & PROCESSES

  Students intentionally take advantage of the qualities and characteristics of art media, techniques, and processes to enhance communication of their experiences and ideas.

Standards for the English Language Arts (Digging Deeper Activity)

- NL-ENG.K-12.5 – COMMUNICATION STRATEGIES

  Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences for a variety of purposes.

FLOWERS UP CLOSE

This activity corresponds to the following Big Idea section(s):

Plant Multiplication, A Puzzle of Plant Parts

Overview

Students explore flowers from the outside in, and connect what they see to what they have already learned. In doing so, they begin to grasp the idea that the job of flowers is to ensure seed production. *Note*: This is activity is intended for students with a more developed understanding of plant reproduction.

Time Allotted

1-2 class session(s)

Student Objectives

After completing this activity, the student will be able to:

1. Dissect and examine a flower.
2. Diagram and describe flower parts.
3. Compare and contrast flower structures and methods of reproduction.
4. Create a list of questions for further inquiry.

Materials

Assorted flowers - 1 for each pair of students, plus a few extras (e.g. lilies [*make sure these still have stamens*], amaryllis, tulips, daffodils, hibiscus, petunias – DO NOT USE DAISIES OR ANY RELATED COMPOSITE FLOWER – *check with florists and funeral homes for donations of unwanted flowers*)

Inside a Flower photo pages (displayed on computer screen or printed out for student use)

Hand magnifying lenses (1 per student)

Paper

Pencils

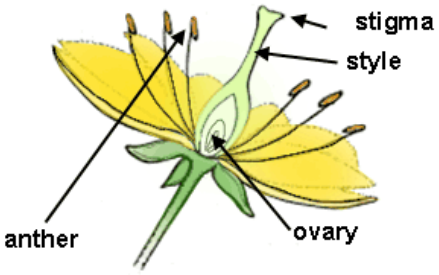
Chart paper (or dry erase board or transparency sheet)

Daffodil or Amaryllis buds (Digging Deeper activity)

Small paintbrushes (Digging Deeper activity)

What to Do

1. Preview the Inside a Flower photo pages and the information on the Web sites listed under Digging Deeper activity (below). Bring up the Inside a Flower pages on one or more computer screens, project them onto a screen, or print copies for each student pair.



Have students describe what they see rather than try to name flower parts.

2. Pair students up and give each pair a flower to examine with a hand lens. Prompt students to focus on each part of the flower (e.g. stamen, petal, etc.) Ask, *what do you notice about your flowers?* Have the partners sketch what they can see of the inside of the bloom and then draw arrows from their sketch to a description of each part. At this stage, it's important to encourage students to observe and describe plant parts (e.g., *6 long, skinny things with flat yellow tops*) rather than name them.

3. Next, have students gently pull away half the flower so they can get a better view of its parts. They can add to their drawing or make another one. When students reach the *stigma* (the female part at the top of the center of the flower), have them feel and describe it (it may be sticky). As they move down the tube (*style*) from there, they should see the rounded *ovary*. Help them cut the ovary open (cut some lengthwise and others crosswise). Ask, *what do you notice? What does it remind you of?* (The ovary contains *ovules*: eggs that can be fertilized to become seeds). As they look at the male *stamens*, which typically surround the female parts, students should be able to see the powdery *pollen* grains on the tops (*anthers*).

4. Give students time to rotate and observe one another's flowers and sketches. Ask, *did you find the same types of parts on all flowers? How were they similar? How were they different? Which parts were hardest to find or identify?*

5. Next, hand out copies of the Inside a Flower photo pages. Ask each pair to try matching parts on their flower with those on the images. Have students move around the room to view one another's flowers; they should discover that the same parts don't look the same on each flower.

Making Connections

6. Ask, *after observing flowers inside out, do you have any clues about what plant part(s) come after the flower is gone?* (Seeds and fruits) *What clues have you noticed in nature or gardens?*

7. Wrap up the activity by generating a chart with these headings: *Things We Know About Flowers* and *Questions We Have About Flowers*. Have students identify which questions could be answered through observations and investigations and which ones require other types of research.

Digging Deeper

- If students haven't yet explored pollination, or had the opportunity to observe the flower-fruit-seed life cycle stages, you can explain that pollen from the male parts of a flower has to be transferred to the top of the female parts so it can join with an egg and become a seed. Ask, *how do you think pollen moves from flower to flower? What have you ever observed to make you assume this? How do you think the different parts help in this process*? If students need more prompting, ask, *why are petals often brightly colored? Why is the top of the flower sticky? How do you think the arrangements of parts helps?*

- ❖ Pose the question, *why do you think there are so many varieties of flowers?* Discuss how different types of flowers attract different types of pollinators.
- ❖ Grow 2 daffodil or amaryllis bulbs in the classroom. Have students “be the bees” by using a small paintbrush to move pollen from the male anthers onto the sticky female stigma. As they observe over time, they should notice a swelling in the ovary (seeds) of the fertilized flower.
- ❖ You’ll find useful background on flower structures on this Great Plant Escape Web page. http://www.urbanext.uiuc.edu/gpe/
- ❖ The informative Why Do Plants Have Flowers? Web page is written for kids. http://www.sacsplash.org/mather/flowers.htm

National Science Education Standards

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- NS.5-8.1 – SCIENCE AS INQUIRY:

  As a result of activities in grades 5-8, all students should develop an understanding about scientific inquiry.
- NS.K-4.3 – LIFE SCIENCE:

  As a result of activities in grades K-4, all students should develop an understanding of characteristics of organisms.

  As a result of activities in grades K-4, all students should develop an understanding the life cycles of organisms.
- NS.5-8.3 – LIFE SCIENCE:

  As a result of activities in grades 5-8, all students should develop an understanding of structure and function in living systems.

  As a result of activities in grades 5-8, all students should develop an understanding of reproduction and heredity.

National Standards for Arts Education

- NA-VA.K-4.1 – UNDERSTANDING & APPLYING MEDIA, TECHNIQUES & PROCESSES

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  Students intentionally take advantage of the qualities and characteristics of art media, techniques, and processes to enhance communication of their experiences and ideas.

INSIDE A FLOWER

Flowers can look very different inside! Compare these with the flowers you examined.

Lily

Honeysuckle

Mallow

Tulip

Daylily


The male and female parts are hidden in a lupine flower.


Female begonia flower Male begonia flower

Some plants have separate male and female flowers.


A bumblebee wriggles its way into this monkshood flower.

FRUIT FOR THOUGHT I: GETTING TO THE CORE

This activity corresponds to the following Big Idea section(s):

Plant Multiplication, A Puzzle of Plant Parts

Overview

Students observe apples, predict what they'll find inside them, and try to explain how they came to be.

Time Allotted

1-2 class session(s)

Student Objectives

After completing this lesson, the student will be able to:

1. Explain how apples are formed.
2. Theorize what apples look like in flower form.
3. Predict how apples will appear when sliced.
4. Identify the different parts of an apple.

Materials

Magnifying lenses (1 per group)

What's Inside an Apple? Worksheet (1 per student)

Apple-blossom, Apple, & Apple2 Photos below (printed or displayed on computer screen)

Apples (1 per group) that have pronounced "flower ends" on the bottom *(The flower ends should have remnants of a small star-shaped calyx; it was once large enough to protect the flower bud. If you pull the sections back, you can find the remains of tiny stamens (male parts)*

Writing utensils

A knife (to cut the apples)



Notice the patterns in the apple flower and fruit photos. The flower has 5 petals, the calyx at the bottom of the fruit has 5 parts, and the core has 5 chambers.

What to Do

For Your Information: Once a flower is successfully pollinated, most of it drops off and the fertilized egg becomes a seed. The ovary wall surrounding the seed typically swells as the seeds develop inside it. This protective package with seeds inside becomes a fruit. The structure of the fruit that grows after a flower is pollinated is often very similar to the structure of the ovary from which it develops.

1. Distribute your collection of apples and invite small groups of students to become fruit sleuths. Their assignment: Think about how the apples came to be! Hand out magnifying lenses and copies of the What's Inside an Apple? Worksheet and have students carefully inspect and draw the fruits and complete the first two questions. (See the description of apple parts in the Materials section, above.)

2. Next cut or have students cut apples in half crosswise and direct the class to draw what they see and respond to the remaining questions. Students should see a star-shaped pattern with five seed chambers. They may also notice small dark dots between the chambers. These are evidence of the stamens. It's not important for students to identify all the parts. Instead, they should note the patterns they see (e.g., fruit parts and flower parts coming in multiples of five).

Making Connections

3. Discuss the following questions as a class:

- *Did the apples look the same inside as you predicted?*
- *What new or interesting things did you notice?*
- *What clues did you find about how the fruit developed?*
- *How many petals do you think an apple flower has*? *How do you think apples came to be?* (After students respond, have them look carefully at the printouts you made of the photos in this activity. They should be able to explain that fruits came from flowers.)
- *In the natural world, what do you think happens next to fruits?* (Get students thinking about what happens to dropped apples, what might eat them, and what happens to the seeds. This can launch a discussion about the role of fruits in protecting seeds and, in many cases, helping seeds disperse.)
- *What questions do you have about apples or fruits in general? How can we uncover answers?*

Digging Deeper

- For background on different types (forms) of fruits, take a look at this Fruit Classification Web page. It contains advanced vocabulary, but provides nice visuals and examples of different types of fruit. http://theseedsite.co.uk/fruits.html
- Complete activity Fruit for Thought II: Flower into Fruit

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  As a result of activities in grades K-4, all students should develop an understanding the life cycles of organisms.
- NS.5-8.3 – LIFE SCIENCE:

  As a result of activities in grades 5-8, all students should develop an understanding of structure and function in living systems.

  As a result of activities in grades 5-8, all students should develop an understanding of reproduction and heredity.

National Standards for Arts Education

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  Students use different media, techniques, and processes to communicate ideas, experiences, and stories.
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  Students intentionally take advantage of the qualities and characteristics of art media, techniques, and processes to enhance communication of their experiences and ideas.

WHAT'S INSIDE AN APPLE?

Name _____

Draw an apple.

What do you see? I noticed…

_____

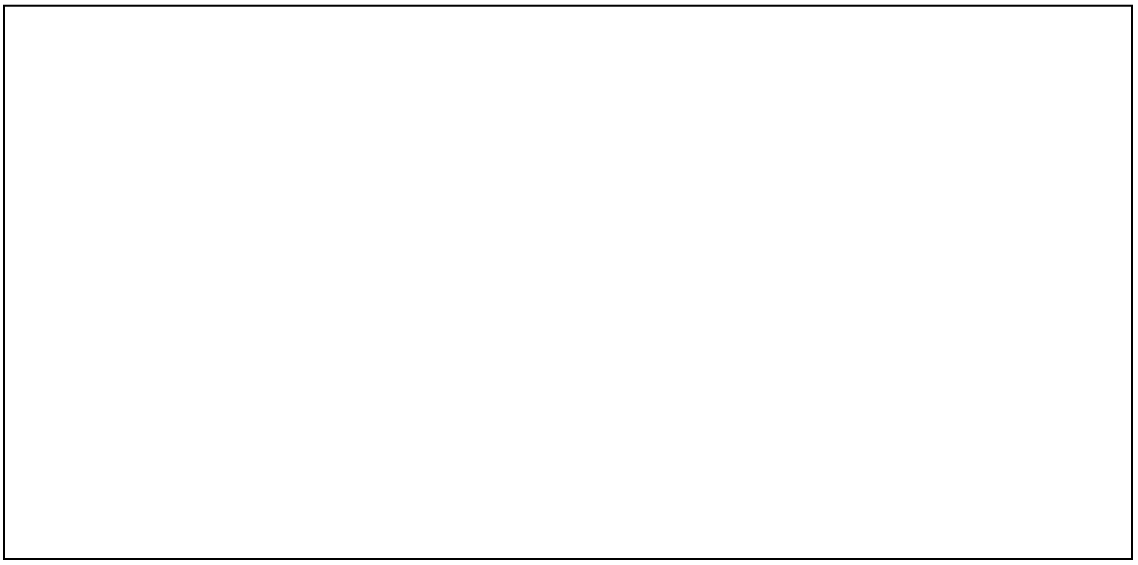
_____

_____

_____

Draw and predict how the inside of an apple would appear if we cut it in half crosswise, right through the core. Label what you predict you'd find inside.

Look at an apple that has already been cut in half. Draw what you see inside the apple.



How close was your prediction?

How do you think the fruit came to be? (Notice as many clues as you can and look at any photos provided by your teacher.) What questions do you have?

FRUIT FOR THOUGHT II: FLOWER TO FRUIT

This activity corresponds to the following Big Idea section(s):

Plant Multiplication, A Puzzle of Plant Parts

Overview

Students ponder what life cycle stage follows flowers and then observe the progression over time from flower to fruit.

Time Allotted

Long term indoor or outdoor observations

Student Objectives

After completing this lesson, the student will be able to:

1. Observe and record plant pollination and growth as a flower becomes a fruit.
2. Predict changes in a plant's life cycle.
3. Create a poster of observation findings.
4. Present observation findings to classmates.

Materials

Magnifying lenses (1 per student)

Poster-making materials

Copies of the Observing Plant Cycles worksheet (1 per student)

Pencils

Yarn (optional)

Digital camera (optional)

What to Do

For Your Information: Once a flower is successfully pollinated, most of it drops off and the fertilized egg becomes a seed. The ovary wall surrounding the seed typically swells as the seeds develop inside it. This protective package with seeds inside becomes a fruit.

1. Create an indoor or outdoor opportunity for students to observe flowers turning into fruits over the course of a month or two. (This timing will vary depending on plants you use). You can grow bean plants to maturity under grow lights in the classroom in 8 weeks or so. Fast Plants (http://www.fastplants.org/) will go from seed to seed in the classroom in just 40 days. You can cut the time required if you focus outdoors on established plants: tree flowers; garden plants such as peas, beans, or squash; or weeds (mustard-family plants are good for this activity).

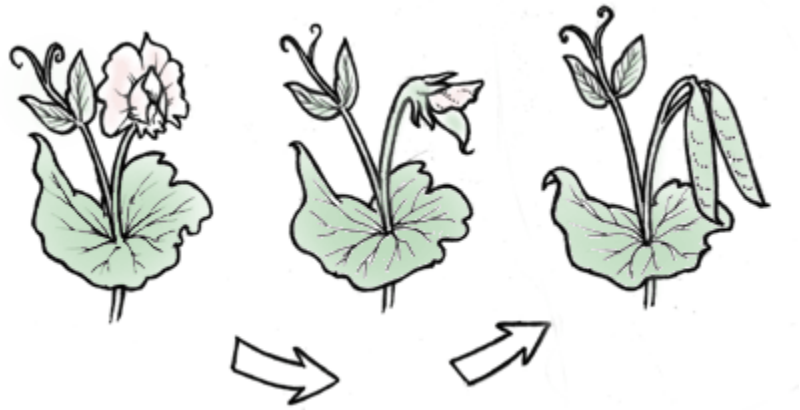
2. As a class, observe indoor or outdoor plants in flower (NOT DANDELIONS) and ask *what do you see?*

What do you think comes after the flowers in the plant's life cycle? What do you predict will change in the next month, and why?

3. Assign individuals or pairs to choose a few plants or flowers to track over time. (They may want to mark individual flowers with yarn.) Tell students they will have a chance to observe their plants at least twice a week using their eyes alone and with magnifying lenses. At each session, they must look for clues — signs of change — and create drawings of one flower on the Observing Plant Cycles worksheets. (You may want to have students take photos instead of or in addition to drawing.)

Making Connections

4. Once fruits and seeds have emerged from former flowers, ask each student or pair to present their findings to the class via a poster. Students can include their drawings, observations (or photos they've taken), and an explanation of what happened along the way. Encourage classmates to question presenters. Use these additional prompts:



This diagram shows the progression from pea flower to fruit.

- *How did your findings compare with your original prediction? With things you already knew?*
- *Why do you think different changes occurred? How might they help the plant?*
- *What questions do you have?* (Identify questions students can answer through more observations and ones that require further research.)

Digging Deeper

- ❖ If students look closely at large flowers on plants like squash and roses, they may see a swollen area at the base even before the petals drop off. This is the ovary with developing seeds. They should also see petals withering and colors (and possibly scents) fading. Why? A fertilized flower has no need to expend energy to attract pollinators once its eggs are fertilized. The fertilized flower's demise signals pollinators to spend *their* energy on other blooms.
- ❖ Have students observe a tree or plant outdoors. Ask, *has this tree/plant flowered yet? How do you know?* Students should defend their answer with knowledge learned from the lesson, their visit to the United States Botanic Garden, and their observations of the tree/plant in question.
- ❖ Complete the activity Fruit for Thought I: Getting to the Core.

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  As a result of activities in grades K-4, all students should develop an understanding the life cycles of organisms.

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OBSERVING PLANT CYCLES

Name _____

Date	My flower looks like…	Changes I noticed…

PLANT ELDERS: SEEDLESS BUT SAVVY

This activity corresponds to the following Big Idea section(s):

Plant Multiplication

Overview

Students collect, observe, and compare seedless plants in different stages of their reproductive cycles.

Time Allotted

2 class or outdoor sessions

Student Objectives

After completing this lesson, the student will be able to:

1. Collect seedless plants from their natural habitats.
2. Observe and compare seedless plants at different stages in their reproductive cycles.
3. Theorize why ferns and mosses evolved prior to flowering plants.
4. List questions for further inquiry.

Mosses cover a shaded rocky hillside.

Most types of ferns prefer moist, shady areas.

Materials

Hand magnifying lenses (1 for per small group)

Pencils

Paper

A variety of moss and fern samples (for student observation if not going into the field - to keep them fresh, put them in plastic bags with moist paper towels)

Get permission from property owners or managers before digging plants. Collect only from areas where a species of fern or moss seems plentiful, taking only a small amount from any one area.

What They Might Find Reference Sheet

Plant Family Tree Image (on computer screen or printed for individual student use)

What to Do

1. Search for some areas around the school or neighborhood where ferns and/or mosses grow. In most of the country, both are fairly abundant in the spring. Mosses rely on water to enable egg and sperm cells to unite, so look for them in areas that are often moist – woodland depressions, drainage ditches, old logs, and so on. Ferns also tend to grow in moist areas in the shade of trees or along creeks and streams. You

might also find them planted around your schoolyard. If you can't find any, check with a local florist about donating old or broken fronds.

2. Show the class one of your fern and moss samples and find out what students recall about these ancient forms of plants from previous experiences or their visit to the United States Botanic Garden *How Plants Work* Exhibit. Explain that the class will have a chance to explore these ancient plants that were around when the dinosaurs roamed.

3. You can have the class make observations in the field or back in class. If they bring samples back with them, have them use bags, as described above, to keep samples fresh. In either case, they should note the characteristics of the environments where they find the plants (e.g., level of moisture and sunlight).

4. As small groups of students examine the samples with hand magnifying lenses, ask them to make sketches and describe what they see. (See What They Might Find Reference Sheet) Ask these types of questions:

- *What details do you observe? Do you recognize any plant parts?*
- *How are leaves (fronds) on different ferns alike? How are they different? Don't forget to look at the bottoms of the leaves*.
- *How are ferns and mosses alike? How are they different?*
- *What are the main differences between ferns (or mosses) and plants such as beans or marigolds?*

Consider putting a frond with scale-like bumps on the bottom between two sheets of white paper and weighing it down with a book overnight. (Only these "fertile fronds" have spores.) As students observe the pattern on the paper the next day, ask them to pose theories about what they see.

5. Ask each group of observers to list at least three questions they have about mosses and/or ferns based on their observations. As a class, identify questions they can answer through further observation and those they can answer through research. If you have time, allow them to pursue some of their questions.

Making Connections

6. Once students have explored these ancient plants, show them this image of the Plant Family Tree and ask what ideas they have about why they came into existence when they did, that is, long before flowering plants. (Ferns and mosses need only wind and water to reproduce. Most flowering plants rely on pollinators; these relationships took more than a million years to evolve!)

Digging Deeper

- ❖ Send your students to the No Flowers? No Problem! Web site written for kids. It describes moss lichen, fungi, ferns, and algae via text, photos, and a glossary. http://www.rbg.ca/cbcn/en/cbcn4kids/kid_noflower.htm
- ❖ Discuss the difference between mosses and club mosses. (Club mosses have stems, roots, and leaves.)
- ❖ To inspire more long-term observations in a simulated environment, you may want to have students set up terrariums that feature mosses and ferns. If you're patient and able to start at the beginning of the year, consider engaging students in growing ferns from actual spores. The following links should inspire you to action:

  Homemade Terrarium

  http://www.astc.org/exhibitions/rotten/terrar.htm

Making and Observing a Mini-Woodland Terrarium

http://eeingeorgia.org/content/ee/docs/terrarium_lesson.pdf

Fond of Fronds (Growing and Observing Ferns)

www.kidsgardening.com/Dig/DigDetail.taf?ID=1092&Type=Art

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- NS.K-4.3 – LIFE SCIENCE:

  As a result of activities in grades K-4, all students should develop an understanding of characteristics of organisms.

  As a result of activities in grades K-4, all students should develop an understanding of the life cycles of organisms.

  As a result of activities in grades K-4, all students should develop an understanding of organisms and environments.
- NS.5-8.3 – LIFE SCIENCE:

  As a result of activities in grades 5-8, all students should develop an understanding of structure and function in living systems.

  As a result of activities in grades 5-8, all students should develop an understanding of reproduction and heredity.

  As a result of activities in grades 5-8, all students should develop an understanding of diversity and adaptations of organisms.

National Standards for Arts Education

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The National Geography Standards

- NSS-G.K-12.2 – PLACES & REGIONS

  Understand the physical and human characteristics of places.

WHAT THEY MIGHT FIND

(Reference Sheet for Teachers)

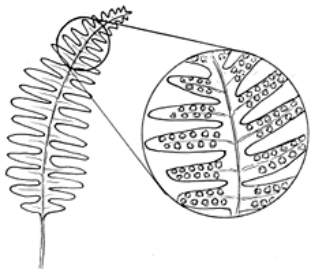
Ferns

On the undersides of some fern *fronds* (compound leaves), scale-like bumps called *sori* contain clusters of structures that house microscopic, dustlike spores. On some plants, such as cinnamon ferns, the fertile frond looks like a stalk covered with colorful powder. It is the spores that will show up between the paper "sandwich" left overnight. When the sori turn brown (outdoors, typically after midsummer), they are ripe and ready to release spores, which travel mainly on the wind. Kids might also observe tiny heart-shaped *plantlets*. These represent another part of the reproductive process during which the sperm and eggs will unite in a film of water. If the union is successful, recognizable leaves will appear. Ferns also reproduce via underground stems.

Mosses

The class may notice that, although ferns appear to have roots, stems, and leaves, mosses have only simple leaf structures (sometimes only a few cells thick) and no roots. They grow close to the ground because they're attached to it by fine threads (*rhizoids*). These can break off to make more plants. (Like ferns, mosses also reproduce via spores.) Students can sometimes see a stalk standing above the green leaves. This contains spores. Mosses require a film of water for egg and sperm cells to unite.

Tiny, heart-shaped plantlets sprout the more recognizable fern leaves.

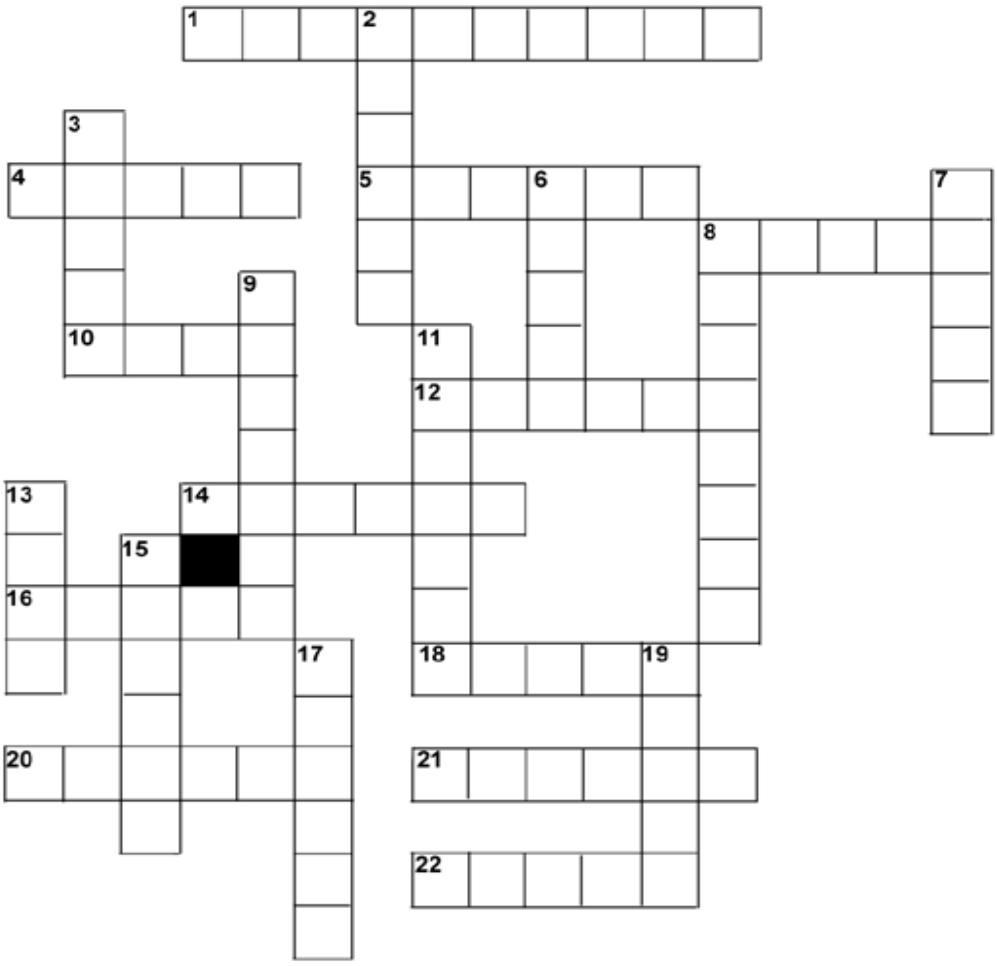


Look for scale-like sori on the undersides of some fern fronds.

Moss flourishes on a rocky bank.

You can sometimes see the moss's spore capsules on tiny stalks.

HOW PLANTS WORK CROSSWORD PUZZLE



Across	**Down**
1. Helps a plant survive in a specific environment. 4. Anchor the plant. 5. Sweet stuff insects like. 8. Basic food made by plants. 10. Where plants find water and minerals. 12. A plant that lives for one year 14. Where a plant with a juicy stem might live. 16. Fruits have these inside. 18. Trees grow from the tips of these parts. 20. Bees pick it up from the male part of the flower. 21. Given off by plant leaves. 22. The growing tips of these plants are sometimes called fiddleheads.	2. We are completely dependent on them. 3. Where you find seeds on a pine tree. 6. Can protect a plant from attack. 7. Contains seeds. 8. Leaves are designed to take it in. 9. Many of these are great “advertisers.” 11. Reaches deep into the soil. 13. Ancient plant with no flowers. 15. Their colors attract bees and other insects. 17. A plant with huge leaves might live here. 19. Support plants and act like pipes.

HOW PLANTS WORK CROSSWORD PUZZLE ANSWERS