It's All About Plants

A series of classroom activities for teachers to engage elementary children with key concepts in plant science.

With funding from the science outreach portion of my National Science Foundation grant (IOS-1456047), in a partnership with Columbia Public Schools, University of Missouri College of Education's ReSTEM Institute, and the University of Missouri Undergraduate Research Office, I had the privilege of launching a new plant science outreach series called "It's All About Plants" with the Benton Elementary Science Club. Our primary aim was to expose, educate, and excite elementary student interest in plants and plant science.

The science outreach program paired undergraduate students with graduate students, including many involved in the existing National Science Foundation funded initiative Freshman Research in Plant Sciences (FRIPS) and the Students for the Advancement of Plant Pathology (SAPP). The lessons developed by student teams were delivered to Benton K-5 students on Monday afternoons from 3:00-4:00 pm each spring.

The 3-year (2016-2018) science outreach program fostered a variety of learning opportunities. Undergraduate and graduate students gained important teaching experience by learning how to take complex ideas and break them down to a more accessible level to engage elementary children with key concepts in plant science. Benton elementary students gained new insights into plant biology and pathology through activities and investigations that we hope stimulated interest in plant science or other STEM career choices.

I want to thank the National Science Foundation for the financial support that made this program possible. I also want to thank the many partners and participants, listed on the next two pages, who contributed to the success of this program. A special thank you to Benjamin Spears, a 3-year graduate student participant in the program, for his assistance in formatting and compiling all of the program activities into this booklet for broader dissemination.

It is our hope that elementary teachers will incorporate these lessons into the classroom to expose, educate, and excite elementary student interest in plants and plant science.

Melissa G. Mitchum

Outreach Program Sponsors, Partners and Participants

Program Sponsor
National Science Foundation

Program Coordinator
Melissa G. Mitchum, Professor, Division of Plant Sciences
Principal Investigator and Program Director
Faculty Sponsor, Students for the Advancement of Plant Pathology (SAPP)

University of Missouri College of Education ReSTEM Institute
Deanna Lankford, Science Outreach Coordinator
David Owens, Science Outreach Coordinator

Columbia Public Schools
Mike Szydlowski, K-12 Science Coordinator
Heather McCullar, Benton STEM Coordinator

MU Undergraduate Research Office
Linda Blockus, Director
Michael Cohen, Assistant Director
Jennifer Brown, Assistant Director

MU Freshman Research in Plant Sciences (FRIPS)
MU FRIPS Graduate Student Coordinators:
Johanna Morrow (PhD, Biological Sciences) – 2015-2016
Chris Garner (PhD, Biological Sciences) – 2016-2017
Sarah Unruh (PhD, Biological Sciences) – 2017-2018

FRIPS Undergraduate Students:
Jessia Barberis – 2015-2016
Wendy Benhardt – 2015-2016
Amanda Blythe – 2015-2016
Hannah Boatright – 2015-2016
Keiran Hyte – 2015-2016
Sarah Gebken – 2015-2016
Adam Kirby – 2015-2016
Kiley Marshall – 2015-2016
Malynda O'Day – 2015-2016
Alex McClelland – 2015-2016

Sterling Evans - 2016-2017
Eyram Kpenu - 2016-2017
Isaac Lorenz – 2016-2017
Marley Moran – 2016-2017
Camille Oster – 2016-2017
Alison Porter – 2016-2017
Rebecca Winkler – 2016-2017
Casey Yocks (Former FRIPS) – 2016-2017

Jenna Bohler – 2017-2018
Will Costigan – 2017-2018
Miki Hodel – 2017-2018
Aidan Ireton – 2017-2018
Haley Massa – 2017-2018
Connor Nordwald – 2017-2018
Carson Pearl – 2017-2018
Garren Powell – 2017-2018
Samantha Smith – 2017-2018

Undergraduate Students
Andrew Ludwig – 2015-2017
Kiley Marshall – 2015-2016
Krista Shucart – 2016-2017

Graduate Students for the Advancement of Plant Pathology (SAPP):
Beverly Agtuca (PhD, Plant Sciences) – 2015-2017
Carola De La Torre Cuba (PhD, Plant Sciences) – 2015-2016
Ha Duong (PhD, Plant Sciences) – 2016-2017
Michael Gardner (PhD, Plant Sciences) – 2015-2016
Nhung Hoang (PhD, Plant Sciences) – 2015-2017
Waana Kaluwasha (PhD, Plant Sciences) – 2015-2016
Ashten Kimble (MS, Biological Sciences) – 2017-2018
John Koehler (MS, Plant Sciences) – 2016-2017
Cuong Nguyen (PhD, Plant Sciences) – 2016-2017
Arati Nepal Poudel (PhD, Plant Sciences) -2017-2018
An Pham (PhD, Plant Sciences) – 2015-2016
Benjamin Spears (PhD, Plant Sciences) -2015-2018

Graduate Students in Plant Biology:
Mani Awale, (PhD, Plant Sciences) – 2017-2018
Katie Guthrie, (PhD, Biological Sciences) – 2016-2017
Eden Johnson (PhD, Biological Sciences) – 2015-2016
Katelynn Koskie (PhD, Biological Sciences) – 2016-2018
Makenzie Mabry, (PhD, Biological Sciences) – 2015-2016
Johanna Marrow, (PhD, Biological Sciences)- 2016-2017

Project Science:
Casey Fogarty, Volunteer Coordinator
Brooke Lappe, Volunteer Coordinator

All Volunteer MU students in the Pre-Med Society, Service Learning

Justin Stewart, MU Journalism Student

Table of Contents

2015-2016 Lessons

Lesson Title	Graduate Mentor, FRIP Student
All About Osmosis!	Benjamin Spears, Alex McClelland
Garden in a Glove	Beverly Agtuca, Jessica Barberis, Sterling Evans
How do Flowers Drink?	Michael Gardner, Andrew Ludwig
Mysterious Microbes!	Waana Kaluwasha, Malynda O'Day
What is on Your Plate? It's All About DNA!	Makenzie Mabry, Sarah Gebken
Why does the Same Plant Look Different?	Eden Johnson, Amanda Blythe, Kiley Marshall
Why is My Apple Turning Brown?	Nhung Hoang, Hannah Boatright
Why is My Plant Sick?	Carola De La Torre Cuba, Wendy Benhardt
Plants and Nutrients: It's All About Color!	John Koehler, Adam Kirby, Marley Moran

All About Osmosis!

Activity Overview

This activity will engage children with an investigation of the important biological phenomenon of osmosis. Children will use potatoes and salt water to directly observe osmosis before their very eyes, using the scientific method to make a hypothesis about their expected results.

Next Generation Science Standards

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival. Use observations to describe patterns of what plants and animals need to survive.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Construct an argument with evidence, data, and/or a model.	A system can be described in terms of its components and their interactions.	Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.

5-PS1-3. Make observations and measurements to identify materials based upon their properties.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Make observations and measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.	Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.	Measurements of a variety of properties can be used to identify materials.

Materials

Potato slices
Salt water
Distilled water
Corn syrup
Decalcified chicken eggs [chicken eggs will remain in vinegar for 24 hours]
Plastic containers
Paper towels
Pencils

Engage

Step 1: Engage students in the set-up of an osmosis lesson involving potato slices placed in salt water and distilled water. Emphasize that distilled water is pure water with no substances like salt, sugar, etc. dissolved in it.

Questions to ask:

- What do you think will happen to the potato slides in salt water?
- What do you think will happen to the potato slides in distilled water?
- How could you design an experiment to answer this question?

Explore
 	
Students will explore the nature of science through experimental design.
 	
Help students think about the potato slices and how they might change.
 	
Ask students to think like scientists and make and test predictions about the potato slices.
	Step 2: Ask students to carefully observe the potato slices:
	<u>Questions to ask:</u>
	• Are the slices stiff or can the slices be easily bent?
	• How will you know if the potato slices have changed after being placed in a salt water solution or distilled water?
	• Ask the students to trace their potato slice carefully
	Step 3: Making Predictions
	<u>Questions to ask:</u>
	• What do you think will happen when the potato slices are placed in each of the two solutions?
	  o Salt water solution
	  o Distilled water
	• Why do you think this might happen?
	
	Step 4: Testing predictions – Instruct students to:
	• After making careful observations of the potato slices [ask students to trace the potato slices to gain insight into an increase in size.
	  o Record observations on the observation sheet
	• Instruct students to place one of their slices in salt water and the other in distilled water.
	• Each child will have a small container of salt water and distilled water to test their hypothesis.
	<u>Questions to ask:</u>
	• Remember your predictions, we will allow the potato slices to remain in the two liquids for the remainder of science club. How will we determine if the potato slices have changed? [Encourage students to think about their initial observations].
	• Why do you think this might have happened?

Explain
 	
Use the Decalcified Chicken Eggs as a model for osmosis occurring within cells.
	Step 5: Decalcified Chicken Eggs
	  o Show the beginning of the YouTube video: https://www.youtube.com/watch?v=SrON0nEEWmo
	    ▪ The beginning of the video introduces the concept of decalcified eggs
	  o Pour a small quantity of corn syrup into one container and a small quantity of distilled water into another.
	• Ask students what they know about the properties of each liquid.
	  o Pour a small quantity of corn syrup into a container.
	  o Pour a small quantity of distilled water into a container.

Explain
 	
Students will explore the concept of osmosis as they observe decalcified chicken eggs placed in distilled water or corn syrup.
	Step 6: How are distilled water and corn syrup different?
	Questions to ask:
	• How would you describe the corn syrup?
	• How is the corn syrup different from the distilled water?
	Step 7: Making predictions!
	• What do you think would happen to the egg placed in distilled water?
	• What do you think would happen to the egg placed in corn syrup?
	Step 8: Testing predictions
	• Allow students to see the egg placed in corn syrup.
	• Allow students to see the egg placed in distilled water.
	Questions to ask:
	• How have the eggs changed?
	• Why do you think the egg placed in corn syrup is so much smaller?
	  o What do you think was in the corn syrup that wasn't in the water?
	  o What does this tell you about the makeup of an egg?
	  o Do either of these look like healthy eggs (sans shell)?
	• Why do you think the egg placed in distilled water is so much larger?
	Step 9: Rethink your prediction/hypothesis:
	• Rethink your hypothesis! Having seen the results of the calcified eggs, ask the kids to remember the hypothesis they made earlier; would they like to change anything about it? [Scientists change their hypotheses all the time!]
	Questions to ask
	• Why did you change your mind? [If they did]
	• Why didn't you change your mind? [If they are confident in their earlier answer]
	• How are the decalcified eggs like your potato pieces? How are they different?
	Step 10: Show the remainder of the video
	• Discuss the changes observed in the decalcified eggs in the video.

Extend **During this portion of the lesson ask students to think about their observations.**	**Step 10:** Explore osmosis by examining the potato slices placed in salt water or distilled water at the beginning of the lesson. Ask students to make careful observations. Questions to ask: • Are the potato slices different? • What do you think happened to the potato slice in distilled water? • Do you think changes in the potato slice in distilled water are similar to the changes in the decalcified egg placed in distilled water? • What do you think happened to the potato slice in salt water? • Do you think changes in the potato slice in distilled water are similar to the changes in the decalcified egg placed in corn syrup?

Analysis	Discuss the results of the experiment with the children, making sure to emphasize the connection between the effects of salt exposure to potato cells and the salt stress experienced by plants in soil//humans drinking salt water. <u>Questions to ask</u> • Did your results match what you expected? Why do you think they did/did not? • How are potatoes or other plants different from mammals like us? • Plants clearly don't like salt water; can humans drink salt water? Why do/don't you think so?

Students examining decalcified chicken eggs

Background Information:

On the surface, the concept of osmosis is very simple. Solvent molecules (mostly water) display a tendency to move down a concentration gradient to areas where concentrations of solute (dissolved molecules like salts, sugars, etc..) are higher. This is largely due to the "random" motion of molecules in a solution favoring the greater net movement of more highly-concentrated molecules! In the classic example, if a semi-permeable membrane only allows the passage of small molecules like water, water levels will "equilibrate" across two solutions with different solute concentrations. On the micro-scale, more water molecules will move across the membrane from the lower-solute side to the higher-solute side than there are molecules moving in the opposite direction (purely a numbers game); as a result, water will flow high-to-low until the solute concentrations across the membrane are equal. In short, osmosis is the movement of water across a membrane to satisfy a solute equilibrium.

It's easy to see how osmosis is a biologically relevant phenomenon- after all, what is a cell but a semi-permeable bag of water, salts and sugars, and a human being but just a larger collection of these bags! The flow of water throughout the body is orchestrated by complex manipulation of osmotic status on the cellular level, an impressive feat if you consider the self-directed movement of water through trillions of cells. Even the simple act of drinking water to rehydrate yourself requires osmosis to move water to dehydrated, "concentrated" cells. Osmosis is just as critical to human life as water itself, and as 60% water-filled fleshy bags, we all know important **that** is!

Plants depend on osmosis on a more fundamental level than we do, in some ways. By nature sessile organisms ("fixed in one place"), plants don't have the luxury of being able to get up to grab a glass of water when they are thirsty. Instead, plants rely on their roots to pull water from the soil and transport it throughout the plant, a process that relies heavily on a combination of evapotranspiration through openings at the top of the plant (stomata) and production of "osmotic pressure" through manipulation of cell solute concentrations. Plants need to use osmosis just to "drink" the water, much less to move it between their cells. Osmosis is important to plant growth on a structural level as well. Plant cells not only have semipermeable membranes just like animal cells, but also feature rigid cell walls made of cellulose that help to maintain the upright "vertical" growth of plants towards the sun. The healthy upright stature of plants depends on the maintenance of turgor pressure of the cell membrane against the cell wall (imagine a bike tire, filled to the maximum). Interestingly, the tough cell wall provides a limiting factor that prevents plant cells from taking in **too much** water, which could cause them to burst (not unlike an overfilled tire). In order to keep turgor pressure high, plants depend on osmosis to act as a sort of biological "bicycle pump" to drive water into the cell against its energy gradient, "inflating" the cell. When un-watered plants start to wilt, it reflects the loss of this turgor pressure within the cell and results in reduced growth and plant health. Plants clearly rely heavily on osmosis to survive!

In the potato experiment, children will directly measure the effects of a hypertonic solution (high solute) in the form of salt water on the cellular structure of potato slices. They should observe a reduction in size in potatoes soaked in salt water, and likely some cellular collapse in the form of a "mushy" feeling relative to an unsoaked potato. This represents water moving from inside the potato cells, across the membrane, and into the salt water solution. The potatoes soaked in pure water may exhibit a small increase in size due to osmosis acting in the **opposite** direction (potatoes are nutrient sinks), but the effect will likely not be noticeable after only 30 minutes.

In the decalcified egg activity, the eggs are essentially tiny semi-permeable bags of **highly concentrated** solutes- perfect examples of osmosis in action! When soaked in pure water, the eggs should expand significantly, representing movement of water into the egg to dilute the solutes inside. When soaked in corn syrup, however, the egg membrane should contract as water leaves to dilute the more-heavily concentrated sugar environment outside.

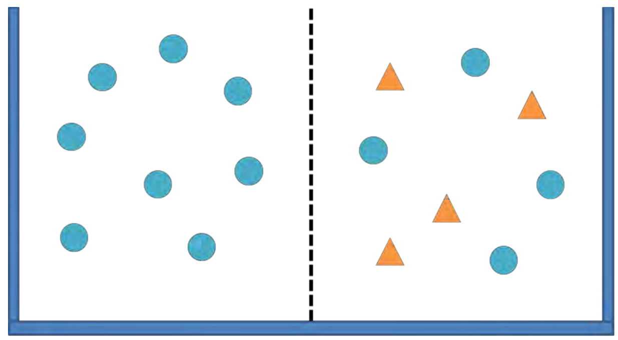
Between these activities, the children should come to understand that osmosis is an important biological process that occurs in both plant and animal cells! Plants rely on it to get a drink of water just as much as we rely on it to keep our cells hydrated. Isn't osmosis cool?

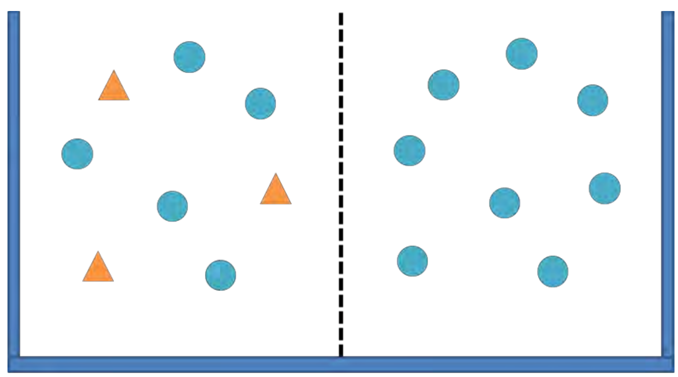
All About Osmosis!

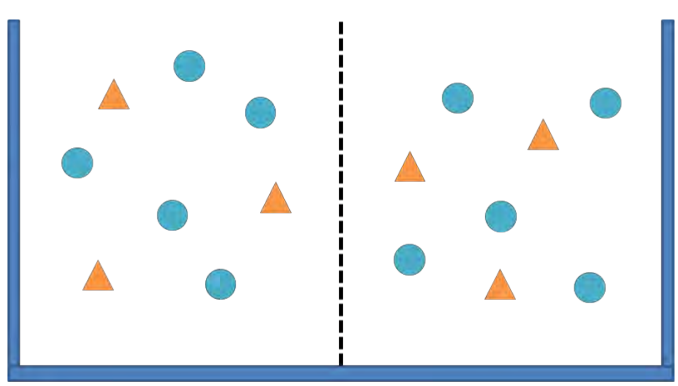
Supplemental Materials

= Salt
= Water

Can you draw an arrow to show how the water molecules will move across the center?







Potato Experiment

Starting potato outline (Trace Here!):

Physical Details:

Visible Details:

Hypothesis

Revised Hypothesis

Final potato outline (Trace Here!):

Physical Details:

Visible Details:

Conclusions

Challenge Page # 1: Potato Slices: Predictions, Observations, & Explanations			
	Salt Water Solution		Distilled Water
Prediction [How do you think the potato slices will change in each liquid?]			
Observation [How did the potato slices actually change in each liquid?]			
Explanation [What patterns did you see? How can you explain your observations?]			

Challenge Page # 2: Decalcified Chicken Eggs: Predictions, Observations, & Explanations			
	Corn Syrup		Distilled Water
Prediction [How do you think the decalcified chicken eggs will change in each liquid?]			
Observation [How did the decalcified chicken eggs actually change in each liquid?]			
Explanation [What patterns did you see? How can you explain your observations?]			

Garden in a Glove

Activity Overview	This activity will introduce children the requirements for seed germination and plant growth. The novel experience of germinating seeds in the fingers of a glove will be engaging for students. This will also have an important focus in plant biology. First, students will be able to observe seed germination and think about the requirements for germination. Second, as the young plant begins to grow the focus will be on the source of raw materials to support plant growth.
Learning Objectives	At the close of this lesson, students should be able to: 1. Identify the basic needs of seeds for germination 2. Provide a basic description of germination [root and shoot growth] 3. Compare the needs of seeds for germination [water and warm temperature] with the needs of plants for growth [water, sunlight, carbon dioxide from the air or 'just air.'

Next Generation Science Standards

K-LS1-1. Use observations to describe patterns of what plants and animals need to survive.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Use observations [firsthand or from media] to describe patterns in the natural world.	Patterns in the natural and human designated world can be observed and used as evidence.	All animals need food in order to live and grow. Animals obtain their food from plants or from other animals. Plants need water, air and light to live and grow.

2-LS2-1. Plan and conduct an investigation to determine if plants need sunlight and water to grow.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Plan and conduct an investigation collaboratively to produce data that will serve as evidence to answer a question.	Observable patterns can be observed in common events. Those events have causes and result in patterns.	Plants depend on water, air, and light to grow.

5-LS1-1. Support an argument that plants derive the requirements for growth from air, water, and sunlight.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Support an argument with evidence, data, or a model.	Matter is transported into, out of and within organisms.	Plants acquire the materials necessary for growth chiefly from air and water. Plants utilize sunlight to manufacture food.

Materials

Clear gloves	Magnifying glass
Seeds	String
Water	Markers
Cotton balls	

Engage **Introduce the concept of a seed as well as the purpose of seeds.**	**Step 1**: Engage children with a discussion of seeds. Share several types of seeds and ask the students to sort the seeds into groups. After students sort the seeds, ask student teams to explain the rule used to sort the seeds. Questions to ask: • How are the seeds alike and how are they different? • Why do you think the seeds look different? • Can you place the seeds into groups? What rule will you use to determine the way in which your group decided to sort the seeds?
Explore **Students will explore the nature of seeds and seed germination.** **They will also begin to think about what plants need to grow.**	**Step 2**: Distribute the clear plastic gloves to the students. Explain that the students will make a garden in the glove. Questions to ask: • Have you ever made a garden in a glove? • What do you think you will need for the seeds to grow into plants inside the glove? What do seeds need to grow into plants? • Ask the students to determine the steps they will take to make a garden in the clear gloves provided. **Step 3:** Prepare the garden by taking the following steps with the children: 1. Label the middle of the glove with each student's name. 2. Wet 5 cotton balls and carefully wring out the excess water 3. Carefully place 3-4 seeds on each of wet cotton balls 4. Using the handout, print the type of seed on each finger of the glove 5. Carefully place a cotton ball with seeds resting on the surface into each finger of the glove. 6. Ask the students to blow into the glove and inflate it like a balloon. Next tie the end of the glove with the string. You will have to help the children by tying the inflated glove with the string. 7. Make extra gloves so that several can be taped to the window in the classroom while the others can be taken home with the students.
Explain **During this portion of the lesson ask students to think about what will happen to the seeds over time.**	**Step 4**: Predict what will happen to the seeds over time. The seeds will germinate within 3-5 days. Students will be able to watch the seeds germinate. Questions to ask: • What will happen to the seeds planted in the gloves? • Ask students to identify the appropriate sequence for the images. Challenge the students to explain the manner in which they sequenced drawings of a seed germinating and growing into a plant. Questions to ask: • How will you order the diagrams? • Why did you decide to order the germination drawings in that sequence? Defend your ideas. • Will this happen to the seeds in your glove? **Step 5:** Students will watch a YouTube video on seed germination and plant growth.

Hanging completed Gardens in Gloves

Garden in a Glove

Supplemental Materials

Garden in a Glove

Name: ____________

VOCABULARY
Annual – life cycle of one year
Perennial – life cycle of more than two years
Germination – to begin to grow (sprout)
Transplant – to remove and plant in another place

What seeds did you plant in each finger?
Write them on the correct line.

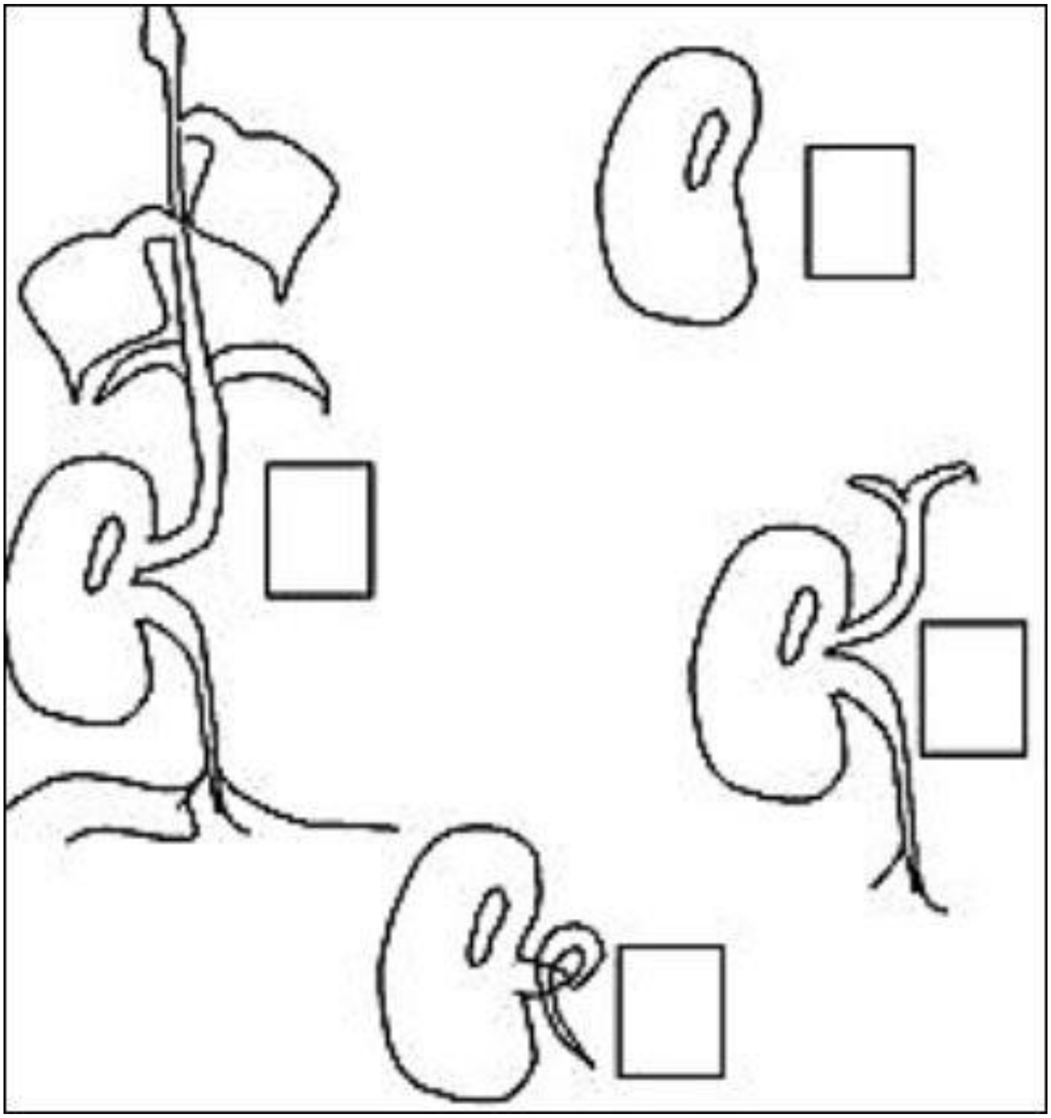
Write the date when you see the first sprout.

____

Number each finger in the order they germinate.

University of Illinois Extension

Activity provided by: Shelley Hall, Pike-Scott County
Agricultural Literacy Coordinator
1301 E. Washington, Pittsfield, IL 62363
Ph. 217.285.5543 Email smhall@uiuc.edu



Study the images of seeds and plants. Ask students to sequence the images by placing the appropriate number in each of the boxes. Challenge students to provide evidence for the sequence of events selected.

Directions: Fill out the crossword using the word bank, then use those words to help label the plant parts shown below.

Across

1. I bring in carbon dioxide and release oxygen. I can also be a variety of shapes including jagged, round, or long.

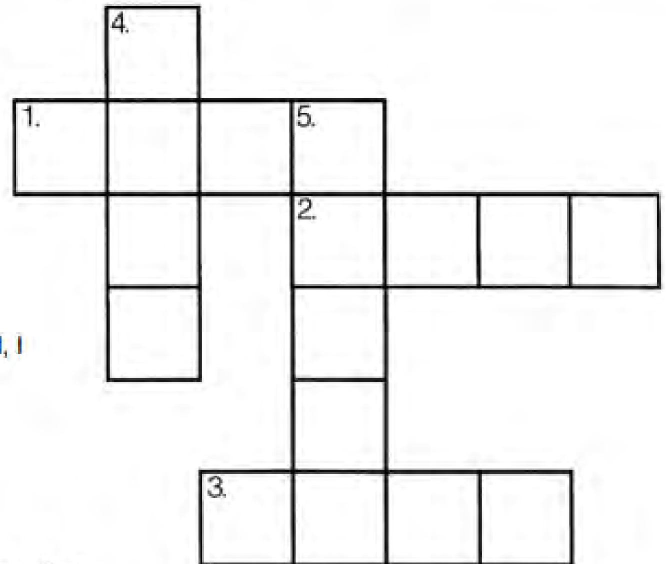
2. I take in food and water from the soil.

3. I hold the plant up.

Down

4. I contain stored food, and when planted, I will give rise to a new plant.

5. I have seeds inside.



Word Bank: stem, seed, leaf, root, fruit.

How do Flowers Drink?

Activity Overview

This activity will introduce children to the structure of plants and the means by which water moves through a plant. Students will observe plant structures and note changes observed when flowers are placed in liquids containing different colored water.

Learning Objectives

At the conclusion of this lesson, students will:

- Be able to identify the tissue in the stem which carries water to the leaves and flowers of a plant
- Use a model to explain that food coloring is transferred with water to affect the colors of white chrysanthemums

Next Generation Science Standards

5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Develop a model to describe phenomena.	A system can be described in terms of its components and their interactions.	Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain water and oxygen from the environment.

2-LS2-1. Plan and conduct an investigation to determine if plants need sunlight and water to grow.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Plan and conduct an investigation collaboratively to generate data to serve as a basis for answering a question.	Events have causes that generate observable patterns.	Plants depend on water and light to grow.

Materials

Cut flowers: White Chrysanthemums
Salt
Sugar
Baking soda
Food coloring [multiple colors]
Water
Containers for the flowers
Celery stalks and food coloring

ReSTEM Institute:
Reimagining & Researching STEM Education

University *of* Missouri College of Education

Engage **Students will think about how to conduct an investigation into the movement of water through a plant.**	**Step 1**: Ask students to carefully observe the white flowers at their table. Questions to ask: • Do you think that plants need water to live? • How do you think the water enters the plant and moves through the roots, stems, leaves and flowers of the plant? • Can we design an experiment to answer the question above? **Step 2**: Ask students to brainstorm about an experiment which would answer this question: https://www.youtube.com/watch?v=VhZyXmgIFAo Questions to ask: • After seeing the video, how could we set up an experiment with the materials available to investigate the means by which materials move through a plant?

Explore
 	
Ask the students what the control would be for the investigation.
 	
Record student predictions, these will be shared with the rest of the class.
	Step 3: The following solutions have been prepared for this investigation:
	1.) 2% salt water
	2.) 2% sugar water
	3.) 2% baking soda
	4.) 2% vinegar
	5.) Add a few drops of food coloring to water for a dye solution
	6.) Soda and water solutions require no dilution
	Explain to the students that they will place one white flower into each of these solutions. Ask students to following the following protocol:
	1.) Put a small amount of a solution into one of your containers, label the container, and then put a single flower into the solution. Repeat this for each of the solutions.
	2.) Place the flowers in an area with high light where they will be out of the way.
	Questions to ask:
	• Talk among your team members and make the following predictions:
	  o How will the flowers change:
	    ▪ Salt solution
	    ▪ Sugar solution
	    ▪ Baking soda solution
	    ▪ Vinegar solution
	    ▪ Red food coloring solution
	    ▪ Soda solution
	
	3.) After 4-5 days take the flowers and examine them closely to see the impact of each solution on the flower's health.

Explain

Step 4: After students have set up the experiment, we will find a location in the room to store the flowers until we meet next week.

Questions to ask:

- What do you predict will happen to the flowers?
- Do you think the flowers will change in some way?
- Explain your thinking.

Step 5: The presenters will pass out flowers that were placed in red or blue food coloring several days ago. All of these flowers were white initially.

Questions to ask:

- How did the flowers change?
- Can you explain how this change occurred?

Step 6: Carefully remove the flowers from the colored water and study the bottom of the stem. Next cut the stem so that you can see a new area of the stem.

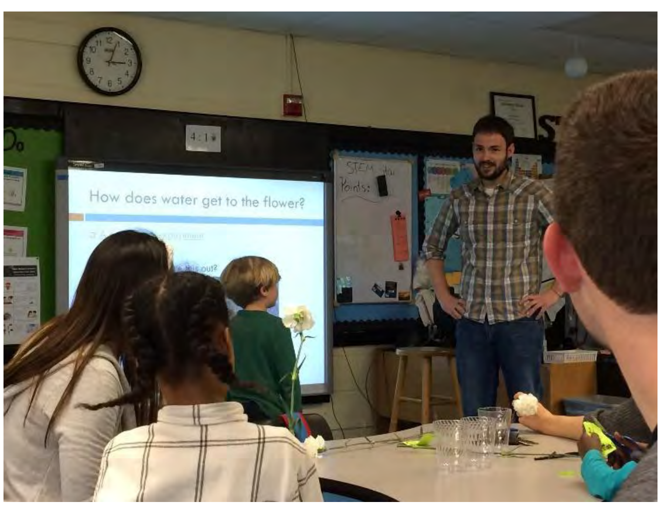
Questions to ask:

- What do you see in the stem?
- Are there tiny dots of color within the stem?
- What do you think those dots might be?

Step 7: Students will watch the brief video on food dye and celery ribs. https://www.youtube.com/watch?v=KIug9Foou3s

Questions to ask:

- After watching the video, how would you explain the dark dots of color in the stem?
- Study the celery ribs brought by your table. How is the celery rib similar to the flower?
- What do you think might have happened to the celery?



Students learning about water transport

Flowers that have taken up blue dye

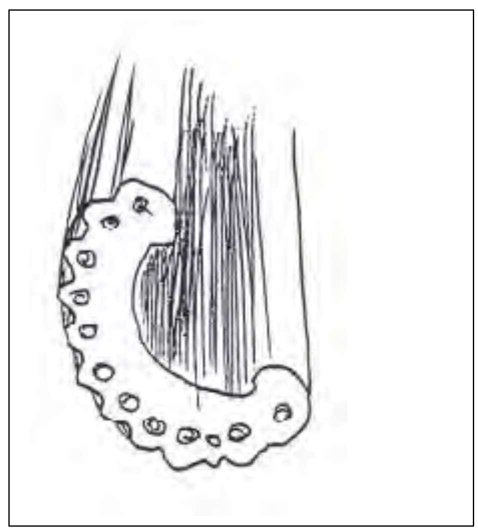
How do Flowers Drink?

Supplemental Materials

Celery and Food Dye, Oh my!

How did water containing red or blue food dye affect the celery?

Color the celery if the stalk was split and each side was placed in water containing a different color of food dye.



This is a picture of a stalk of celery that was placed in red water. Color the stalk the way you think it will look.

What do you think those little circles and what color would they be? __________

Mysterious Microbes!

Activity Overview

This activity will introduce children to the concept of microbes. It is often difficult for elementary children to understand that microbes such as bacteria, fungi, nematodes and viruses have the potential to make us very sick. These same microbes can also make plants sick. The students will also learn that not all microbes are harmful. In fact, some microbes can be very beneficial.

Next Generation Science Standards

K-LS1-1. Use observations to describe patterns of what plants and animals need to survive.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Use observations [firsthand or from media] to describe patterns in the natural world.	Patterns in the natural and human designated world can be observed and used as evidence.	All animals need food in order to live and grow. Animals obtain their food from plants or from other animals. Plants need water, air and light to live and grow.

2-LS2-2. Make observations of plants and animals to compare the diversity of life in different habitats.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Make observations to collect data which can be used to make comparisons.	The shape and stability of structures of nature and designed objects are related to their functions.	There are many different kinds of living things within any area and they exist in different places on land and in water.

5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers and the environment.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Develop a model to describe phenomena.	A system can be described in terms of its components and their interactions.	Organisms can survive only in environments in which their particular needs are met.

Materials

Warm water
Yeast & sugar
Microbe fact sheet
Matching microbes sheet
Plants infected with viruses and nematodes
Culture plates of bacteria and fungi

Engage

Step 1: Engage children with a discussion focused on microbes.

Questions to ask:

- Why is it important to wash your hands? Should you wash your hands even when they do not look dirty?
- Have you noticed that sicknesses [like cold and flu] are often spread from one person to another?
- What do you think makes you or others sick?

Explore **Students will explore the nature of microbes and discover that there are many different types of microbes and not all are harmful.** **Make the point that microbes are very important.**	**Step 2**: Show brief video about germs from Cincinnati Children's Hospital: https://www.youtube.com/watch?v=YBGsoimPXZg Questions to ask: • Do you wash your hands several times each day? • Can you think of other ways to avoid getting sick? **Step 3:** Beneficial microbes Questions to ask: • We talked about harmful microbes that can make us sick. Can you think of ways in which microbes help us every day? • Do you like bread? o Explain that nonpathogenic yeast [a form of fungi] are used to make bread rise and they do not make us sick. We eat bread all the time and those amazing fungi make the bread rise. **Step 4:** Engage children in a hands-on yeast activity • Place a small quantity of yeast in tube, add warm water and sugar • Place the lid on the tube • Explain that you will come back to the yeast and sugar solution in a few moments **Step 5:** Engage children with the All About Microbes sheet: • Work with the children in your group to complete the sheet • Discuss examples of each group of microbes. Show the cultures plates of fungi and bacteria. Examine the plants infected with viruses and nematodes. • Focus on the harmful and helpful aspects of each microbe. **Step 6:** Observe the yeast, sugar, and water mixture. Ask the children if they can see any changes. Questions to ask: • Has the yeast, water, and sugar mixture changed? • How the mixture has changed? • Why do you think we use yeast to make bread?
Explain During this portion of the lesson ask students to think about their observations.	**Step 7:** If time permits, complete the last portion of the lesson by matching the boxes. • Ask students to match the boxes by putting the cards together which accurately describe bacteria, fungi, nematodes, or viruses.

Background information:

Micro-organisms, more commonly known as germs or microbes, are tiny living organisms too small to be seen with the naked eye. They are found almost everywhere on earth. Microbes are single-celled organisms, most of which are helpful or beneficial, although some of them cause illness and disease. Although extremely small, microbes come in many different shapes and sizes. There are several main groups of microbes:

Viruses are the smallest of the microbes and are generally harmful to humans. Viruses cannot survive by themselves. They need a 'host' cell in order to survive and reproduce. Once inside the host cell, they rapidly multiply and destroy the cell in the process!

Fungi are multi cellular organisms (made up of more than one cell) that can be both beneficial and harmful to humans. Fungi obtain their food by either decomposing dead organic matter or by living as parasites on a host. Fungi can be harmful by causing infection or being poisonous to eat; others can be beneficial or harmless, e.g. Penicillium which produces the antibiotic penicillin. There are also fungi that are not microbes and some that can be eaten like Agaricus, commonly known as the white button mushroom.

Bacteria are single-celled organisms that, under the right conditions, can multiply once every 20 minutes. During their normal growth, some produce substances (toxins) which are extremely harmful to humans and cause disease (e.g. Staphylococcus); other bacteria are completely harmless to humans, and others can be extremely useful to us (e.g. Lactobacillus in our food). Some are even necessary for human life such as those involved in plant growth (e.g. Rhizobacterium). Harmless bacteria are called non-pathogenic, while harmful bacteria are known as pathogenic. Over 70% of bacteria are non-pathogenic.

One of the main ways in which microbes are beneficial is in the food industry. Cheese, bread, yogurt, chocolate, vinegar and alcohol are all produced through the growth of microbes. The microbes used to make these products cause a chemical change known as fermentation – a process by which the microbes break down the complex sugars into simple compounds like carbon dioxide and alcohol. Fermentation changes the product from one food to another. When the bacteria

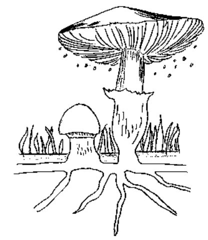
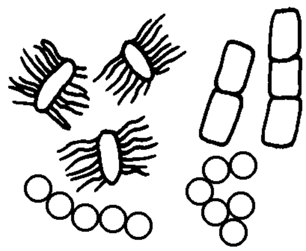
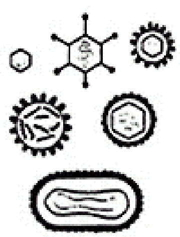
Streptococcus thermophilous or *Lactobacillus bulgaricus* are added to milk they consume the sugars during growth, turning the milk into yogurt. So much acid is produced in fermented milk products that few potentially harmful microbes can survive there. Lactobacillus is generally referred to as a good or 'friendly' bacterium. The friendly bacteria that help us digest food have been termed probiotic bacteria, literally meaning 'for life'. It is these bacteria that we find in yogurts and probiotic drinks. Yogurt is made from the fermentation of the lactose in milk by the rod-shaped bacteria *Lactobacillus delbrueckii subsp. bulgaricus* to produce lactic acid, which acts on milk protein to give yogurt its texture and its characteristic acidic taste. Other bacteria found in yogurt are *Lactobacillus acidophilus*, *Streptococcus salivarius subsp. Thermophiles*, and *Bifidobacterium bifidus.*

Mysterious Microbes!

Supplemental Materials

Types of Microbes

Cut, match, and paste these boxes to group the facts together.

Bacteria	These are the smallest type of microbe. They are very simple and are not cells.	
They are worm-like, and are often very small, or even microscopic		Fungi
They reproduce by growing and then splitting in two.	Viruses	These are tiny, single cells. The cells are different from ours because they do not have a nucleus.
They are easy to see because they have big reproductive structures. They make dust-like spores that spread in the air.		Often live in soil, but can live in almost every environment.
They need to be in the cells of other living things to reproduce, this is why they cause diseases.	Nematodes	Most of these are formed from thin, threads called hyphae.
		

Use the names of the types of microbes to finish off the sentences...

....................are used to make bread and beer.

Food poisoning is usually caused by....................

.... cause illnesses such as flu, colds and measles.

.... generally live in soil and can feed on plants, animals, and humans.

.... are used to make cheese and yogurt.

Mold on bread is caused by ....

.... are the smallest pathogens.

.... are usually made up of branched threads.

.... can only reproduce inside the cells of animals or plants.

……………… are worm-like organisms.

Use the names of the types of microbes to finish off the sentences... [key]

Fungi are used to make bread and beer.

Food poisoning is usually caused by **Bacteria**

Viruses cause illnesses such as flu, colds and measles.

Nematodes generally live in soil and can feed on plants, animals, and humans.

Bacteria are used to make cheese and yogurt.

Mold on bread is caused by **Fungi**

Viruses are the smallest pathogens.

Fungi are usually made up of branched threads.

Viruses can only reproduce inside the cells of animals or plants.

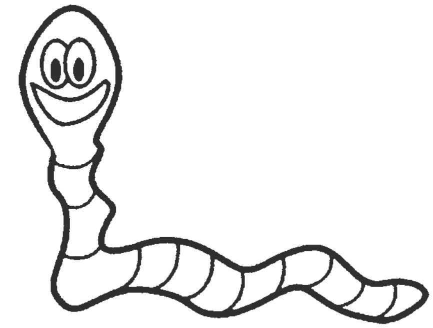
Nematodes are worm-like organisms.

All About Microbes! [Key]

Microbes	What are they [Circle one]	Where are they found?	How do they move from person to person?	Harmful or Helpful Examples?
Bacteria	o A very simple and tiny cell? o Only a part of a cell? o A small cell that is similar to plant and animal cells? A small, worm like organism	**All around us and even on our skin and even inside our bodies**	**Face to face contact Touching surfaces Even in the air**	**Can be harmful but we also rely on non-pathogenic bacteria to help us digest our food and protect our skin from pathogens.**
Fungi	o A very simple and tiny cell? o Only a part of a cell? o A small cell that is similar to plant and animal cells? o A small, worm like organism	**Throughout the environment and sometimes fungi live on us too**	**Typically found in soil and even on your body.**	**Can be harmful but we also rely on non-pathogenic fungi to make bread, yogurt, and cheese.**
Viruses	o A very simple and tiny cell? o Only a part of a cell? o A small cell that is similar to plant and animal cells? o A small, worm like organism	**All around us, basically anywhere there are cells to infect**	**Through direct contact with another person Touching contaminated surfaces Sneezes & coughs**	**Can be harmful but scientists use non-pathogenic viruses in the laboratory.**
Nematodes	o A very simple and tiny cell? o Only a part of a cell? o A small cell that is similar to plant and animal cells? o A small, worm like organism	**Most live in soil, but can live in almost any environment**	**Typically found in soil, can be transmitted by insects**	**Some, like soybean cyst nematode can be harmful, but others help keep soil fertile.**

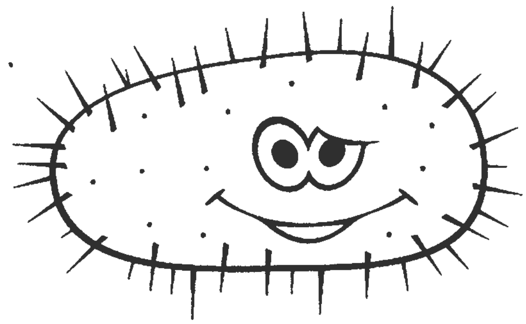
All About Microbes!

Microbes	What are they [Circle one]	Where are they found?	How do they move from person to person?	Harmful or Helpful Examples?
Bacteria	o A very simple and tiny cell? o Only a part of a cell? o A small cell that is similar to plant and animal cells? o A small, worm-like organism			
Fungi	o A very simple and tiny cell? o Only a part of a cell? o A small cell that is similar to plant and animal cells? A small, worm like organism o A small, worm-like organism			
Viruses	o A very simple and tiny cell? o Only a part of a cell? o A small cell that is similar to plant and animal cells? o A small, worm-like organism			
Nematodes	o A very simple and tiny cell? o Only a part of a cell? o A small cell that is similar to plant and animal cells? o A small, worm-like organism			



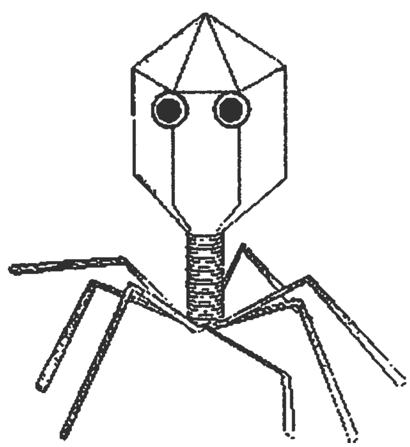
Nelly Nematode

Benny Bacteria

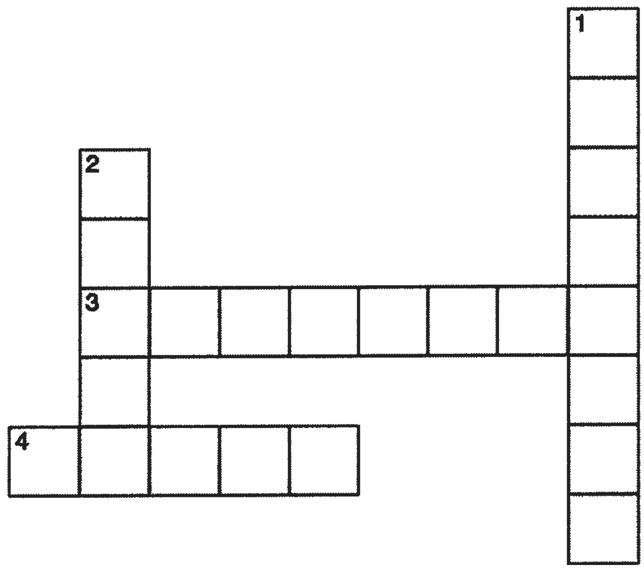


Freddy Fungi

Vinny Virus



Plant-Microbe Interactions

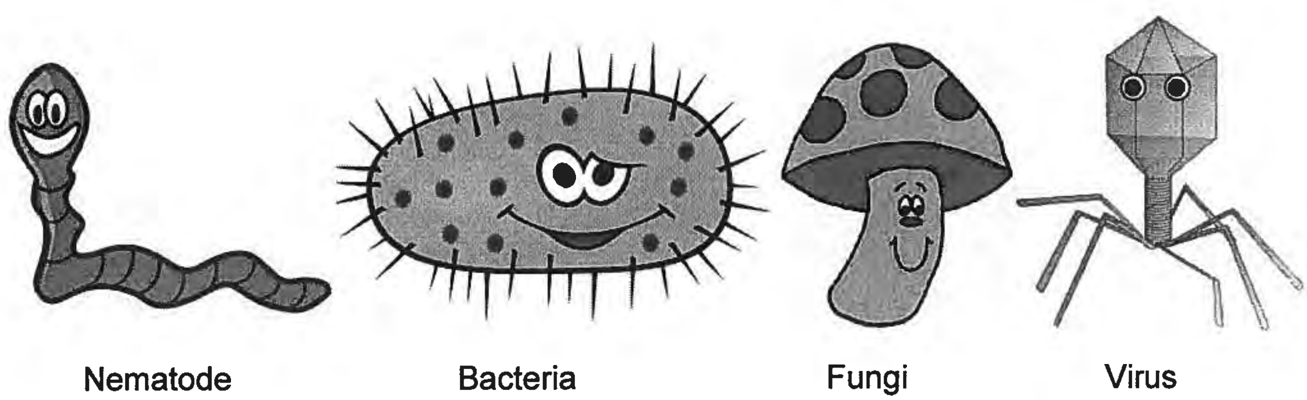


Down

1. They are single-celled microorganisms. Their cell structure is unique in that they don't have a nucleus and have cell walls similar to plant cells.
2. They are a group of living organisms which are classified in their own kingdom. They get their food by decomposing matter or eating off their hosts as parasites.

Across

3. They are free-living, nonsegmented round worms that are transparent or colorless.
4. They are small particles that hijack the cells of living organisms. They inject their genetic material right into the cell and take over.



What is on Your Plate? It's All About DNA!

Activity Overview

This activity will introduce children to the concepts of DNA and genetics. We will be extracting DNA from vegetables. When asked if DNA is in the foods we eat, many children and adults will indicate that there is no DNA in food. This is a common misconception. Today, we will explore the extraction of DNA from broccoli and think about the steps taken during the lab to extract this amazing molecule.

Learning Objectives

At the conclusion of this lesson, students will:

- Be able to extract DNA from a vegetable.
- Identify DNA as the underlying basis for the relationships observed among living things.
- Use a phylogenetic tree as a model to visualize relationships among living things.

Next Generation Science Standards

3LS3-1. Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Analyze and interpret evidence to make sense of phenomena using logical reasoning.	Similarities and differences in patterns can be used to sort and classify natural phenomena.	Many characteristics of organisms are inherited from their parents. Different organisms vary in how they look and function because they have different inherited information.

3-LS4-2. Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Use evidence [observations and patterns] to construct and support an explanation.	Cause and effect relationships are routinely identified and used to explain change.	Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing.

Materials

Broccoli	Blender	Falcon Tubes
Water	Funnel	Ice Ethanol
Cheese cloth	Beaker	Salt
Dawn dish soap	Multicolored pipe cleaners	
Hole punch	Safety Goggles	

ReSTEM Institute:
Reimagining & Researching STEM Education

University *of* Missouri College of Education

Engage **Students will study pictures of different fruits and vegetables and think about why they are different.**	**Step 1**: Ask students to carefully observe the vegetables at their table. Questions to ask: • Do all of these vegetables look the same? • How do you think the vegetables are different? • Why do you think the vegetables look different? • What do you think determines the color, shape, and the taste of different vegetables? **Step 2**: Show YouTube rap about DNA: **https://www.youtube.com/watch?v=5-7ZOLrLyyo** Questions to ask: • After seeing the video, what do you think makes the vegetables and fruits different from one another? • Why do you think that humans are different from one another?
Explore **The goal of this portion of the lesson is to extract DNA from broccoli.** **Students will go through several steps to accomplish the extraction.** **Challenge students to explain the reason for each step.**	During this portion of the lesson students will complete several steps which lead to the extraction of DNA from vegetables. It is important to note that when asked if DNA is in the food we eat, many students will indicate that it is not. During this exercise, we want students to think about the cells which make up all living things and the DNA directions or recipe for that specific organism or structure. **Step 3**: Lead students through the following steps to extract DNA from broccoli: 1. Break apart the broccoli into small parts, just the heads 2. The broccoli heads will be collected in a bowl and blended for the class. • A dish soap, salt, and water solution will be added to the broccoli heads during the blending process Questions to ask: • What do you think the purpose of blending or breaking up the broccoli into very small pieces would be? 3. Explain that dish soap, salt, meat tenderizer, and water are added to: • Break down cell membranes and keep the DNA together 4. Filter the mixture through cheese cloth and funnel into beaker 5. Tilt beaker and slowly pour cold ethanol alcohol into the beaker to the side so that it forms a layer on top of the broccoli. Pour until you have about the same amount of alcohol in the beaker as the broccoli mixture. 6. Look for clumps- that is your strands of DNA! 7. Invite students to extract the DNA with the wood splints provided.

Explain

__Step 4__: Ask students if they think that DNA might be the factor that determines the color, taste, and shape of broccoli.

__Questions to ask__:

- Do you think there might be DNA in your cells also?
- Where do you think your DNA came from

Extend

How can they explain the extraction of DNA from the broccoli cells?

Each of the pipe cleaner colors represents a different Vertebrate.

Be certain to remind the students that all of the vertebrates have a backbone and are related to one another.

Step 5: There are obvious relationships between living things. For instance, there are many types of squash vegetables. Today, we will explore the similarities between organisms which are similar. We will use different colors of pipe cleaners to show the relationship between these plants. Please guide your group and follow the directions provided. Allow children to contribute whenever possible.

1. Make sure all of the pipe cleaners are gathered together and flush at each end
2. Twist all of the pipe cleaners together for about 2 inches so they are intertwined and will not fall apart.
3. Separate the 'Pink' pipe cleaner from the others and twist the remaining pipe cleaners together for another 1 ½ - 2 inches.
4. Continue to repeat # 3 with each pipe cleaner color in the following order:
    a. First separate the purple pipe cleaner and twist the other pipe cleaners [except for Pink and Purple] together for about ¾ of an inch.
    b. Next, separate out the green pipe cleaner and twist the other pipe cleaners [except for Pink, Purple, and Green] for about ¾ of an inch.
    c. Finally, separate out the blue pipe cleaner, this leaves only the orange pipe cleaner.
5. Bend the pipe cleaners so that they appear identical to the image below:

1	2	3	4	5

Pipe Cleaner Colors and Numbers:

1 – Pink: represents Fish

2 – Purple: represents Frogs

3 – Green: represents Retiles

4 – Blue: represents Mice

5 – Orange: represents Human beings

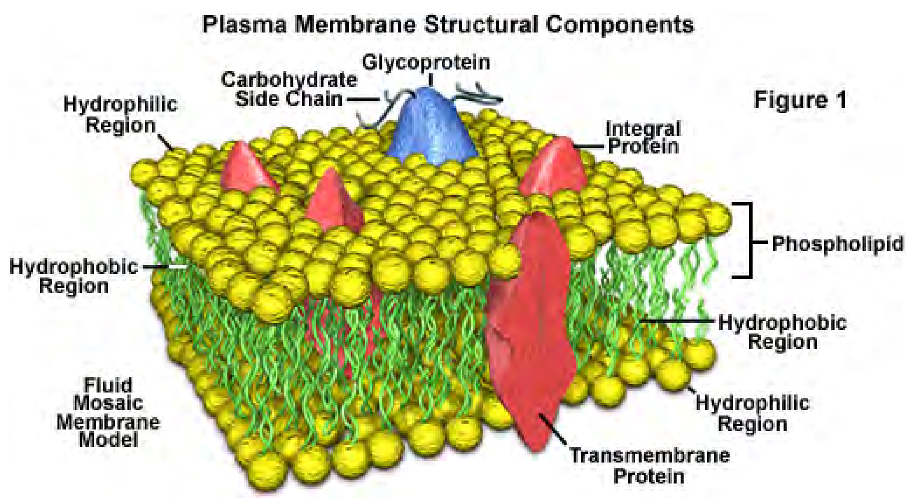
Students learning about the DNA in their food

Extracting broccoli DNA

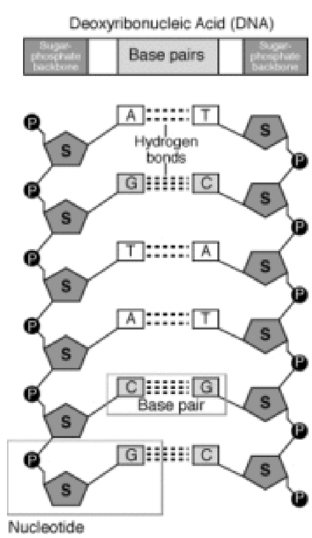
What is on Your Plate? It's All About DNA!

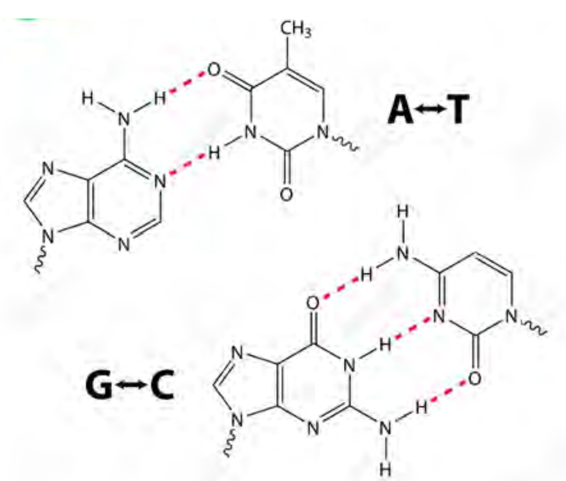
Supplemental Materials

Note the diagram of the cell membrane below. It is important to remember that the cell membrane is largely made up of fats or lipids. Why do you think that is true? (hint: the make-up of the cell membrane prevents some materials form entering the cell).



A diagram of DNA is shown below. Notice that the nitrogen bases (Adenine & Thymine, Guanine & Cytosine) combine to form the rungs of the ladder-like DNA structure. The backbone or sides of the molecule are made up of 5-carbon deoxyribose sugar and phosphate groups.





Food for Thought:

Brainstorm with your students about the purpose of each step in this process. Why do you think we did this to extract DNA?

Dish Soap	Salt	Alcohol (Methanol)
Role in DNA Extraction	Role in DNA Extraction	Role in DNA Extraction

1. It is important that you understand the steps involved in the extraction procedure and why each step was necessary. Each step in the procedure aided in isolating the DNA from other cellular materials. Match the procedure with its function:

<u>PROCEDURE FUNCTION: </u> Place the appropriate letter from the column on the left to the functions on the right:

A. Filter strawberry slurry through cheesecloth
B. Mush strawberry with salty/soapy solution
C. Initial smashing and grinding of strawberry
D. Addition of ethanol to filtered extract

____ To precipitate DNA from solution
____ Separate components of the cell
____ Break open the cells
____ Break up proteins and dissolve cell Membranes

2. What did the DNA look like? Relate what you know about the chemical structure of DNA to what you observed today.

3. Explain what happened in the final step when you added ethanol or methanol to your strawberry extract.
(Hint: DNA is soluble in water, but not in ethanol)

4. A person cannot see a single cotton thread 100 feet away, but if you wound thousands of threads together into a rope, it would be visible much further away. Is this statement analogous to our DNA extraction? Explain.

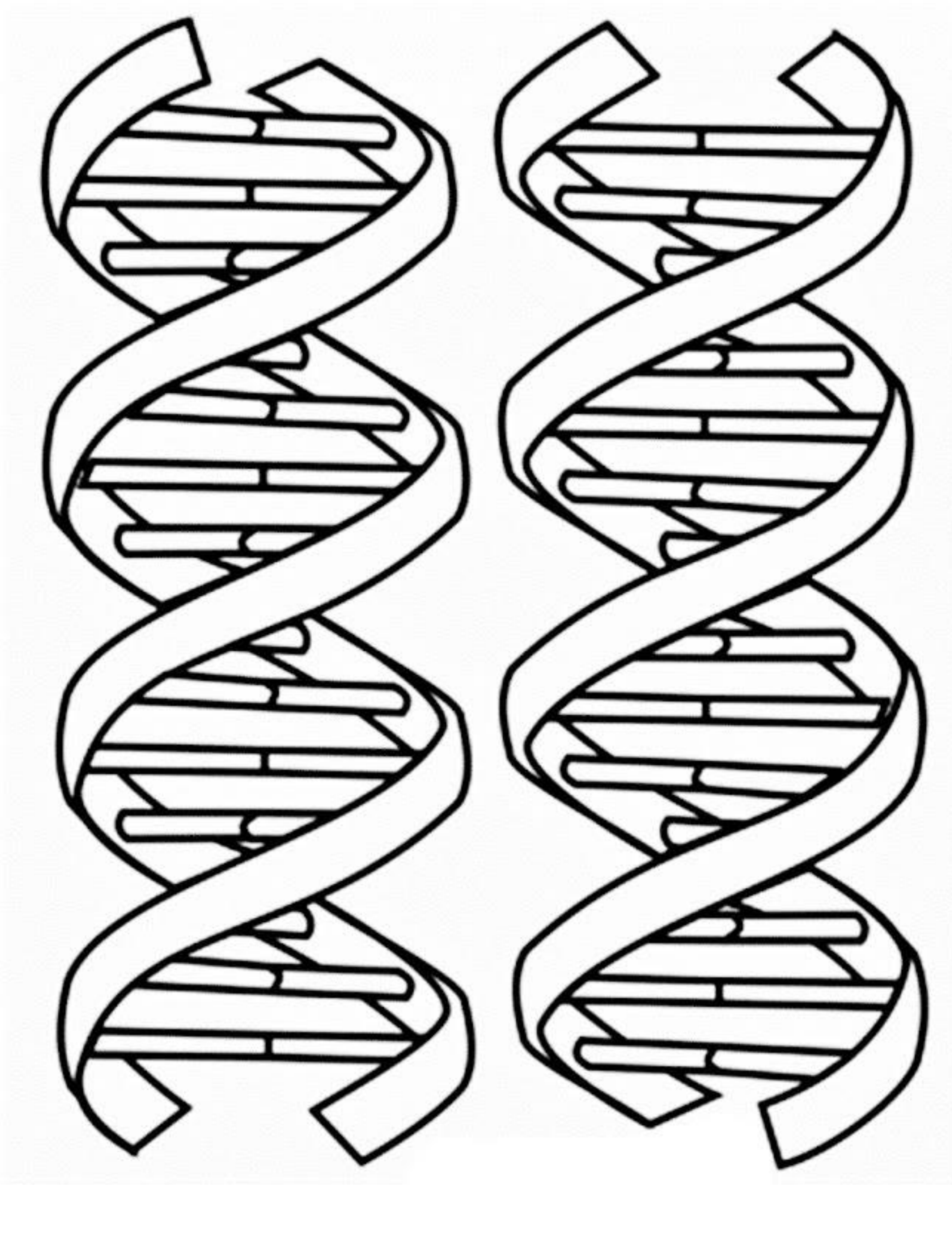
5. Why is it important for scientists to be able to remove DNA from an organism? List two reasons.

6. Is there DNA in your food? _________ How do you know?

The image above contains pictures of different vegetables. As you can see the outside and interior of the vegetables are very different. Ask students to study this list and think about how they could group these:

Suggestions:

- Which of these vegetables/fruits grow above ground:
- Which of these vegetables/fruits grow below ground:
- Which of these vegetables/fruits contain seeds:
- Which would you classify as vegetables? Why?
- Which would you classify as fruits? Why?
- Why are these examples of vegetables/fruits so consistent? Why do the always look and taste the same? For instance, You would not confuse an apple with an orange or a watermelon.



Why does the Same Plant Look Different?

Activity Overview

This activity will introduce students to the idea of segregating traits, or the differences in phenotypes between individuals of the same species of plant (e.g., grapes). Students often do not realize that, although things may look very different (e.g., a raisin and a grape), they may be products of one plant. Using this activity, students will gain insight into the fundamentals of genetics.

Learning Objectives

At the close of this lesson, students will be able to:

- Create an explanation of inherited traits vs. acquired traits.
- Identify parents as the source of inherited traits.

Next Generation Science Standards

3-LS3-1. Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Analyze and interpret data to make sense of phenomena using logical reasoning.	Similarities and differences in patterns can be used to sort and classify natural phenomena.	Many characteristic of organisms are inherited from their parents. Different organisms may vary in how they look and function because they have different inherited information.

3-LS3-2. Use evidence to support the explanation that traits can be influenced by the environment.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Use evidence gathered through observation to support an explanation.	Cause and effect relationships are routinely identified and used to explain change.	Some characteristics result from individuals' interactions with the environment which can range from diet to learning. Many characteristics involve both inheritance and environment.

Materials

Grape varieties
Magnifying lens
Grape plants
Grape stems
Worksheet
Pictures of animals and plants
Butcher paper
Markers

Engage	**Step 1**: Engage children with a discussion focused on inheritance. Ask children to sort the pictures into categories based upon similar characteristics. Pictures can be photos of fruit, animals, and humans. Questions to ask: • What are some of the differences between all of these objects? • Do you think a green grape is different from a red grape? • Do you think both grapes come from the same kind of plant? • Can you think of things that look different, but are actually the same thing (like dogs, cats)?
Explore **Children will explore the concept of inherited and acquired traits.** **Inherited traits are not under the control of the organism. For instance, eye color is inherited, but learning to speak Spanish is an acquired trait.**	**Step 2**: Ask children to study the grapes brought for the lesson. Again, ask the children to think about similarities and differences among the grapes. This might include leaf shape, color of the grapes, sweetness, and variations in grape flavor. Point out that the grapes are all very similar - they are all grapes – however, there are distinct differences between the grapes. Just as all of the children are human but each child is unique and can be differentiated from the others. Questions to ask after they observe the grapes: • Do you have siblings? Do they look the same as you? • What differences do you see between your mom and dad? • Do you think a species of plant could have the same variety between individuals as we see between people? • What do you think could be causing these differences? **Step 3:** Ask Children to complete the inheritance worksheet and distinguish between a trait that is inherited from parents and an acquired trait that is not inherited but developed as a result of environmental conditions. Environmental conditions could include response to injury, disease, learned behavior, etc. Encourage students to think about the traits they observe in plants, animals, and each other which are inherited or acquired. Questions to ask: • Which traits do you think were inherited? Remember that inherited traits are not under your control. Work through the worksheet with the children and discuss each trait ask the children to decide if the trait is inherited or acquired. • Always insist that the children provide a rationale for their ideas and also support their thinking with evidence.

Explain	**Step 4:** Engage child with a discussion of traits and build upon their experiences within the context of the lesson. Focus of Presentation: • Desirable vs. undesirable traits. In dogs we breed them sometimes to have an exceptional sense of smell [like bloodhounds or hunting dogs], sometimes dogs are bred to be herd dogs for sheep or goats, other times dogs are bred to be small and furry companions. Do you think plants can be bred for desirable characteristics? What would be some desirable traits you like in a grape? • Importance of grapes or whatever we are looking at – agriculture, food, drink, studying traits (like sugar content – different flavors – same in apples!) **Step 5:** Thinking about inheritance. Engage children with the butcher paper to record their ideas to key questions. Responses will be shared with the class. Questions to ask: • What traits do you think could be inherited from parents? Think about a little puppy. What traits will the puppy inherit from his/her parents? • What about plants, do plants inherit traits from their parental plants? This is not as easily understood by students because plant parents are not as clearly understood as animal or human parents are. **Step 6:** End the lesson with the YouTube video which is focused on genetics and inheritance. **https://www.youtube.com/watch?v=p99rQV3ek3o**
Explain **During this portion of the lesson ask students to think about their observations.**	**Step 7:** Allow students to share their ideas about inheritance and post the butcher paper around the room.

Background Information:

Genes are in every living organism. They determine characteristics about an organism such as color, height, and other characteristics! Human cells contain approximately 30,000 genes. The genes are a segment of a DNA molecule found in a chromosome. As you know, human cells contain 23 pairs of chromosomes or a total of 46 chromosomes. Each chromosome pair contains one chromosome from each parent. The explanation for this form of inheritance is that humans, like many organisms reproduce sexually. This means that offspring inherit half of their genetic material from each parent.

Genes are important because they determine characteristics by influencing chemical and physical processes during growth and aging. Studying genetics is important in human medicine but also very important in agriculture for crop and livestock improvements as well as in other areas.

Some simple facts to remember about genes in plants are:

- The genes of plants determine their physical uniqueness; characteristics such as height, color, length of growth, productivity, etc.
- Everyone can grow plants with particular characteristics.
- Genetics is the study of genetic make-up and inheritance patterns.
- Gene banks are very important in preserving plant species. Gene banks are places where many varieties of seeds are preserved. These gene banks help researchers develop new varieties of plants and find improvements.

Some simple facts about grapes and grape varieties:

- Grapes are berries that grow on woody vines. They are a fruit and have high sugar content. They may be black, blue, golden, green, purple, red, or white. Grapes may be used by wineries, eaten fresh, dried into raisins, made into juice or jelly, or canned. Most of the grapes grown in the United States come from California.
- At one time, all red grapes had seeds. The Agricultural Research Service of the United States Department of Agriculture created a red seedless grape called the Flame Seedless. Recently, they have developed a black seedless grape called Black Emerald.
- Grape Production: In 1997, 13,690,463,378 pounds of grapes were grown in the United States. Of those, 12,404,514,545 were grown in California.
- Grapes are diverse, there are two types of grapes-European and North American. European grapes grow in areas with milder climates than the North American grapes.
- In the winter, 12 to 18 inch cuttings called canes are cut from grapevines. They are buried in moist sand and stored in a cool place until spring. In the spring, the cuttings are planted in a nursery. The cuttings are planted in the vineyard and approximately one year later they develop into vines. The third and fourth year, the grapevines produce a partial crop and afterwards they produce a full crop.

Why does the Same Plant Look Different?

Supplemental Materials

All About Inheritance			
Traits	**Inherited**	**Acquired**	**Your Explanation**
Humans & Animals			
Eye Color			
Riding a Bike			
Webbed Feet			
Male or Female			
Speaking Spanish			
Fur Color			
Bank Account			
Scars			
Pierced Ears			
Ear Shape			
Plants			
Woody Stem			
Leaf Shape			
Fruit size			
Fruit Taste			
Fruit Color			
Fruit Sweetness			
Flower Color			
Stem Scar			
Brown Spots			

All About Inheritance [Key]			
Traits	**Inherited**	**Acquired**	**Your Explanation**
Humans & Animals			
Eye Color	X		Inherited from parents in animals and in humans
Riding a Bike		X	Learned behavior in humans
Webbed Feet	X		Inherited from parents in aquatic birds and frogs
Male or Female	X		Inherited from parents in animals and in humans
Speaking Spanish		X	Learned behavior in humans
Fur Color	X		Inherited from parents in animals
Bank Account		X	Learned behavior in humans
Scars		X	Acquired through injury to animals and humans
Pierced Ears		X	Acquired in humans
Ear Shape	X		Inherited from parents in animals and in humans
Plants			
Woody Stem	X		These traits are all inherited from the parental generation.
Leaf Shape	X		
Fruit size	X		
Fruit Taste	X		
Fruit Color	X		
Fruit Sweetness	X		
Flower Color	X		
Stem Scar		X	Acquired following an injury to the plant
Brown Spots		X	Acquired following an injury or disease

Genetics and Inheritance Card Sort

Learning Objective: Students will be engaged with a Card Sort activity to enhance understanding of inheritance by observing pictures of different organisms [plants and animals].

Directions:

1. Ask students to study the cards and next to sort the cards into major groupings.
    - Initially students will sort the cards into a plant stack and an animal stack
2. Next, ask the students:
    - What rule did you use to sort the cards?
    - Look at the cards in the groups you sorted. Can you sort the cards into smaller groups based on the characteristics of the organisms in each group?
3. Allow the students to sort the cards into subgroups.
    - Subgroups could include:
        - Animals with hair or fur
        - Animals with feathers
        - Trees
            - Fruit producing trees
        - Root vegetables
        - Carrots
        - Seed producing vegetables [soybeans, corn]
        - Flowering plants
4. Next, ask the students:
    - How did you decide the subgroups into which the cards would be sorted?
    - What do you think made these organisms different from one another?
    - Did these animals look like their parents?
    - What do you think the animals might have inherited from their parents?
    - Remember that inheritance refers to something inherited from someone else.
        - In this instance inheritance refers to the characteristics inherited from parents [feathers, feather color, fur, fur color, size, etc.]


Swallowtail on rough blazing star
©Nicholas











Why is My Apple Turning Brown?

Activity Overview

This activity will introduce children to the concept of chemical reactions and the chemistry of life. Students have all bit into an apple and noticed that the white flesh of the apple soon turned brown. This is a simple and fascinating experience which involves a chemical reaction involving oxygen and enzymes within the apple.

Next Generation Science Standards

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival. Use observations to describe patterns of what plants and animals need to survive.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Construct an argument with evidence, data, and/or a model.	A system can be described in terms of its components and their interactions.	Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.

5-PS1-3. Make observations and measurements to identify materials based upon their properties.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Make observations and measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.	Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.	Measurements of a variety of properties can be used to identify materials.

Materials

Sliced apples
Cups or small containers
Baking soda
Distilled water
Vinegar
Lemon juice
Milk
Red cabbage indicator

Engage

Step 1: Engage children with a discussion focused fruit and the manner in which fruit changes when sliced or peeled and exposed to the air.

Questions to ask:

- What color is the inside of an apple?
- If you take a bite from an apple and allow the apple to be exposed to the air, how will the interior of the apple change?
- How would you explain your observation?

Explore
 	
Students will explore the nature of acids and bases and also note the impact of acidic and basic solutions on the enzymes in apples.
 	
Ask the students if their parents or grandparents put orange juice or lemon juice on a fruit salad. Why would they do that?
	Step 2: Students will set up their investigation.
	• Each table will have 5 containers for the following liquids:
	  o Milk
	  o Baking soda & water solution
	  o Vinegar
	  o Lemon juice
	  o The 5th container will be left empty
	
	Step 3: Making Predictions
	<u>Questions to ask:</u>
	• What do you think will happen when the apple slices are placed in each of the 5 environments?
	  o No liquid
	  o Milk
	  o Baking soda and water solution
	  o Vinegar
	  o Lemon juice
	• Why do you think this will happen?
	
	Step 4: Testing the liquids – Instruct students to:
	• Place 15 drops of the red cabbage indicator into four of the wells of the micro-chemistry plates
	• Place a small quantity of each liquid into one of the wells containing the red cabbage indicator
	<u>Questions to ask:</u>
	• Did you see any changes in the red cabbage indicator after adding drops of the solutions: milk, baking soda and water, vinegar, and lemon juice?
	• Why do you think this might have happened?

Explain **Link the pink color change in the cabbage juice indicator to the changes observed in the apple slices.**	**Step 5:** Fill out Challenge Page #2 • Work with the children in your group to complete the sheet • Discuss the changes the children observed when the different solutions were added to the red cabbage indicator • Ask students what they know about the properties of each liquid. **Step 6:** Observe apple slices and complete Challenge Page # 1 and describe the apple slices in each of the liquids in Challenge Page #2.

Extend **During this portion of the lesson ask students to think about their observations.**	**Step 7:** Explore the distinction between common 'monocot' and 'dicot' plants • Provide students with a series of plant leaves, flowers, and seeds. Questions to ask: • Can you group the seeds into two groups? What rule would you use to separate the seeds? **Step 8:** Ask the students to study the plant leaves at the table. Questions to ask: • Can you group the plant leaves into two different groups? What rule would you use to separate the leaves **Step 9:** Show the brief video distinguishing monocots and dicots. https://www.youtube.com/watch?v=OBz1unaMr6I

Background Information:

Apples turn brown when exposed to air because of the oxidation process that goes on when the inside of the apple gets exposed to the ambient air which contains oxygen and water molecules. The skin of the apple protects it from this process. This oxidation process is very sensitive to the ambient temperature.

Before the apple is cut, the apple peel protects the white fruit of the apple. However, when the apple is cut two things occur:

- First, enzymes within the apple are released. Second, these enzymes react with oxygen and actually oxidize the damaged cells of the apple to form a protective barrier between the atmosphere and the pulp of the apple. This is not unlike the formation of a scab in humans when you cut yourself. The scab prevents pathogens like bacteria from gaining access to the body.
- Enzymes are proteins which carry out specific functions within the body. Unique environments have the potential to interfere with protein folding. When proteins are denatured or altered by environmental factors, the ability to maintain a specific conformation is compromised and the protein is not able to fold in the correct orientation. The inappropriate shape assumed by the protein renders it incapable of catalyzing a specific reaction. For this reason, exposure to an acidic environment interferes with the protein inhibiting the oxidation reaction which results in the browning of the apple.
- Enzymes also have an optimum temperature range. If enzymes are heated, the heat has the potential to denature the protein and render it incapable of catalyzing the oxidation reaction. This is also true of extremely cold environments. Therefore, if apple slices were to be placed in the refrigerator, the lower temperature would inhibit enzyme activity and slow the browning of the apples.
  - An important consideration is the difference of the two temperature extremes on enzyme structure. Enzymes are denatured by high temperatures, this means the molecular configuration of the enzyme is affected resulting in a permanent change. However, cooler temperatures [comparable to those within a refrigerator] would slow enzyme function and inhibit the reaction catalyzed by the enzyme.

Why is My Apple Turning Brown?

Supplemental Materials

Challenge Page # 1: Predictions, Observations, & Explanations					
	No Liquid	Milk	Baking Soda Solution	Vinegar	Lemon Juice
Prediction [How will the apple slice change?]					
Observation [How did the apple slice change?]					
Explanation [What patterns did you see? How can you explain your observations?]					

Challenge Page # 2: Testing the Liquids							
		Red Cabbage Indicator Color Change			Is the solution acidic, neutral or basic?		
Liquids	Description of Apple Slice	Pink	No Change	Green	Acidic	Neutral	Basic
Milk							
Baking Soda & Water Solution							
Vinegar							
Lemon Juice							

Why Is My Plant Sick?

Activity Overview

This activity will introduce children to pathogens common to crop plants [e.g., soybeans]. Because students often do not realize that plants, like humans, also get sick. Students will gain insight into specific plant pathogens such as nematodes.

Next Generation Science Standards

5LS1-1. Support an argument that plants get the materials they need for growth chiefly from air and water.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Support an argument with evidence, data, or a model.	Plants acquire materials required for growth chiefly from air and water	Matter [water and gases] can be transported into, out of, and within plant systems.

K-LS1-1. Use observations to describe patterns of what plants and animals need to survive.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Use observations [firsthand or from media] to describe patterns in the natural world.	Patterns in the natural and human designated world can be observed and used as evidence.	All animals need food in order to live and grow. Animals obtain their food from plants or from other animals. Plants need water, air and light to live and grow.

Materials

Plants (infected with pathogen of choice)
Plastic Tubs
Water
Magnifying Glass
Crayons or colored pencils [green, yellow & brown]
Paper
Scissors
Paper towels & plates

Engage

Students will study both the roots and shoots of a healthy and an infected plant.

Step 1: Ask students to carefully observe the plants at their table. Work with students to construct a written list of observations for each plant. Guide students to differentiate between the two plants.

Step 2: Coloring page: Instruct students to use the colored pencils and/or crayons at their table to color the two plants on the coloring page. As the children color the plants, ask them to think about how the plants are alike and different.

- Encourage the children to differentiate between the plants as they color the images.

Explore **The goal is to stimulate interest in the plants and guide the children through a careful observation of the two plants.** **Remember that one of the plants is infected with a pathogen while the other is healthy.** **Encourage the children to think about how they look and feel when they are sick.**	During this portion of the lesson, students will explore the structure of both the shoots, leaves, and roots of the plants. The goal is to emphasize the differences between the two plants. Use the questions below as the starting point to guide the exploration. Describe the parts of the plants: • Identify the shoot as consisting of a stem and leaves. As students look at the plants and the plants they colored earlier, remind them of the names [leaves, stem, etc.] Questions to ask when observing the plant shoot above the soil: • Do you think the two plants are different? • What made you think the two plants were different? What characteristics indicated that one plant was different from the other? • What colors did you use to show the plants were different? Encourage students to observe the plants carefully using the magnifying glasses provided. Questions to ask as students use magnifying glasses to observe the plants: • Using the magnifying glass at your table, can you see differences in the leaves on the two plants? Follow the directions below to make the roots of the plants visible: 1. Carefully remove the plants from the soil. Take care not to break the stem. 2. Gently remove the soil from the roots of the plants. Again, take care not to damage the roots. 3. Wash the remaining soil from the roots with the water in the tub. 4. Place the plants with washed roots on the paper towels provided. 5. Encourage the children to use a magnifying glass to carefully observe the roots. 6. Complete the picture by coloring in the roots. Questions to ask: • Have you ever been sick? How do you look when you are sick? • Do you think that plants can get sick as well? How could you tell if a plant is sick? How do you think the plant would change? • Do you see anything different between the two plants? Could one of the plants be sick? What did you observe when studying the plants that made you think one of them could be sick?

Explain	During this portion of the lesson, students are encouraged to focus on plant health. Ask students to share their ideas about what makes them sick.
During this portion of the lesson ask students to think about their observations.	Questions to ask: • What do you think makes you sick? • Why do you think your teacher tells you to wash your hands before you eat lunch? • Can you get germs on your hands? How do you think that happens? • Can germs make you sick? • Do you think that germs can make plants sick?

How can they explain the differences between the plants?	Direct students' attention back to the plants and ask the students to observe the roots.
	
	Questions to ask:
	• Look at the two plants. Do you think one of the plants could be sick?
	    o Why would you think that?
	    o When you get sick does your appearance change? Does your teacher say that you look like you do not feel well?
	    o Study the plant roots again. Ask students if they see anything different between the plant roots.

Equate disease in plants to human disease to help students explain how plants might get sick.	Introduce the concept of pathogens to the students. Explain that pathogens could be anything that would make the plants sick. Human pathogens include bacteria and viruses. [parasites may be a bit much for the children to understand] When plants get sick, they too are affected by pathogens. Sometimes pathogens are bacteria or viruses. Other times the pathogens include unique organisms like Nematodes.
	• This might be a good time to share slides of nematode pathogens with the students.
	• Differentiate between earthworms and Nematodes.
	• Point out that the Nematodes are very small and able to live within the roots of the plants.
	    o Briefly establish root function for the students. Questions to ask:
	        ▪ What do you think the job of plant roots might be?
	        ▪ How do you think plants get water and minerals from the soil?
	        ▪ Do you think that the plant would get sick if the roots were damaged by a Nematode?

Extend	Review the parts of a plant: https://www.youtube.com/watch?v=ql6OL7_qFgU • This video identifies the parts of a plant and supports students' understanding of plant structure. Emphasize that plants, like humans, have the potential to become sick. The sickness is caused by pathogens [bacteria, viruses, parasites like nematodes] which live within the plant and make the plant sick.

Background Information:

http://www.apsnet.org/edcenter/K-12/TeachersGuide/ThingsToDo/Pages/Background.aspx

- All plants, native and cultivated, are prone to diseases and injuries. There are many definitions of plant disease. One definition is that disease is suboptimal plant growth brought about by a continuous irritant, such as a pathogen (an organism capable of causing disease) or by chronic exposure to less than ideal growing conditions.

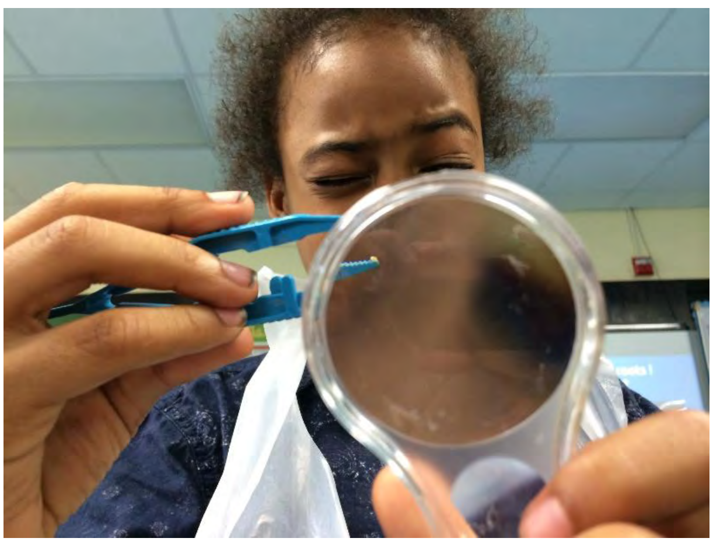
- Plant injury is defined as the loss of plant vigor resulting from an instantaneous event, such as a lightning strike, hail damage, chemical burn or mechanical damage. Because of the instantaneous and "cause-and-effect" nature of injuries, they are often easy to diagnose. In the case of diseases, the effects are caused by a continuing process or irritation.

- Therefore, the source of continuous irritation may be abiotic (non-living) or biotic (caused by a pathogen). Abiotic diseases are also referred to as non-infectious diseases as they do not spread from plant to plant. Examples can include nutrient deficiencies growing under too much or too little light, and air pollutants such as automobile exhaust. Biotic diseases are caused by pathogens and are often referred to as infectious diseases, because they can move within and spread between plants. Plant pathogens are very similar to those that cause disease in humans and animals and include viruses, bacteria, fungi, and nematodes.

- Pathogens may infect any part of the plant including leaves, shoots, stems, roots, fruit, and seeds. For an infectious disease to develop, a susceptible host, a pathogen capable of causing disease and a favorable environment for the pathogen to grow is required. If any one of these factors is absent, disease will fail to develop. In the case of infectious plant diseases, practices that favor plant growth over pathogen activity tend to decrease the amount of disease observed. For example, plants that are fertilized and watered correctly will be less likely to develop disease.

- Regardless of which pathogen, disease development on a plant requires that the pathogen must: (a) come into contact with a susceptible host (referred to as inoculation); (b) gain entrance or penetrate the host through either a wound, a natural opening on plant surface (stomata, lenticels, etc.) or by direct penetration of the host; (c) establish itself within the host; (d) grow and multiply within or on the host; and (e) be able to spread to other susceptible plants. Successful pathogens must also be able to survive long periods of unfavorable environmental conditions in the absence of a susceptible plant host. Together, these steps are referred to as the disease cycle. If this cycle is broken, the disease will be less severe or fail to develop.

- Symptoms of disease in plants are visual or noticeable changes of a plant which result from disease or injury. Early after infection, disease symptoms are often invisible since they take time to develop. Examples of common symptoms are: yellowing of leaves; wilting of leaves; dropping of leaves or fruit; and stunting of plant parts or the whole plant.



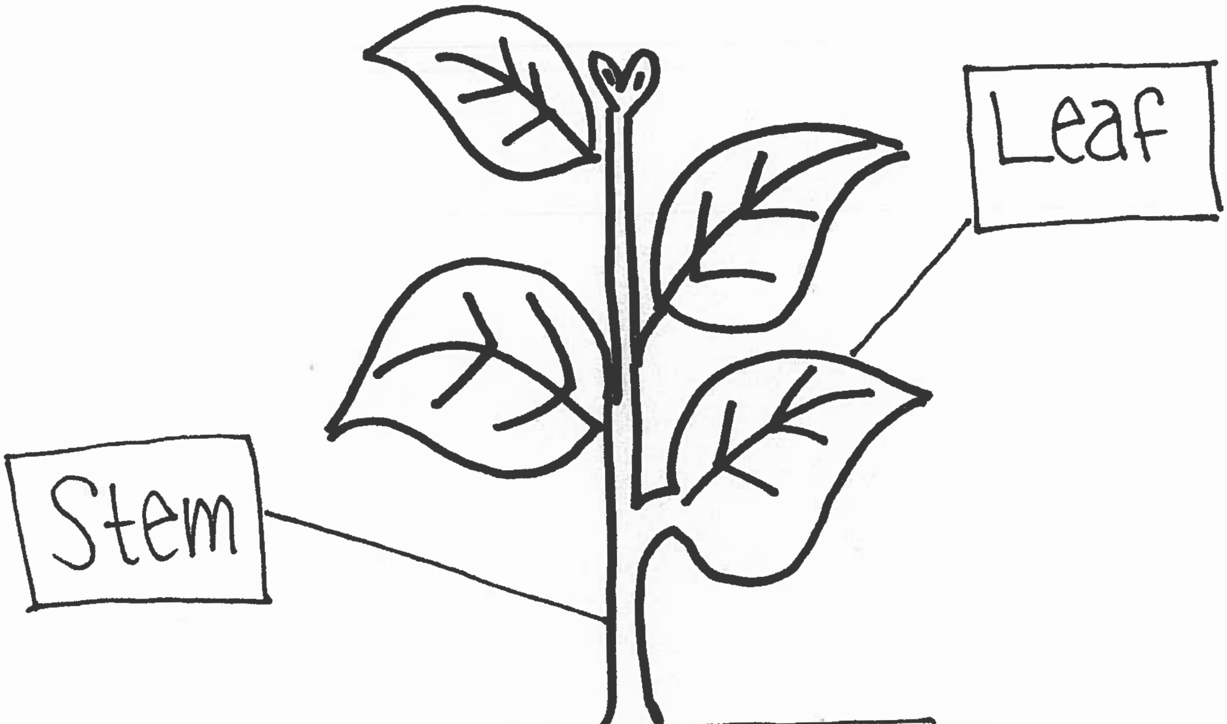
Up close and personal with a nematode cyst

Graduate and undergraduate student lesson leaders teaching about sick plants

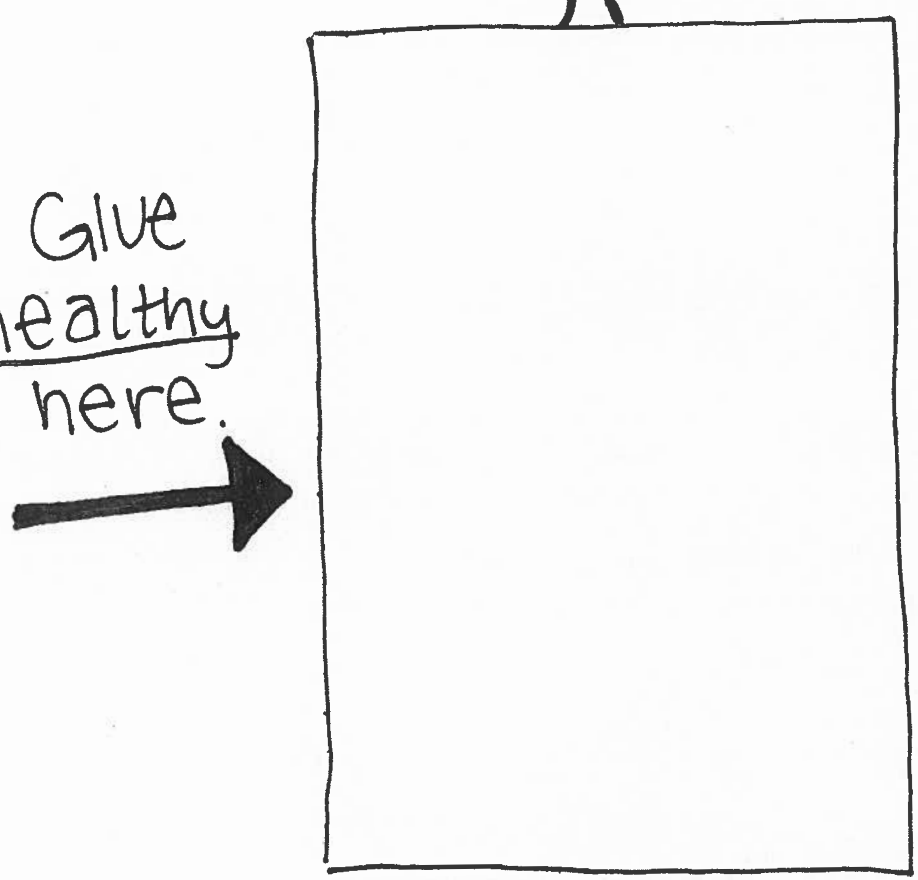
Why is My Plant Sick?

Supplemental Materials

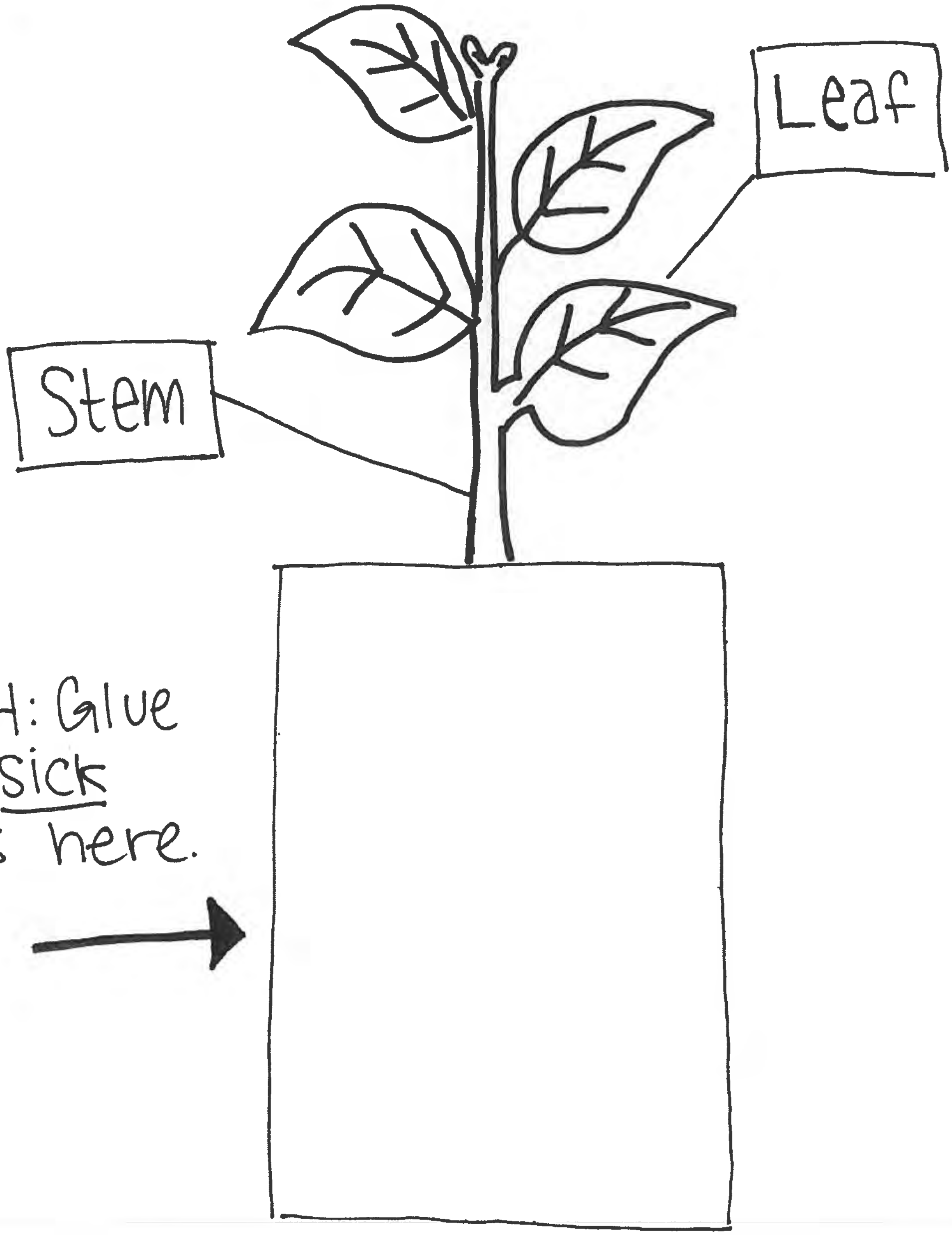
Step 1: Color the healthy plant.



Step 2: Glue the healthy roots here.

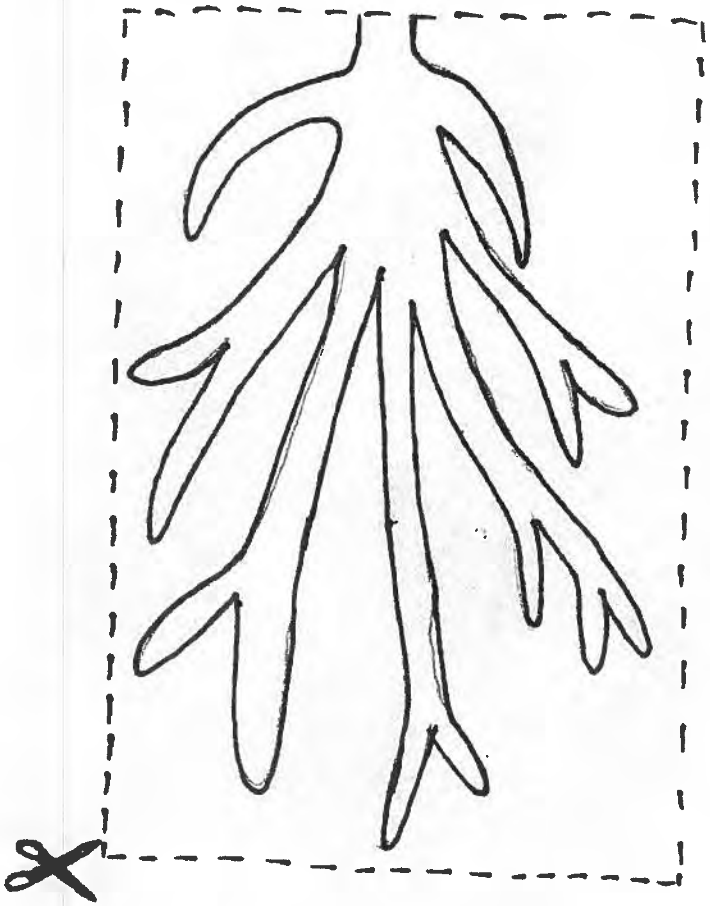


Step 3: Color the sick plant.



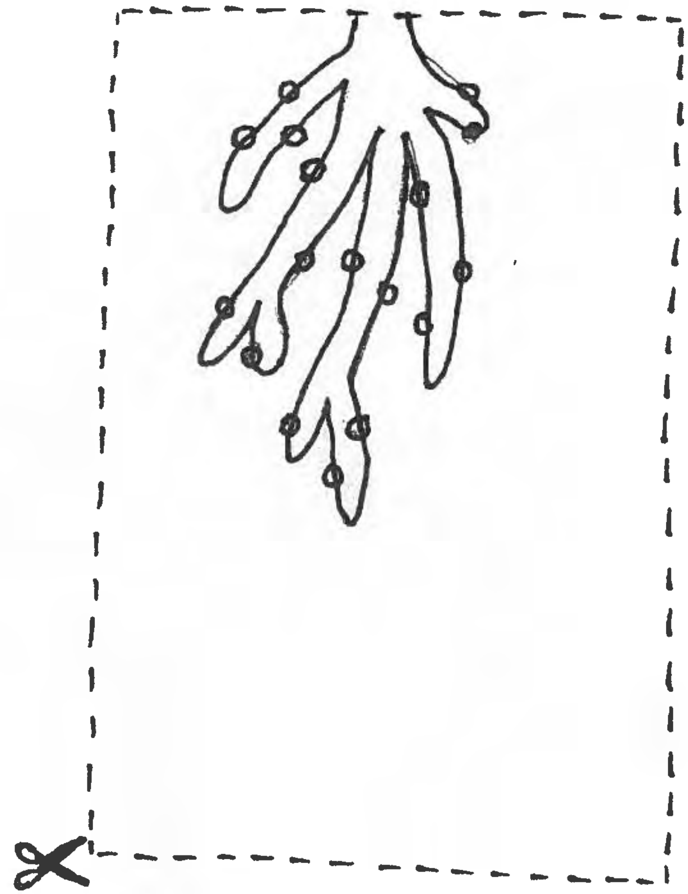
Step 4: Glue the sick roots here.

Step 5: Color the <u>healthy</u> roots.

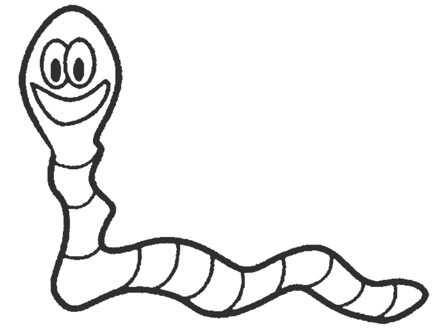


Step 7: Cut out the <u>healthy</u> roots.

Step 6: Color the <u>sick</u> roots.

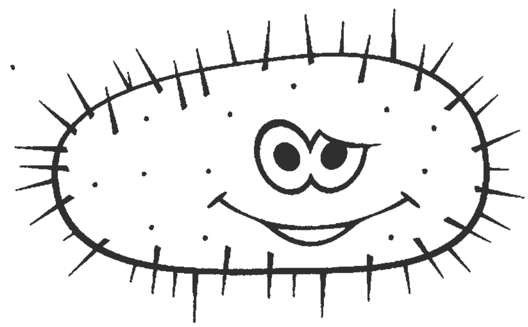


Step 8: Cut out the <u>sick</u> roots.



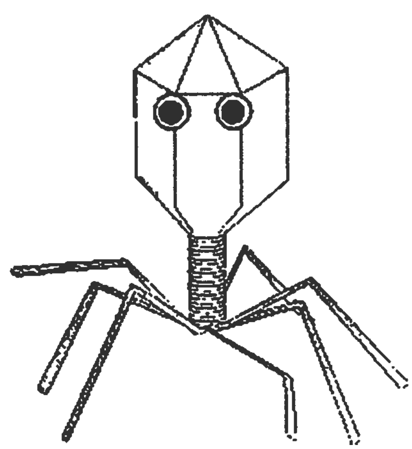
Nelly Nematode

Benny Bacteria

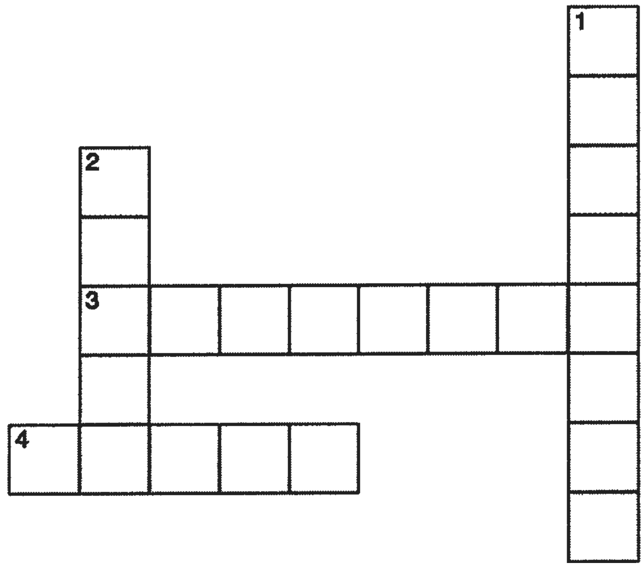


Freddy Fungi

Vinny Virus



Plant-Microbe Interactions

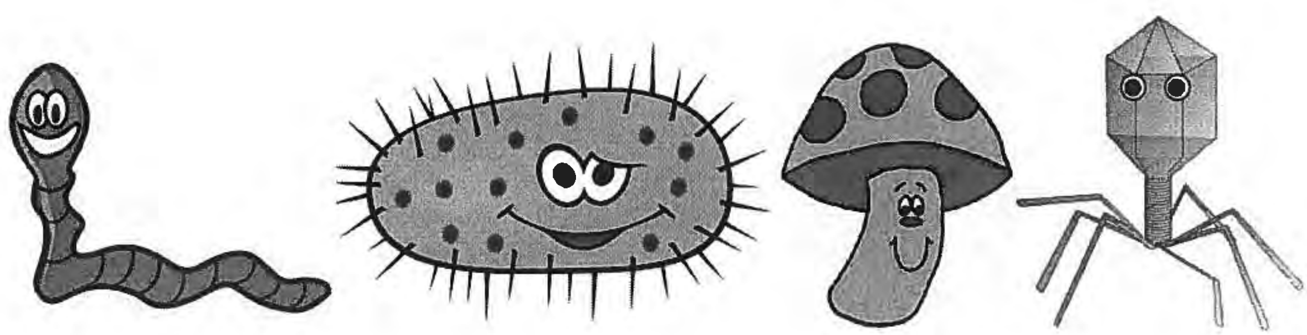


Down

1. They are single-celled microorganisms. Their cell structure is unique in that they don't have a nucleus and have cell walls similar to plant cells.
2. They are a group of living organisms which are classified in their own kingdom. They get their food by decomposing matter or eating off their hosts as parasites.

Across

3. They are free-living, nonsegmented round worms that are transparent or colorless.
4. They are small particles that hijack the cells of living organisms. They inject their genetic material right into the cell and take over.



Nematode Bacteria Fungi Virus

Plants and Nutrients: It's All About Color!

Activity Overview

The focus is on nutrition and plants.

The goal is to support students' understanding of the relationship between color and nutrition.

The purpose of this lesson is to engage students with the concept of plant nutrition. With the emergence of fast food, vegetable choices for many students are focused on French fries rather than broccoli, kale, green beans, etc. Focusing student attention on the vast array of plants and the nutritional benefits from each is very important.

The taste and color of edible plants may actually arise from the nutrients held within the cells and tissues of the plants. It is important to note that a healthy diet is derived from a balanced diet with includes edible plants. These plants supply multiple minerals, vitamins, and nutrients which are critical to maintaining a healthy life style.

It is also important to note that science [biotechnology] has contributed and will continue to contribute and enhance plant nutrients. As children and adults, Benton students are consumers and the foods they choose to eat have the potential to impact their health.

Learning Objectives

At the close of this lesson, students will be able to:

- Match nutrients with plants
- Identify plants as an important addition to a healthy diet.

Next Generation Science Standards

The focus of the performance standards is on the development of a model or explanation supported by evidence.

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Construct an argument with evidence, data, and/or a model.	A system can be described in terms of its components and their interactions.	Plants and animals have both internal and external structures that serve various functions in growth, survival, and reproduction.

5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Develop a model to describe a phenomenon.	A system can be described in terms of its components and their interactions.	The food of almost any kind of animal including humans can be traced back to plants. Matter cycles between the air and soil and among plants, animals, and microbes.

Materials

Broccoli, Blueberries, Kale, Oranges, Strawberries, Brussel Sprouts, Tomatoes, Banana
Puzzle game
Video clip for golden rice

Engage

Step 1: Engage children with a discussion focused on healthy eating. Ask students a series of questions about foods they like to eat. Ask students to sort pictures of different fruits and vegetables. The students will sort the food by its color.

Questions to ask:

- Why do you think these foods have different colors?
- Do you think that color has something to do with the taste of the food?
- Do you think color has something to do with the nutrition in the various foods you just sorted?

Table of tastes and colors:

Name of edible plant	**Characteristic**	**Nutrients**
Lemon	Plant Part: Fruit Taste: Sour Color: Yellow	High vitamin C
Sweet potato	Plant Part: Tuber [Root] Taste: sweet Color: Orange	Vitamin A
Kale	Plant Part: Leafy stem Taste: Similar to lettuce Color: Green	Vitamin A & C; Dietary Fiber
Blueberries	Plant Part: Fruit Taste: Sweet Color: Blue	Anthocyanins (antioxidant)
Broccoli	Plant Part: Stem and Buds Taste: Similar to Brussel Sprouts Color: Green	Vitamin C Iron
Hummus (from chickpeas)	Plant Part: Seed Taste: Similar to peas Color: Tan	High in protein; Dietary Fiber

Explore	**Step 2**: Ask the children if they can name nutrients in the foods we eat. It is important to note that there are key nutrients. Questions to ask: • What nutrients do you know of that are in the foods we eat? • Why do you think we need these nutrients? **Step 3:** Ask the students to think about the nutrient match up and draw lines from each nutrient to the function of the nutrient in our bodies. Questions to ask: • Can you name some examples of food we eat every day that contain the nutrients listed in the Nutrient Match Up? **Step 4:** Continue to focus on nutrients by asking students to identify foods that contain the nutrients identified in each of the diagrams. Questions to ask: • Why do you think your body needs carbohydrates? • Why is protein important? • Can you think of some minerals in the food we eat? • There is one nutrient missing. What do you think it might be? [vitamins]

Explain	**Step 5:** Challenge the children to sort the fruits and vegetables.
	• First sort the fruits and vegetables by color alone
	• Next, ask students to sort the fruits and vegetables by the nutrients they likely contain.
	  o There is a chart at the end of the lesson with a list of nutrients and the foods which contain each.
	  o There will be a good deal of overlap
	
	Questions to ask:
	• Do you think vegetables are important and should be eaten every day?
	
	Step 6: End the lesson with the puzzle activity. Please see directions at the close of the lesson.
	Step 7: Scientists are changing vegetables so that they are more nutritious. One of the success stories is 'golden rice'. Golden rice is rich in vitamin A unlike regular rice. We will show the video below.
	
	https://www.youtube.com/watch?v=mxsIx4sgWM8
	• Golden rice has been genetically altered to produce beta-carotene which is vitamin A. this form of rice offers the potential for people throughout the world to avoid vitamin A deficiency.

Background Information:

Color is More than a Pretty Plant:

For millions of years, insects have relied on flower color to find the right food source. Now nutrition researchers are discovering that the rainbow of color pigments in fruits and vegetables may do more than simply attract attention or please the eye.

The orange pigment, beta carotene—best known of the plant color compounds—first caught researchers' eyes when population studies linked low rates of certain cancers with a high intake of fruits and vegetables containing lots of beta carotene.

A current theory holds that cancer, heart disease, stroke, and other diseases of aging result from cumulative damage to cells by free radicals—most of which our cells generate through ordinary metabolism. So nutrition and medical researchers are dissecting the fruits and vegetables consumed by healthy populations, looking for the best combinations to prevent such damage.

What they are finding is that fruits and vegetables contain hundreds of other pigments besides beta carotene—as well as non-pigment compounds—that may play a role in preventing oxidative damage.

Studies to date suggest certain plant chemicals, or phytochemicals, appear to maintain health by boosting the immune system, reducing inflammation and allergies, detoxifying contaminants and pollutants, and/or activating enzymes that block unbridled cell division.

Why include vegetables in your diet?

Harvard researchers found that people with the highest intake of fruits and vegetables, especially those rich in lutein, had half the risk of macular degeneration as those with the lowest intake.

Lutein—along with several other carotenes—gives summer squash, apricots, peaches, and oranges their yellow to light-orange color. But its richest sources are kale, spinach, and collard greens, in which the yellow pigment is masked by the more abundant green chlorophyll pigments.

Lycopene gives tomatoes their bright red hue and invariably stains our clothes when we indulge in a plate of spaghetti. High intakes may protect against prostate cancer. In a study of men 40 years and older, those who consumed more than 10 servings of tomato products per week had two-thirds the risk of prostate cancer as those who ate less than 1.5 servings weekly.

Plants and Nutrients: It's All About Color!

Supplemental Materials

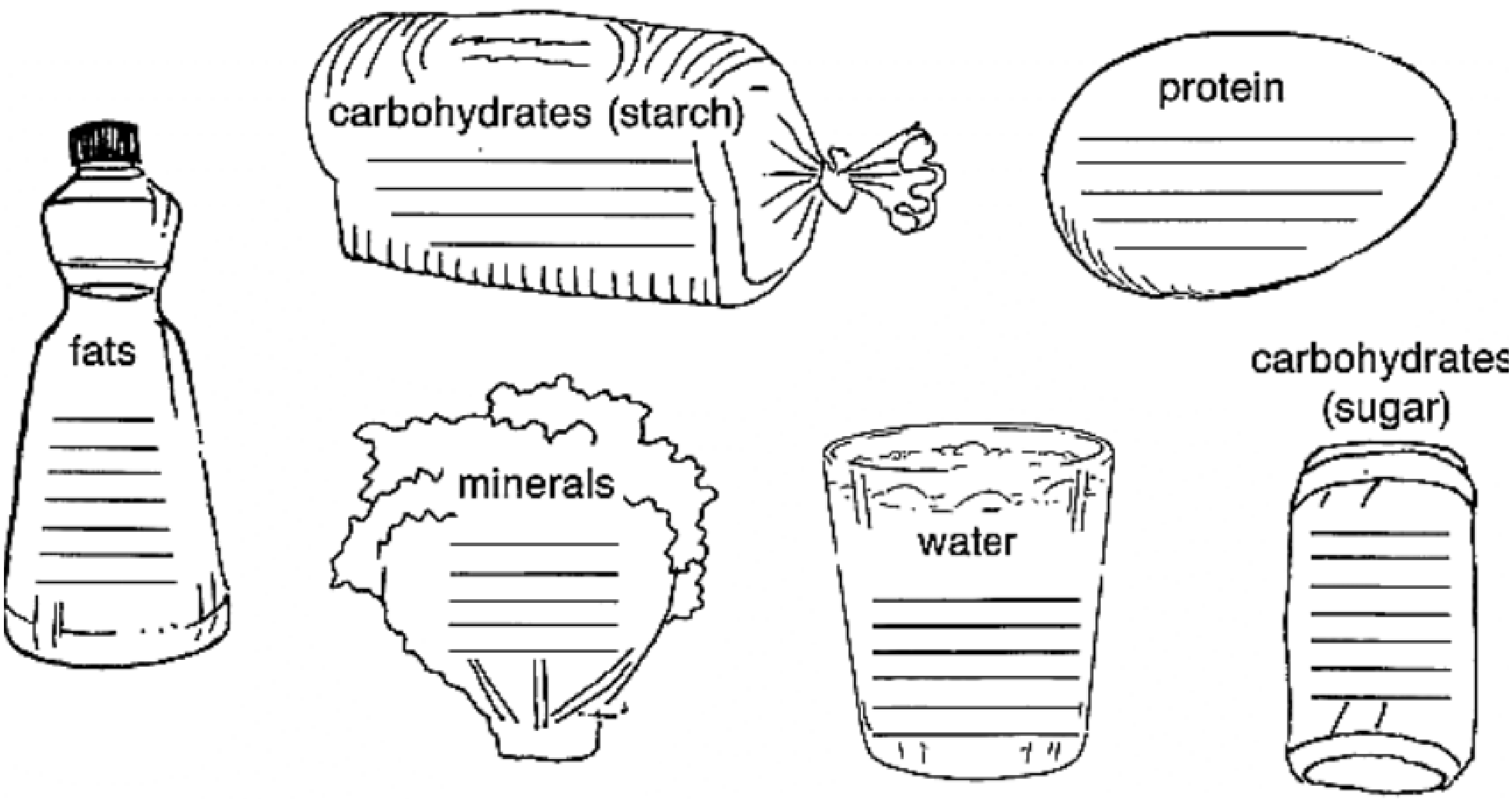
Challenge 1: match the nutrients with the function of each in our bodies.

MATCH UP

Nutrient cards	Function cards
protein	builds and mends muscles and other tissues
carbohydrates	give us energy for work and play
fats	give us energy for work and play
minerals	keep the body healthy
vitamins	keep the body healthy
water	keeps body temperature steady and stops the body from drying out

Challenge 2: Identify foods that contain the nutrients listed below.

What foods do you know of that contain the nutrients listed below?



Vitamins	Function	Food Source	Mineral	Function	Food Source
Vitamin A	Prevents vision problems Immune function Skin health	Kale, Carrots, Pumpkin, Apricots, Peaches, Papayas, Mangos, Grains	Calcium	Vital for strong bones and teeth. Most effective during childhood	Broccoli, dark green leafy vegetables, soybeans.
Vitamin C	Healthy skin, bone, gums, and blood vessels Promotes healing	Citrus fruits, red berries, tomatoes, broccoli, spinach	Iron	Vital for making red blood cells to carry oxygen throughout the body.	Lentils, beans, soybeans, green leafy vegetables, raisins, and grains
Vitamin D	Strengths bones and helps the body to use calcium	Made in skin cells	Magnesium	Critical for muscle and nervous function	Whole grains, nuts, seeds, green leafy vegetables, potatoes. Beans, avocados, bananas, kiwi, broccoli, and chocolate
Vitamin E	Protects cells from damage	Vegetable oils, nuts,	Phosphorus	Critical for healthy bones and teeth also helps the body turn carbohydrates into energy	Found in nearly all food sources.
Vitamin B6	Important for brain and nervous system function	Potatoes, bananas, beans, seeds, and nuts	Potassium	Critical for muscle and nervous system health.	Broccoli, potatoes, green leafy vegetables, peas, and lima beans
Vitamin B1 [Thiamin]	Helps the body convert carbohydrates into energy to support muscles and nervous tissue	Whole grains [whole wheat bread]	Zinc	Vital for normal growth and a strong immune system	Nuts, dried beans, soybeans, and whole grains
B2 [Riboflavin]	Helps the body turn food into energy	Peas, lentils, nuts, green leafy vegetables, broccoli, asparagus			
B3 [Niacin]	Helps the body turn food into energy	Peanuts			
B9 [Folate}	Helps the body to make red blood cells. Helps the body to make DNA and is very important for developing babies	Legumes and beans, green leafy vegetables, asparagus, oranges and other citrus fruits			

Key:

Name of edible plant	Characteristic	Nutrients
Lemon	Plant Part: Fruit Taste: Sour Color: Yellow	High vitamin C [This vitamin makes your skin heal from injury more quickly –also found in oranges and grapefruit]
Sweet potato	Plant Part: Tuber [Root] Taste: sweet Color: Orange	Vitamin A [This vitamin is very important for your eyes – without this vitamin you could go blind]
Kale	Plant Part: Leafy stem Taste: Similar to lettuce Color: Green	Vitamin A [This vitamin is very important for your eyes – without this vitamin you might be blind] Vitamin C [This vitamin makes your skin heal from injury more quickly –also found in oranges and grapefruit]
Blueberries	Plant Part: Fruit Taste: Sweet Color: Blue	Anthocyanins (antioxidant) [This nutrient combines with harmful substances that form inside your cells]
Carrots	Plant Part: Root Taste: Sweet Color: Orange	Vitamin A [This vitamin is very important for your eyes – without this vitamin you could go blind]
Broccoli	Plant Part: Stem and Buds Taste: Similar to Brussel Sprouts Color: Green	Vitamin C [This vitamin makes your skin heal from injury more quickly –also found in oranges and grapefruit] Iron
Hummus (from chickpeas)	Plant Part: Seed Taste: Similar to peas Color: Tan	High in protein; Dietary Fiber [This nutrient helps your body to grow and make new muscle and bone tissue]

Student Page

Name of edible plant	Characteristic	Nutrients
Lemon	Plant Part: Fruit Taste: __________ Color: __________	Vitamin ____ [This vitamin makes your skin heal from injury more quickly –also found in oranges and grapefruit]
Sweet potato	Plant Part: __________ Taste: sweet Color: ___________	Vitamin ___ [This vitamin is very important for your eyes – without this vitamin you could be blind]
Kale	Plant Part: ____________ Taste: Similar to lettuce Color: ___________	Vitamin C Vitamin ____ Dietary Fiber [This vitamin is very important for your eyes – without this vitamin you might be blind]
Blueberries	Plant Part: _____________ Taste: Sweet Color: ____________	Anthocyanins (____________) [This nutrient combines with harmful substances that form inside your cells]
Carrots	Plant Part: __________ Taste: Sweet Color: ____________	Vitamin ____ [This vitamin is very important for your eyes – without this vitamin you could be blind]
Broccoli	Plant Part: _____________ Taste: Similar to Brussel Sprouts Color: ____________	Vitamin ____ & Iron [This vitamin makes your skin heal from injury more quickly –also found in oranges and grapefruit]
Hummus (from chickpeas)	Plant Part: Taste: Similar to peas Color:	High in _____________ [This nutrient helps your body to grow and make new muscle and bone tissue]

The following pages include pictures of fruits and vegetables. These images have been cut into cards which will be sorted by the students.

Step 1:

Sort the fruit and vegetable cards by color only.

Step 2:

Sort the fruit and vegetable cards by the nutrients they are likely to contain. There are several tables included in the lesson which will provide the necessary information to guide the Benton students through the card sort.


FRUIT IN ENGLISH
Woodward ENGLISH
apple
apricot
avocado
banana
blackcurrant
blackberry
blueberry
cherry
coconut
fig
grape
kiwi(fruit)
lemon
lime
lychee
mango
nectarine
orange
papaya
passion fruit
peach
pear
pineapple
plum
quince
raspberry
strawberry
watermelon
www.grammar.cl
www.woodwardenglish.com
www.vocabulary.cl


VEGETABLES
Woodward ENGLISH
artichoke
asparagus
beetroot
bell pepper
broccoli
Brussels sprout
cabbage
carrot
cauliflower
celery
corn
cucumber
eggplant
green bean
lettuce
mushroom
onion
pea
potato
pumpkin
radish
sweet potato
tomato
zucchini
www.grammar.cl
www.woodwardenglish.com
www.vocabulary.cl

2016-2017 Lessons

Lesson Title	Graduate Mentor, FRIP Student
How Plants Communicate!	Nhung Hoang, Isaac Lorenz
Plant Detectives: What Happened to My Leaf?	Benjamin Spears, Casey Yocks
Plants Move Too!	Johanna Morrow, Alison Porter
Pollination Investigation	Katelynn Koskie, Krista Shucart
Radical Roots- Plants Need Water Too!	Katie Guthrie, Rebecca Winkler
Why do Leaves Change Color?	Cuong Nguyen, Eyram Kpenu

How Plants Communicate!

Activity Overview

Animals communicate in a variety of different ways, from vocal barks, meows, and human speech to nonverbal signals in the form of body position and posture. Students may be surprised to learn that plants communicate as well, even if we can't see it with the naked eye! In this lesson, students will be introduced to the ways in which plants communicate with each other, as well as the significance of these messages to a plant's ability to protect itself in environment full of living (biotic) and non-living (abiotic) stresses.

Next Generation Science Standards

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival. Use observations to describe patterns of what plants and animals need to survive.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Construct an argument with evidence, data, and/or a model.	A system can be described in terms of its components and their interactions.	Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.

5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Science explanations describe the mechanisms for natural events.	A system can be described in terms of its components and their interactions.	Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter back into the environment.

Materials

Small potted plants (1 per group)
Styrofoam/plastic cups
String
Spray bottles
Paper Towels
Microscopes (if available)
Fungal mycelium microscope slides (if available)
Scented compounds to add to water (ie vinegar, vanilla extract, lemon extract, etc..)

Engage	**Step 1**: Have the students consider all of the different types of communication that they can think of, and what those communications can be used for- Do animals communicate like we do? What do we communicate about? Vocalization can be a fun activity to get students in the mood to learn! (ie what does communication between cows or dogs sound like?) <u>Questions to ask:</u> • Do all animals communicate in the same way? Do all communications need sound? • What tools do we use to communicate? (Phones/IM chat). What do we use these tools to accomplish? Do they help us with our survival?
Explore **Students will consider how plants communicate in response to stress** **Ask students to think like plants and how they might respond to a potential threat**	**Step 2**: Introduce the students to the concept of plant communication (powerpoint slides will be helpful). Stress two different points of communication: Above the ground (chemical signals between plants) and below the ground (chemical signals from the roots and interactions between plants and fungal symbiotes). Include a very basic description of plant physiology. Hand out the small potted plants to each group, and have them remove the soil and clean roots as much as possible to see the different regions of plant communication. <u>Questions to ask:</u> • You can tell that someone has been exercising if they're kind of stinky- can plants use a similar sort of chemical signal to 'talk' to each other? • What is a symbiote? Have you seen interactions between wildebeests and birds, and whales and remora fish? • Are plants more or less complicated than you thought before today? • How can chemical signals allow plants to help their neighbors respond to threats? • How can chemical signals allow plants to convince other organisms to help them grow? **Step 3: Spray bottle communication activity** Show the students examples of what differently-stressed leaves (insect attack, drought, or salt stress) look like with the provided images. Stress that plants will release volatile compounds to warn its neighbors, who will adjust to reduce harm to themselves.

	Multiple stations should be set up around the classroom, each containing three labeled spray bottles w/ diluted scent additives corresponding to a particular one of the three stresses discussed. Each station will also have a single stress card, that the plants (students) will be responding to. Have the students spray the bottle that correspond to the stress that they (the 'plants') are exposed to. Then, have the students move to a different 'environment' (station) and see if they can figure out which stress is in that environment based on the lingering smell (ie chemical signal) and the smells of each 'stress' bottle. Explain that this is very similar to how plants may communicate using volatile chemicals! **Step 4: Stress picture activity** At each station, after students have identified chemical stresses by smell, present them with the set of three 'stressed plant' pictures and three 'stressor' pictures. For each stressed plant, have the students match the image to the stressor. Once students have correctly identified the image pairs, present them with the set of 6 pictures depicting a plant's response to an insect attack and have them set back at their tables. As a group activity, walk students through the steps of the plants response and chemical communications and have them assemble the images in chronological order, making sure to emphasis the similarities between their smelling the 'stress signals' and plants perceiving their neighbor's volatile chemicals.
Explain **Students will consider a second method of communication between plants**	**Step 5: Communication through fungal 'telephone lines'** Begin by explaining what fungal mycelium are, and how they are different from plant roots. Have a brief discussion with the students about how plants and fungi can have mutualistic relationships, providing each other with nutrients or other beneficial properties. Introduce the concept of plants sharing nutrients or chemicals through fungal connections, not unlike a telephone line. If light microscopes and fungal mycelium samples in soil are available, have students examine them under magnification to compare to plant roots. In the next activity have students construct cup phones out of foam/plastic cups and string. Demonstrate to the students how the cup phones work (the string must be taught, and speaking quietly is more than enough to hear a message!) Have pairs of kids take turns sending messages back and forth, checking to see if they are able to hear what the other is saying. These messages could reflect the functional purpose of this communication during plants stress, like "A bug is attacking me!" or, "I'm thirsty! There may not be any water here!"

Extend **Students will review the material discussed during the lesson**	**Step 6: Knowledge check activity** Hand out the worksheet that with quiz students on some of the basic concepts that were introduced in this lesson. Have students work in groups, but each student should complete their own activity.

Students examining plant roots and fungal mycelia

How Plants Communicate

Supplemental Materials

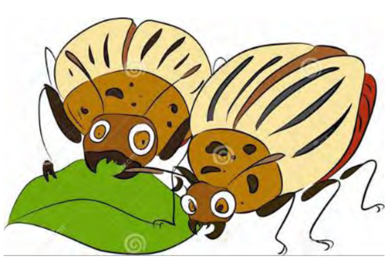
Knowledge Check!

Name: _______________________________

1.) In an earlier activity, your table was given a total of 6 pictures. As a group, please arrange these pictures in the correct order on your table. Check box when completed.

☐

2.) On the left are 3 different plant stresses. On the right are 3 pictures of what a plant would look like because of each stress. Draw lines to match the <u>type of stress</u> with <u>what the plant would look like because of the stress</u>.



Salt

3.) What do plants do when insects attack them?

a. Scream

b. Cry

c. Release chemicals to their environment

d. Run away

4.) What do plant roots use to communicate with each other underground?

a. Cell phones

b. Fungi

c. Their voices

d. Insects

5.) What is one way that plants can communicate? What is one way that humans can communicate?

Cutouts for spray bottle activity

Salt

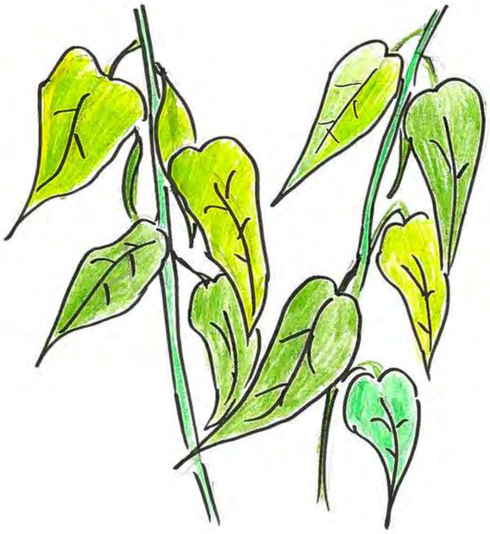
Salt

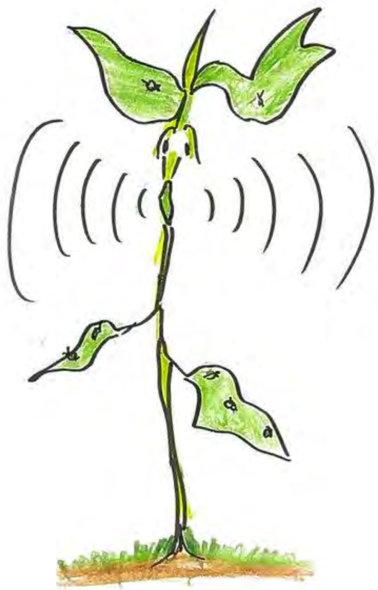
Salt

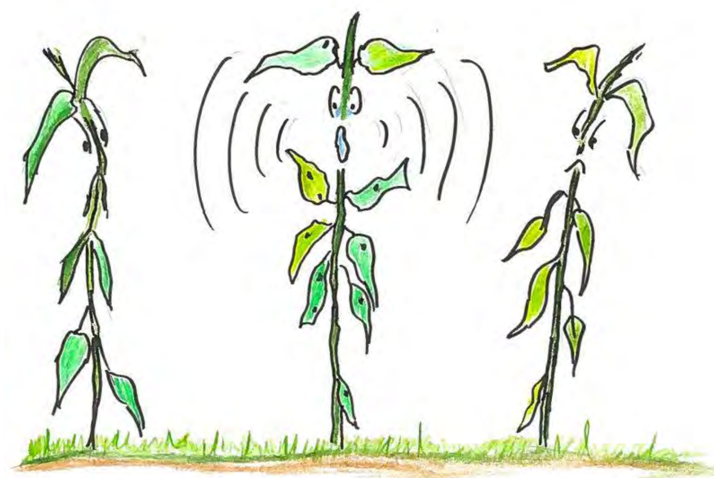
Cutouts for spray bottle activity question #2

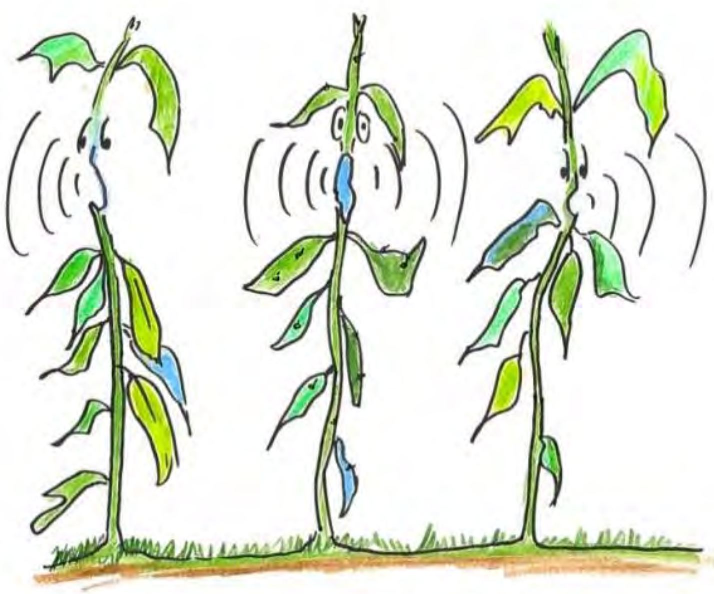
Salt









Plant Detectives: What Happened to My Leaf?

Activity Overview

Students will be introduced to the idea of the leaf as an organ and source of food for plants, as well as the consequences of leaf damage to plant health. They will explore different ways that a leaf can be damaged, with the larger goal of understanding that different organisms or environmental stresses can cause different types of damage, with variable health effects depending on plant species.

Next Generation Science Standards

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival. Use observations to describe patterns of what plants and animals need to survive.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Construct an argument with evidence, data, and/or a model.	A system can be described in terms of its components and their interactions.	Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.

5-PS1-3. Make observations and measurements to identify materials based upon their properties.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Make observations and measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.	Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.	Measurements of a variety of properties can be used to identify materials.

Materials

Variety of Lettuce and/or leafed vegetables
Butter Lettuce/Iceberg Lettuce/Cabbage/Kale
Magnifying glasses
Various hole punches
Paper towels
Prepared flash cards
Pencils
Challenge Sheets

Engage	**Step 1**: Discuss with the students the concept of plants producing food from sunlight and air (CO_2). A cartoon diagram would likely be helpful. Questions to ask: • Where do you think plant food comes from? Have you ever seen a plant go to the grocery store? • What parts of a plant are important for making its food?

Explore
 	
Students will explore the nature of science through experimental design.
 	
Help students think about the damaged leaves and what might have caused their condition.
 	
Ask students to think like scientists and make and test predictions about the leaves they will treat.
	Step 2: Present the students with an assortment of damaged leaves (prepared before class) and guide them through observing and describing the leaves using challenge sheet #1 **Engage**
	Questions to ask:
	• What do you think happened to these leaves?
	• What do the damaged edges look like? What about with the magnifying glass?
	• What do you think is different about each of these leaves?
	
	Step 3: Have the students examine undamaged butter lettuce, iceberg lettuce, and cabbage samples in the same manner, recording observations on challenge sheet #2
	
	Step 4: Have the students damage the butter lettuce, iceberg lettuce, and cabbage in various ways (tearing, hole punching, crushing); set aside to observe later in the class period.
	Questions to ask:
	• What do you think is different about each of these leaves?
	• What do you think will happen to these leaves?
	• Which leaves do you think will be hurt the most? What about the leaves makes you think that?
	
	Step 5: Making predictions – Instruct students to:
	• Predict which leaves will be the most/least damaged by the end of the session
	    o Record hypothesis on challenge sheet #2
	• Show the students the leaves from step 2 again; For each treatment, encourage the students to predict which of the leaves from **step 2** might have been damaged in the same way.
	    o Record hypothesis on challenge sheet #2
	
	Questions to ask:
	• Remember your predictions, we will check on the leaves again at the end of this science club session. How are we going to tell which leaf has

	been damaged the most/least? How can we tell which of the **original** leaves received the same treatment? [Encourage students to think about their initial observations]. • Do you think different types of damage will affect the leaves in different ways?
Explain **Use cause-effect flash cards to highlight that different organisms and stressors will cause different types of damage .**	**Step 6:** "Who did it?" Flash Card activity • Prepare a set of flash cards featuring matching pairs of damaged leaves and their causal agents (Rabbits, insects, bacteria, sun/temperature, etc) for each group • Guide the students through matching up each pair • Make connections back to back to the damaged leaves in step #2 <u>Questions to ask:</u> • [For animals] What sort of teeth/mouthparts does this animal have? How do you think this animal eats? Could this have an effect on the way the leaf is hurt? • [For bacteria/heat/drought stress] What do leaves need to work? Why might these conditions hurt the leaf? • Do these leaves look the same? Do you think your leaves that you damaged earlier will look the same? • Do the plants need to be able to handle these different kinds of damages?
Explain **Students will observe the effect of leaf damage on general plant health and growth.**	**Step 7:** Showcase the effects of leaf damage to a plant's growth either through powerpoint diagram or by presenting the students with a houseplant (or in our case Arabidopsis) with healthy, intact leaves compared side-by-side to a plant with manually damaged//removed leaves. <u>Questions to ask:</u> • Which of these plants is healthier? • What do you see differently about the two plants? • What do you think might happen if all of a plant's leaves turn brown or die? • If we want to eat this plant as food, does it matter if the plant is having trouble making its own food?

Extend **During this portion of the lesson ask students to think about their observations.** **Analysis** **Reflection**	**Step 8:** Return to the set of leaves that the students manually damaged earlier in the session. By this time any sort of bruising or physical damage should be pronounced enough to see. Instruct students to: • Examine the damaged area(s) of the leaves carefully • Record observations on Challenge Sheet #2 • Compare the leaves to the **original** damaged leaves recorded on Challenge sheet #1 <u>Questions to ask:</u> • Do the leaves we treated seem hurt or sick? On a plant do you think this would change how well it can make food? • Do the leaves look like any of the damaged leaves we saw before? What does that say about what happened to those leaves? • Why do you think the different leaves (iceberg lettuce, butter lettuce, cabbage) handle damage differently? What was different about them that might cause those differences? • Where are some of the places that you see leaves? (park, backyard, garden, grocery store) • What color leaves do you usually see? • Do you think brown lettuce leaves would be good to eat? • Does a brown color mean something is wrong with the leaf? What else could you see that tells you the leaf is unhappy? • Do you know why it might be important that a plant is happy? What sorts of reasons can you think of?

Background Information:

The leaf of a plant is far more than just beautiful decoration. Just as we rely on our individual organs to keep our bodies functioning, the leaf is a critical organ for plant life. By taking in sunlight, water, and air as a carbon source (CO_2), the plant is able to produce its own food within the leaves in a process called **photosynthesis** which is then transported to the rest of the plant. Organisms capable of performing this incredible task are known as "photoautotrophs".

Most plants need to actively photosynthesize to live, so the leaf is an invaluable organ. We humans, however, rely heavily on the function of plant leaves to maintain our own living environments. A major output of photosynthesis is oxygen (O_2), which we need to breathe. A trip to the grocery store also reveals many different types of leaves that we enjoy as our own food sources. In removing Global-Warming aerial carbons like CO_2 from the atmosphere, producing breathable O_2, and serving as nutritious food forhumans, plant leaves play an important role not only in plant life, but in human life as well!

When plant leaves are damaged, they are less effective at producing food for themselves and breathable air for us- that's a problem! There are a variety of ways in which a leaf can be damaged. These include biotic (living) stresses like herbivorous rabbits or insects chewing on the leaves, or bacteria colonizing a leaf and damaging it from the inside; or abiotic (nonliving) stresses like heat or drought stress that produce an environment unsuitable for plant life (you don't like being outside in hot and dry weather, and neither do plants!). It's important for the students to understand that different kinds of stresses will damage a leaf in different ways, some visible, some not. To minimize damage, a plant must be able to tell exactly what kind of damage it's leaves are experiencing (and by extension what is causing that damage), and respond accordingly. Hopefully these activities will demonstrate to the students in a visual manner the following concepts:

1) The plant leaf is an important organ that is necessary for both plant **and** human life

2) Leaves can be damaged in many different ways by many different agents, which harms the plant and by extension, us.

3) If a plant can identify the type of damage its leaves are experiencing, it can respond in a more effective way to stay as healthy as it can (plants are smarter than we think!)

The goal of the hands-on activities is to connect the student's ability to identify the types of damage they are causing to their lettuce leaves (crush vs. hole punch vs. tear) to a plant's ability to detect what is happening to its vital organs, in addition to having them understand that certain types of leaves will be better suited to handle certain kinds of stresses than others. (ie crushing butter lettuce vs. crushing red cabbage).

Plant Detectives: What Happened to My Leaf?

Supplemental Materials

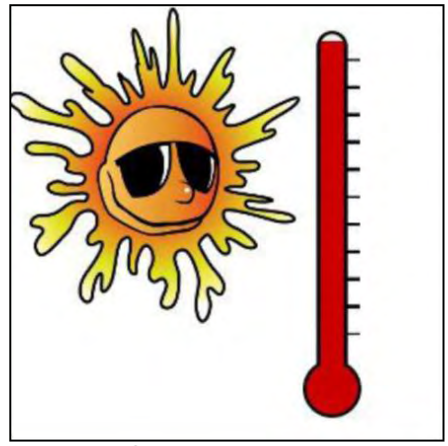
Challenge Page # 1: What do damaged leaves look like?					
Leaves to Test:	Sick Leaf (1)	Sick Leaf (2)	Sick Leaf(3)	Sick Leaf (4)	Sick Leaf (5)
Leaf Colors [Are purple leaves hurt less than green leaves?]					
Leaf Size/Thickness [Are smaller or thinner leaves hurt more than bigger leaves?]					
Leaf Edges [Looking under the magnifying glass, can you see any differences in the leaf edges where they have been damaged?]					
Cool Observations! [What sort of interesting things do you see?]					
Make a Guess! [What do you think happened to these leaves?]					

Challenge Page # 2: Can we damage leaves in different ways?			
	Leaf #1	Leaf #2	Leaf #3
Leaf Color [Are purple leaves hurt less than green leaves?]			
Leaf Size/Thickness [Are smaller or thinner leaves hurt more than bigger leaves?]			
Prediction #1 [Which leaves (1-3) do you think will be hurt the most by the end of class?]			
Prediction #2 [Which leaves (1-5) from Challenge sheet #1 do you think were hurt in the same way?]			

Flash Cards (1)-------Print and match to Flash Cards (2)

A

B



C

D

E

Flash Cards (2)-------Print and match to Flash Cards (1)

A

B

C

D

E

Plants Move Too!

Activity Overview

This activity will teach students that while plants are rooted in the ground, plants use a variety of processes to move based on several different environmental signals for a variety of purposes, such as: food and water acquisition, protection, and to make space between their neighbors.

Learning Objectives

At the close of this lesson, students should be able to:

1. identify several distinctive movements of plants
2. provide reasoning why plants move
3. denote the benefits of these plant movement processes

Next Generation Science Standards

K-LS1-1. Use observations to describe patterns of what plants and animals need to survive.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Use observations [firsthand or from media] to describe patterns in the natural world.	Patterns in the natural and human designated world can be observed and used as evidence.	All animals need food in order to live and grow. Animals obtain their food from plants or from other animals. Plants need water, air and light to live and grow.

1-LS1-1. Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Use materials to design a model that is useable to identify a specific problem and solution to that problem.	The shape and stability of structures of natural and designed objects are related to their function(s).	• All organisms have external parts. Plants and animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in nutrients, water and air that help them survive and grow. • Plants and animals respond to external inputs with behaviors that help them survive.

3-LS4-3. Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Construct an argument with evidence.	Cause and effect relationships are routinely identified and used to explain change	For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, and behavior.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Construct an argument with evidence, data, and/or a model.	A system can be described in terms of its components and their interactions.	Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction

Materials

Green, and Blue pipe cleaners
Yellow and Brown pipe cleaners (cut in half)
Card deck of stimuli pictures (one deck per table)
Posters of stimuli (for "Act like a Plant" activity)
Non-vine plants
String
Tape
2 sponges per plant
water

Engage

Introduce the concept that plants move based on a variety of reasons as well as how that movement benefits the plant.

Step 1: Engage children with a discussion of why and how plants move. Explain that while plants are rooted in the ground, they still need to gather nutrients and water to grow, as well as use movement in defense response. Show a picture of a particular stimulus (i.e. sun, moon, gravity, deer, bug, etc.) and have students demonstrate (standing in place) how they predict that plant will move. Posters of stimuli can move around the room as students show how the plants move over time. After the students predict, show a picture of an example of this movement.

Questions to ask:

- How do you predict the plant will move?
- Why do you think the plant will move how you predict?
- Why is this movement beneficial to the plant?

Explore **Students will make a model to demonstrate plant movements based on different stimuli.**	**Step 2**: Distribute the pipe cleaners to the students. Explain that the students will make a flower out of the pipe cleaners (Green=stem, brown=roots, yellow and blue=flower). 1. Start with a green pipe cleaner for "stem" of plant. 2. Wrap brown pipe cleaner(s) around "stem" to denote "roots" of plant near the base of the "stem". 3. Wrap yellow and/or blue pipe cleaner(s) near the top of the "stem" to denote "flowers" of plant. 4. Wrap short green pipe cleaner(s) around "stem" to denote "leaves" of plant. **Step 3:** Once flowers are made, using a card game at each table with pictures of various stimuli on each, students will demonstrate how plants move in response to the picture of the stimuli on card. Questions to ask: • How do you predict the plant will move based on this stimulus? • Why do you think the plant moves that way? • How does this movement benefit the plant? • How does the plants environment affect its movement?
Students will set up a gravitropism experiment with a non-vine plant.	**Step 4**: Set up Gravitropism experiment with plants 1. Pull plant out of pot. 2. Wet 2 sponges and place root ball of plant between sponges. 3. With string, tie sponges together lengthwise and widthwise. 4. With string, hang plant upside down in a well-lit area. 5. Continue to wet the sponges though out the week. Questions to ask: • How do you think the plant will look in 1 week? • What stimulus is the plant responding to?
Explain **Ask students to think about why plants move and how their environment can affect this behavior.**	**Step 5**: Follow up the above activities with questions regarding plants movement. Questions to ask: • Why do plants move, benefits, etc.? • How do you think the environment affects plants movement? Would they respond similarly in a different environment? • What types of stimuli made plants move in a similar manner, different manner? **Step 6:** Students will watch the YouTube video on plant movement. https://www.youtube.com/watch?v=2rshuxfrD1U

Pollination Investigation

Activity Overview

This activity will introduce children to the concept of pollination. Students will demonstrate pollination by using bees to spread glitter pollen to different prepared flowers around their table.

First, students will learn about the parts of a flower by putting together a flower puzzle. Each table will be a group, so students can work together and discuss the parts of the flower, their function, and why they are important. Second, we will begin the pollination activity. Students will color their 'before' flower on their worksheet, then predict what their flower will look like after the activity on the 'after' flower. Then students will perform the pollination activity using their fuzz ball bees and glitter pollen flowers. Lastly, students will fill out a worksheet to demonstrate the sequence of growth from seed to fruit.

Learning Objectives

At the end of the activities, students should be able to:

1. Identify basic reproductive structures of a plant.
2. Provide a simple mechanism for pollination between plants.
3. Predict what happens after pollination.

Next Generation Science Standards

2-LS2-1. Plan and conduct an investigation to determine if plants need sunlight and water to grow.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Plan and conduct an experiment to produce data that will serve as evidence in support of the mechanism.	Observable patterns generate events.	Plants require water and light to grow.

2-LS2-2. Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Develop a simple model based on evidence to represent the proposed mechanism.	Functions of objects are determined by the shape and stability of structures.	Plants depend on animals for pollination and distribution of their seeds.

2-LS4-1. Make observations of plants and animals to compare the diversity of life in different habitats.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Make observations on the collected data which can be used to make comparisons.	n/a	Ecosystems consist of many different living organisms which exist on land and in water.

Materials

Glitter	'pompom' bees
Construction paper	crayons
Styrofoam bowls	pencils/crayons
Double sided tape	markers
Scissors	handouts

Engage **Introduce the concept of floral structures.**	**Step 1**: Engage children with a discussion of flower reproductive parts and pollination. Students will use a puzzle to put a flower together. Discuss the function of each floral structure. <u>Questions to ask:</u> • What do the floral parts do? • How are the floral structures arranged? • What's the difference between perfect and imperfect flowers? • Once the pollen leaves the stamen, where does it land?
Explore **Students will explore the mechanism of pollination by animals (bees).**	**Step 2**: Distribute the prediction worksheet and fuzz ball bees to the students. Explain to student how to pollinate each of the flowers at their table. <u>Questions to ask</u>: • Have you learned about pollination before? • Have you seen pollination in action? • How much pollen do you think will be transferred? • Is there a reward for bees pollinating flowers? • What attracts bees to flowers? • Is there any other way pollination can occur? (wind) **Step 3:** Students will demonstrate pollination with their bees: 1. Students will fill out the 'before' and 'after' pollination worksheet. 2. Dip bees in each of the glitter flowers around the table. 3. Observe the different colors of glitter on their bee and on the tape within the flower.
Explain **Students will explain what happens after pollination.**	**Step 4**: Students will predict what happens after the flower is pollinated. <u>Questions to ask</u>: • What will the seeds develop into? • What kinds of foods have seeds? • Have you ever planted seeds before? Students will demonstrate how seeds develop into fruits by putting images on a worksheet in proper sequence. • Why did you put the images in that sequence? **Step 5:** Students will watch a YouTube video on reproductive organ structures and pollination.

Coloring and assembling paper flower structures

Pollination Investigation

Supplemental Materials

Development Worksheet

NAME: ___________________

Put the following images in order of how a plant will grow.

☐ 

☐ 

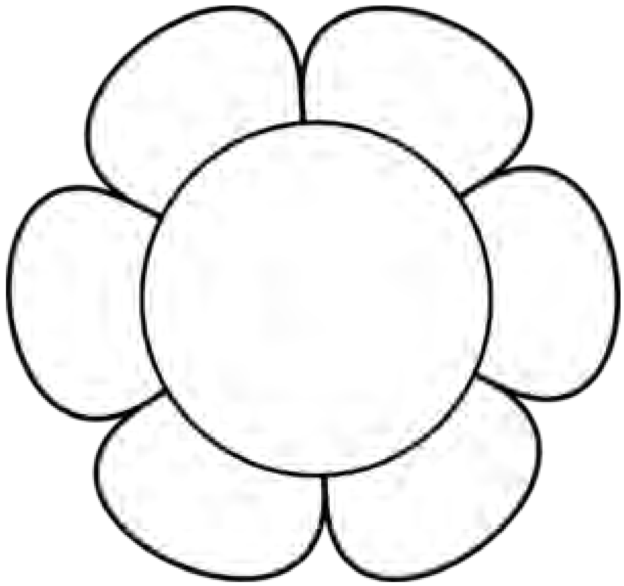
☐ 

☐ 

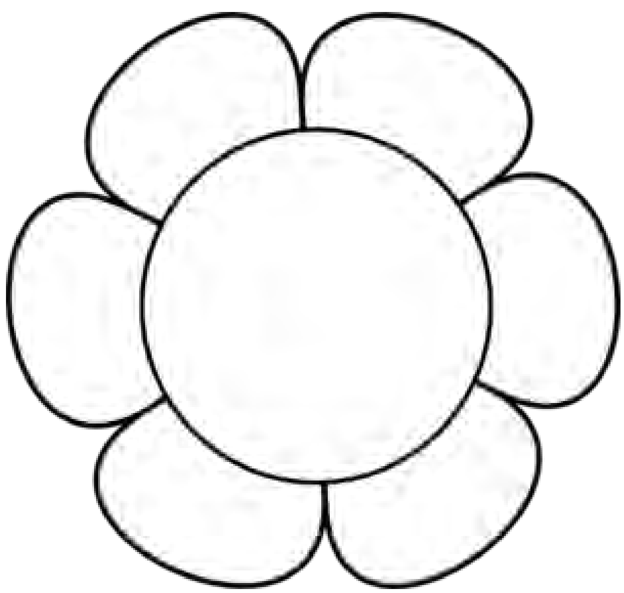
Pollination Prediction

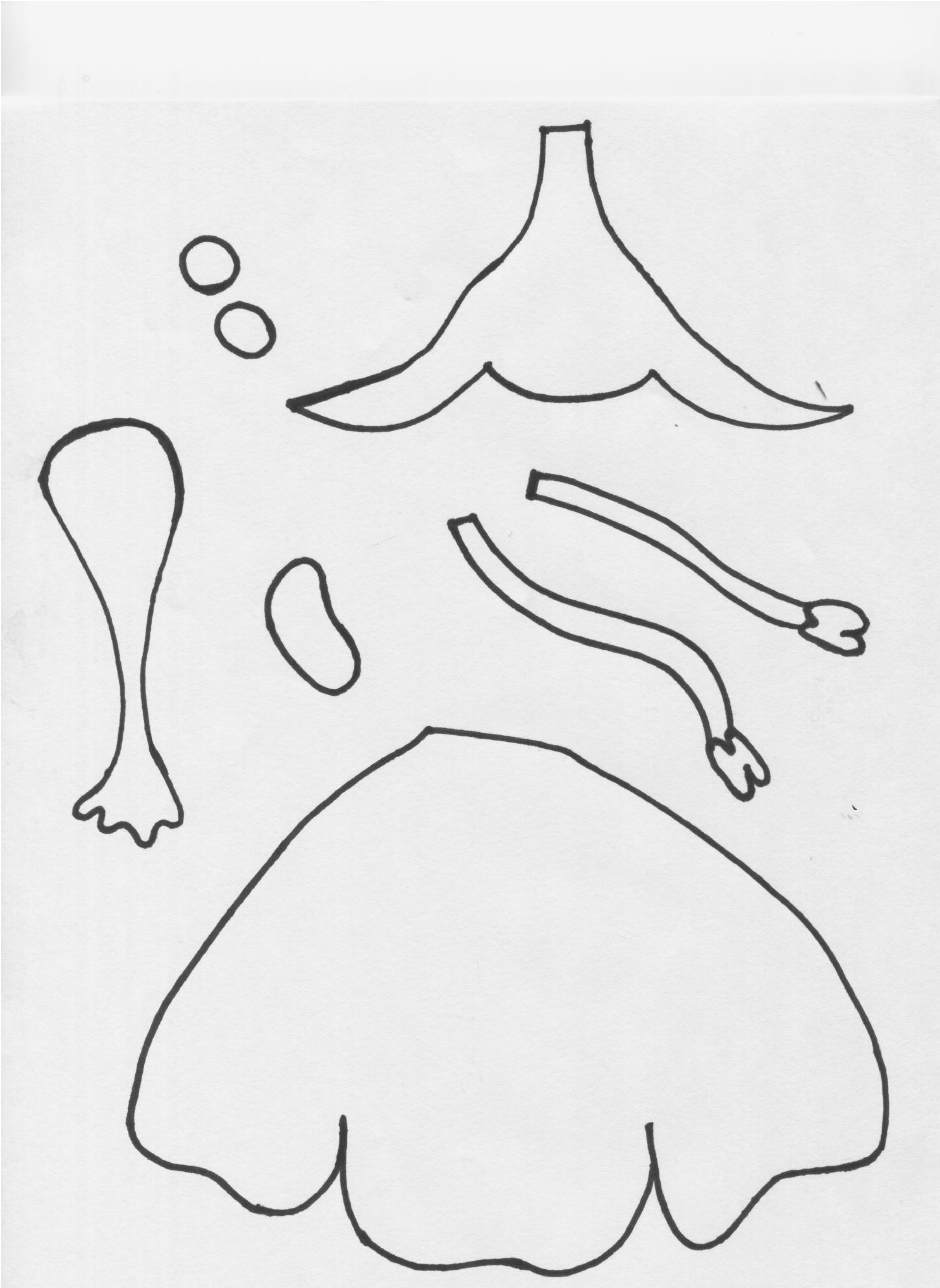
Name: ____________________

BEFORE



AFTER





Radical Roots-Plants Need Water Too!

Activity Overview

This activity will elaborate on the basic biology concept that plants need water to grow and survive just like animals. Students will learn about different types of roots and how they might look different in different environments, but all uptake water through the same method: osmosis.

Learning Objectives

At the close of this lesson, students should be able to:

1. Identify the functions of roots
2. Conceptualize how roots uptake water (osmosis)
3. Identify differences of roots from different environments

Next Generation Science Standards

K-LS1-1: Use observations to describe patterns of what plants [...] need to survive.

Science & Engineering Practices	**Crosscutting Concepts**	**Disciplinary Core Ideas**
Scientists look for patterns and order when making observations about the world.	Patterns in the natural and human designated world can be observed and used as evidence.	All animals need food in order to live and grow. Animals obtain their food from plants or from other animals. Plants need water, air and light to live and grow.

2-LS2-1: Plan and conduct an investigation to determine if plants need sunlight/water to grow

Science & Engineering Practices	**Crosscutting Concepts**	**Disciplinary Core Ideas**
Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.	Events have causes that generate observable patterns.	Plants depend on water and light to grow

2-LS4-1: Make observations of plants [...] to compare the diversity of life in different habitats

Science & Engineering Practices	**Crosscutting Concepts**	**Disciplinary Core Ideas**
Scientists look for patterns and order when making observations about the world.		There are many kinds of different living things in any area, and they exist in different places on water and land.

5-LS1-1: Support an argument that plants get the materials they need for growth chiefly from air and water

Science & Engineering Practices	**Crosscutting Concepts**	**Disciplinary Core Ideas**
Construct an argument with evidence, data, and/or a model.	Matter is transported into, out of, and within systems. (5-LS1-1)	Plants acquire their material for growth chiefly from air and water. (5-LS1-1)

Materials	Cups (3 per group) Food dye (at least 2 colors) Paper Towels Water Pen and Paper for observations
Engage: **1: Intro to Roots** What do they do? Why are they important to plants? **2: Discussion/ Diagramming**	**Step 1**: Engage children with a discussion of what plants are and why they are important. Show them examples of different types of roots, specifically ones they might be familiar with and might not be familiar with. Address the question of why plants need water, and have them try to answer what plants do with the water once they have it based off prior Science Club class discussions. <u>Questions to ask:</u> • Why are roots important for plant survival? • Why are there so many different types of roots? • Do all roots function to "drink" or take up water the same way? **Step2:** Have them hypothesize how rots might be different in a really wet, tropical environment versus a dry dessert environment, and begin thinking about how plants actually take up water. Provide characteristic features of tropical versus desert root systems after brief activity. <u>Tasks</u>: • On a blank piece of paper draw the roots of a plant that grew in a wet environment and a dry environment. Share our rationale. <u>Questions to ask:</u> • Do all roots uptake water the same way, regardless of environment?
Explore **Students will make a model to demonstrate water uptake by roots.**	**Step 3**: Creating water movement model, one per table group. 1. Line up three clear plastic cups in a row, fill the outer two cups halfway with water 2. Add 5-10 drops of dye into the outer two cups. Wait until all the water is dyed. 3. Tear off one piece of paper towel, roll up long wise to make an arch 4. Repeat the last step with another paper towel 5. Place one end of one paper towel into a cup with dye and the other end in the empty cup. Take the second paper towel and place one end in the empty cup and the opposite end in the second cup with dye. 6. Wait and make observations **Step 4:** Once the root system is made, but before osmosis has finished occurring, bring back the root examples at the beginning of the class. Have them hypothesize through group discussion about what environments these roots examples came from.

	Questions to ask: • Are these roots long or short? Are they thin a fibrous or fat like a carrot? • Are there many tiny roots or one big root? • Do you think these roots have any other functions for the plants besides water uptake? Tasks: • Have them take notes on what they see happening in their on root systems periodically throughout the second activity. • (Optional) Handout if need to buy time.
Explain **During this portion of the lesson ask students to think about why plants move and how their environment can affect this behavior.**	**Step 5**: Follow up the above activities by asking them to explain what happened to the food dye in the mock root system in their own words. This will be followed by a short concluding presentation that ties together the lesson and defines their observations as the scientific concept of osmosis. Questions to ask: • Did all of your root systems work the same way? (regardless of color, paper towel length, paper towel crumpled-ness, etc.?) • (Tie-in from introduction) What do plants do with the water once they have it? • Can you think of any other system that might use this type of water uptake (osmosis)? **Step 6:** Students will watch the YouTube video on osmosis in roots/roots from different environments.

Students learning through living and model root system

Radical Roots- Plants Need Water Too!

Supplemental Materials

Root Word Search

Can you find all of the words?

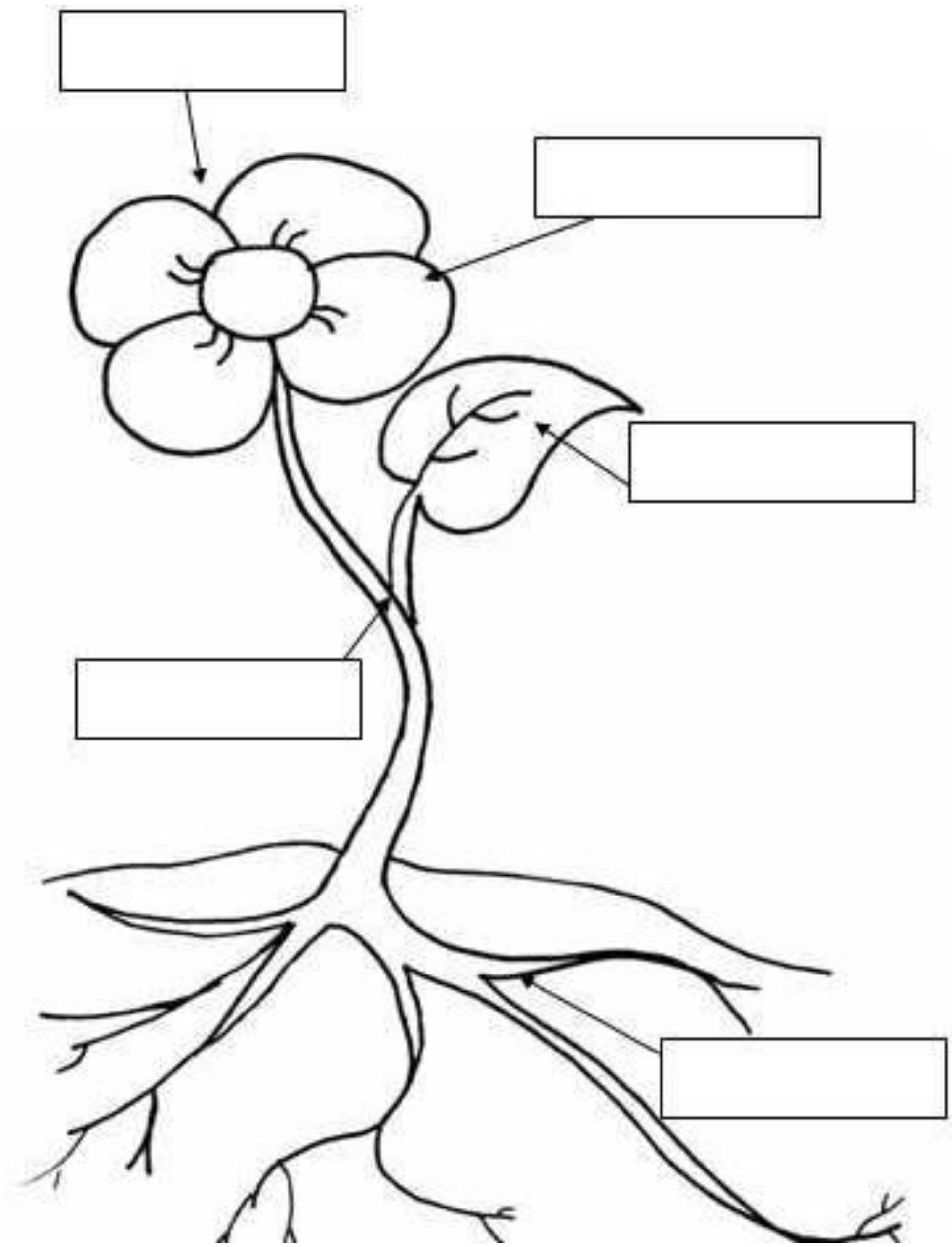
S	Z	X	A	V	X	G	F	U	G	S	F	U	Y	F
S	T	D	G	S	G	L	Y	S	T	R	G	O	O	O
P	P	O	O	V	O	Z	R	N	Z	T	O	R	W	C
S	L	I	O	W	B	Q	E	G	I	Q	L	W	O	N
E	L	A	E	R	Y	I	T	G	R	E	E	N	L	H
E	Q	R	N	Y	R	L	A	K	M	V	N	S	U	H
D	L	X	J	T	A	U	W	D	N	I	W	Y	P	Q
D	E	U	U	T	S	M	U	O	C	A	D	S	F	Z
H	A	N	E	I	I	E	R	S	T	M	H	L	A	I
S	V	P	J	B	F	J	R	K	L	C	O	A	I	V
R	E	A	K	Q	I	Y	C	C	N	E	P	P	K	J
R	S	J	B	P	K	G	N	H	K	C	S	U	V	G
E	W	L	I	R	Q	V	F	A	T	U	O	R	P	S
U	E	J	M	U	V	G	F	U	T	F	T	H	J	J
E	H	P	S	U	N	L	I	G	H	T	B	G	X	K

FLOWER
GREEN
GROW
LEAVES
NUTRIENTS
PETAL
PLANTS
ROOTS
SEED
SOIL
SPROUT
SUNLIGHT
WATER
WIND

Plant Parts

Label each part of the plant: stem, leaf, roots, flower, and petal.

Color your plant!



Why do Leaves Change Color?

Activity Overview

Every student will have seen that leaves change colors between spring, summer, and fall, and can recognize that plant leaves can come in many different colors; but why is this the case?

Photosynthesis is one of the most important processes in green plants to produce food. Plant uses sun light as an energy source to convert CO_2 and water to sugar and O_2. This process happens in the leaves where chlorophyll (green color) is the key pigment contributing to the process. Although other leaf pigments, such as red and yellow carotenoid- derived compounds, cannot be seen in the green leaves, they play significant role in photo-protection to help photosynthesis to be more efficient. The derived carotenoid compounds can be seen in leaves when plants are stressed, older, or in fall season. This is due to the degradation of chlorophyll.

In this lesson, students will perform chromatography to show in the green leave we can detect yellow and red pigments. We also use older leaves (yellow leaves) to point out that stress indeed leads to degradation of chlorophyll. We also use leaves from different species (kale with different color) to point out diversity of color is due to the different combination of chlorophyll and carotenoids.

Learning Objectives

At the close of this lesson, students should be able to:

1. Identify different pigments and molecules contributing to leaf color
2. Understand how the amounts of these individual pigments can change a leaf's color
3. Explain how chromatography can let us come to these conclusions

Next Generation Science Standards

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival. Use observations to describe patterns of what plants and animals need to survive.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Construct an argument with evidence, data, and/or a model.	A system can be described in terms of its components and their interactions.	Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.

5-PS1-3. Make observations and measurements to identify materials based upon their properties.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Make observations and measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.	Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.	Measurements of a variety of properties can be used to identify materials.

5-LS1-1. Support an argument that plants derive the requirements for growth from air, water, and sunlight.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Support an argument with evidence, data, or a model.	Matter is transported into, out of and within organisms.	Plants acquire the materials necessary for growth chiefly from air and water. Plants utilize sunlight to manufacture food.

Materials

Safety goggles	Small (100 μL) flask or beaker	Plastic wrap
Chromatography paper	Mortar and pestle	Pasteur Pipettes
Pencils	Green/purple kale	Old/Young leaves
Rulers	Acetone	Coloring Utensils

ReSTEM Institute:
Reimagining & Researching STEM Education

University *of* Missouri College of Education

Engage

Introduce the concept of photosynthesis and the role of pigments

Step 1: Engage children with a short presentation about photosynthesis, including the role of different pigmentation in the absorption of light (Ideally this lesson may follow the 'Why so green' lesson plan). Include a very basic discussion of chromatography as 'a way to separate tiny things like pigment molecules'. The handout should include pictures of the individual molecules corresponding to green, red, orange, and yellow.

Questions to ask:

- What color are plant leaves? Are they always that color?
- Do you think there is a reason for leaf color variety? What does it mean when a tree's leaves start turning colors?
- What does a plant need to do with light to turn it into food?
- Is color something that you can hold? What makes paint different colors?
- What might be different about these colors that we could separate them by? (Remember the handout).

Explore

Students will explore the different pigments present in different kale leaves

Step 2: Distribute the necessary materials between student groups, making sure that an adult supervisor is monitoring the students with chromatography solvent (don't touch!). Have students grind either the green and purple kales, or the old (yellowing) and young (green) leaves with the mortar and pestle to a liquid paste.

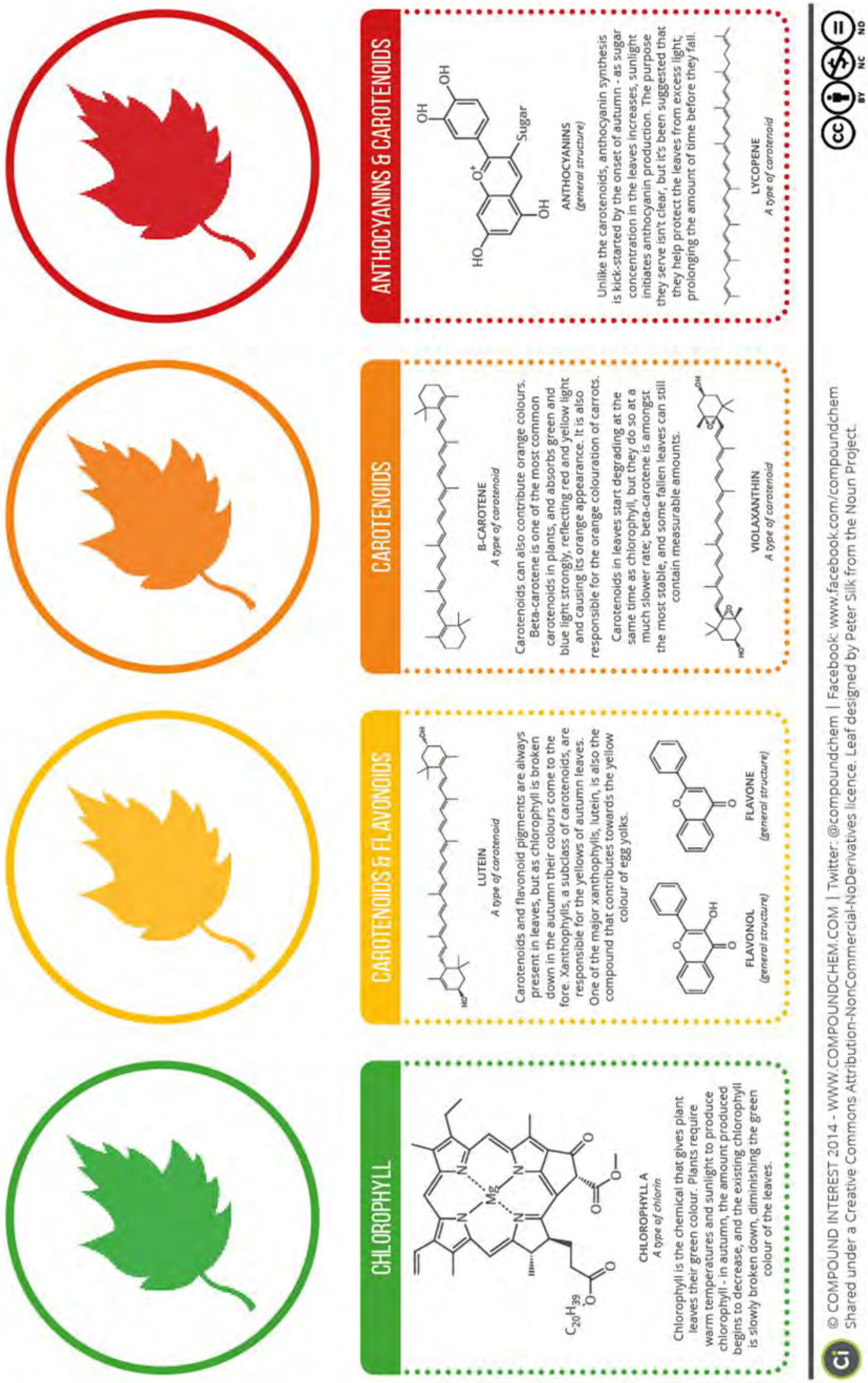
Step 3: Using the Pasteur pipette, spot the ground leaf mixture onto the chromatography paper and place upright in the beaker with a low level of acetone. Allow the solvent to travel up the chromatography paper for ~30 minutes or until it reaches ~1 cm from the top of the paper.

They will also consider what these pigments are used for	**Step 4:** Using colored pencils or crayons, have students recreate their chromatography results on the provided worksheet. Have them compare and contrast the pigment patterns of their individual samples (kales) and share their findings with a neighbor working on the other sample group (old/young leaves). <u>Questions to ask:</u> • Are the color patterns of your two samples the same? If not, how are they different? • What do these different colored spots represent? What does this tell us about the nature of color? • Could there be similar compounds in your colored markers as you found in the leaves? • What might these different compounds be helping the plants to do?
Explain **During this portion of the lesson ask students to think about the different pigments that have been discussed**	**Step 5**: In a class discussion, ask students to think about what the different patterns from their chromatography experiment may tell them about the types of pigments present in their plant tissues. <u>Questions to ask</u>: • What is chlorophyll used for? • Does the chlorophyll band change between the old and the young leaf? What does this tell us about why an older leaf might be dying? • Does every type of leaf have the same set of pigments present? • What could be an advantage of having different set of pigments?

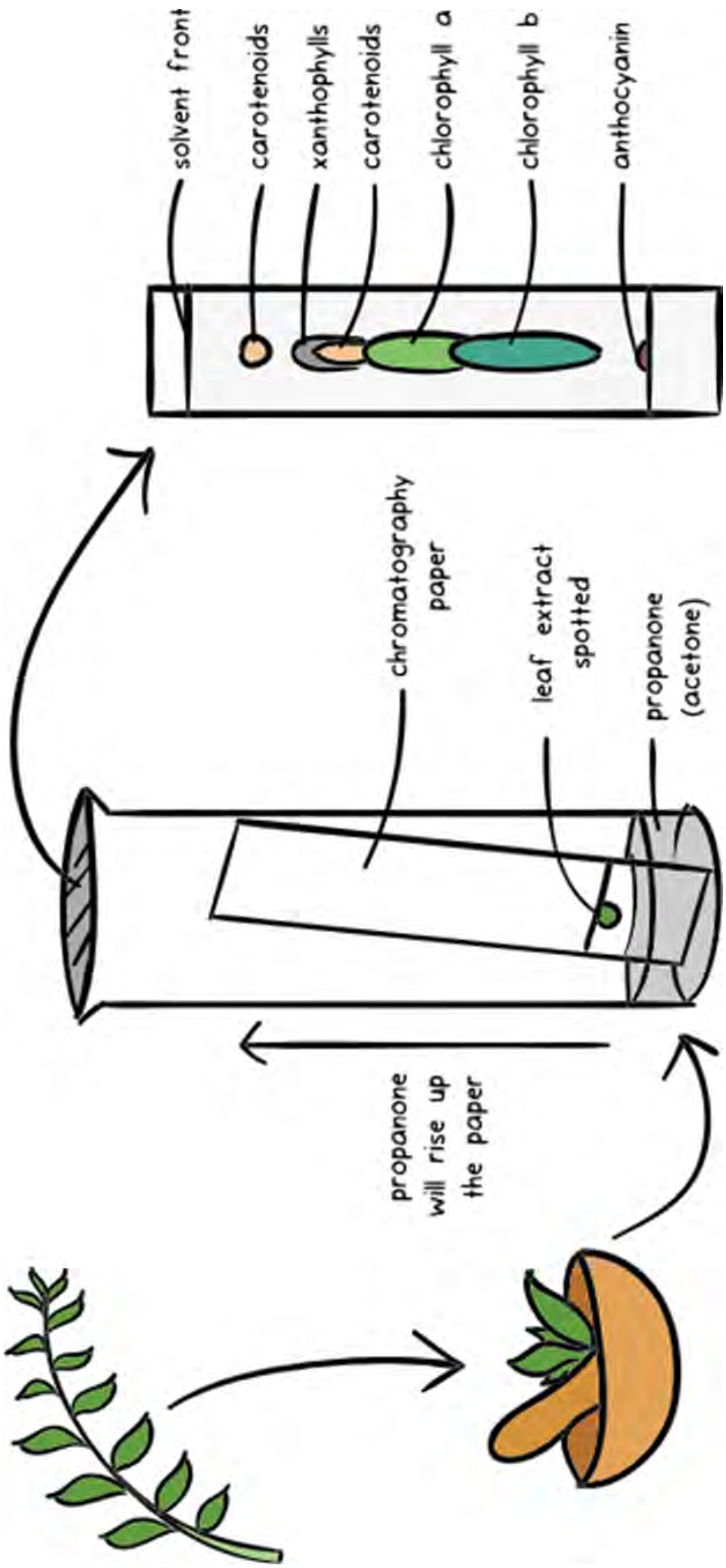
Why do Leaves Change Color?

Supplemental Materials

Common Leaf Pigments



Chromatography Setup



Using your coloring tools, record your observations onto the example chromatography paper below:

Purple Kale

Green Kale

Young Leaf

Old Leaf

Name: ______________________________ Pigment - Paper Chromatography Lab

Hypothesis (what are you testing in this investigation):

Materials:

Protocol:

Data Table: Construct a data table to organize your data. Remember, your observations will be made on a daily basis (a minimum of two observations per week).

Food for Thought Questions:

Sample Rf Problem

Band #	Distance moved (mm)	band color
1	12 mm	olive green
2	21 mm	bright green
3	27 mm	bright yellow
4	53 mm	yellow-orange

Solvent front moved 53 mm

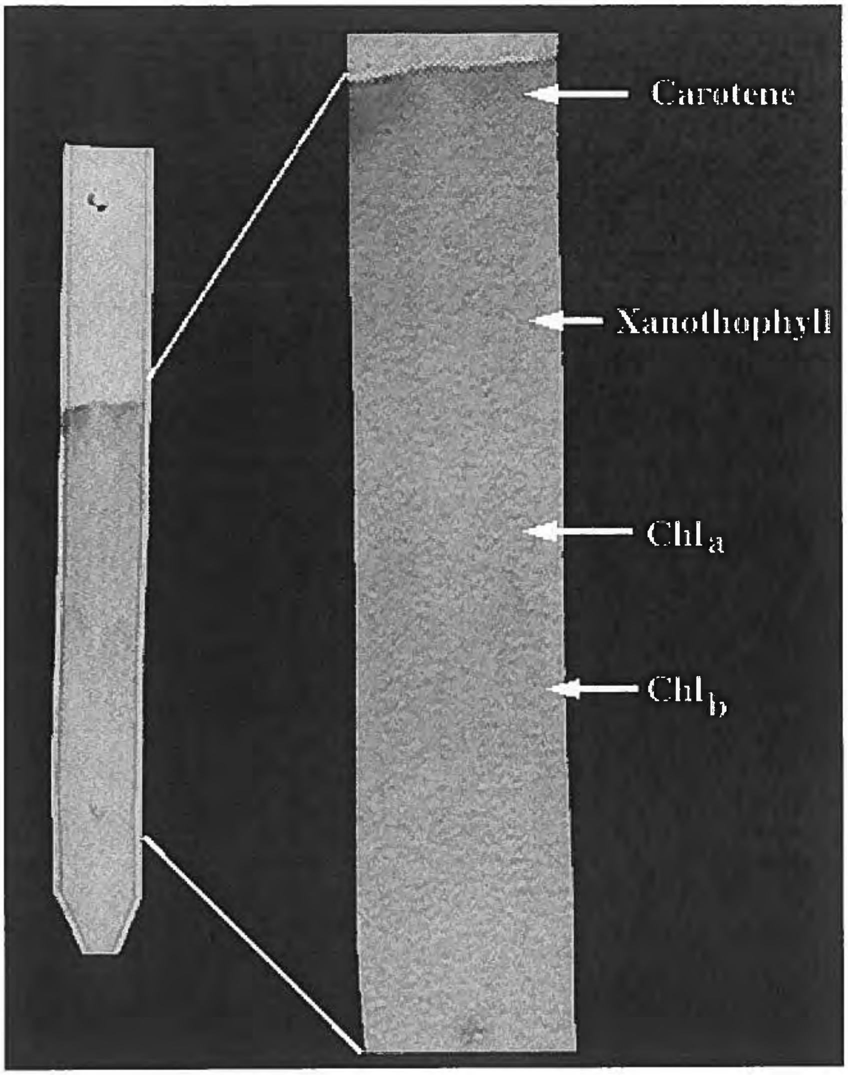
Pigment		Rf value
Carotene	53 mm ÷ 53 mm =	1
Xanthophyll	27mm ÷ 53 mm =	0.51
Chlorophyll a	21 mm ÷ 53 mm =	0.40
Chlorophyll b	12 mm ÷ 53 mm =	0.22

1. Why are the Rf values different for the different pigments?

2. What is the role of pigments in plants?

3. What wavelength(s) of light are most likely used by plants during photosynthesis?

4. What wave length(s) of light are most likely NOT used by plants during photosynthesis?



The image to the left identifies the importance of various molecular characteristics within paper chromatography. These characteristics include:

- Molecular size: small molecules travel farther than larger molecules
- Polarity: polar molecules are more likely to move further in polar solvents
- Solubility within the solvent influences the distance traveled by the pigment:
    - ◊ R_f of pigment 1 = a/b
    - ◊ a - distance traveled by pigment 1
    - ◊ b - distance traveled by the solvent

⇒ In paper chromatography, the sample mixture is applied to a piece of chromatography paper, as shown in the diagram above. **[Note: Strips of filter paper can be used if chromatography paper is not available]**

⇒ One end of the paper is immersed in a solvent. As the solvent wicks up the paper through capillary action, the pigment will dissolve in the solvent and be carried with the solvent as it moves upon the paper.

⇒ The distances traveled by the various pigments included in the original sample will vary based upon solubility in the solvent. Pigments which are less soluble will be absorbed in the paper and not move as far as the more soluble pigments.

⇒ It is important to note that performing a chromatographic experiment is basically a three-step process:

1) Application of the pigment to the chromatography paper
2) Exposing the pigment to a solvent that wicks up the chromatography paper
3) Calculating Rf values and comparing the distance traveled by each pigment on the chromatography paper
4) Calculate the R_f using the equation below

$$R_f = \frac{\text{Distance traveled by specific pigment from the application point}}{\text{Distance traveled by the solvent from the application point}}$$

2017-2018 Lessons

Lesson Title	Graduate Mentor, FRIP Students
Even Plants Can Fight Back!	Arati Nepal Poudel, Aidan Ireton, Garren Powell
How Plants Make Food!	Ashten Kimble, Samantha Smith
Journey into Germination	Katelynn Koskie, Haley Massa, Carson Pearl
Plants and Nutrients: What Plant Parts do We Eat?	Mani Awale, Jenna Bohler, Will Costigan
There's More Than Just Roots Down There!	Benjamin Spears, Connor Nordwald
Why so Green? An Activity on Plants and Light	Benjamin Spears, Miki Hodel, Connor Nordwald

Even Plants Can Fight Back!

Activity Overview

Plants can be attacked by many insect pests throughout their lifecycle. Plants have developed a number of ways to deal with these attacks. Students will be introduced to one defense mechanism plants use: the production of an important hormone called jasmonic acid. The presence of jasmonic acid makes it possible for plants to fight back and the absence of it makes plants defenseless, therefore likely to be eaten up by caterpillars or other insect pests. Activities and discussion will stress how altering 'palatability' can be an effective defense strategy to avoid being eaten- just ask broccoli!

Next Generation Science Standards

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival. Use observations to describe patterns of what plants and animals need to survive.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Support an argument with evidence, data, or a model.	A system can be described in terms of its components and their interactions.	Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.

K-LS1-1. Use observations to describe patterns of what plants and animals need to survive.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Use observations [firsthand or from media] to describe patterns in the natural world.	Patterns in the natural and human designated world can be observed and used as evidence.	All animals need food in order to live and grow. Animals obtain their food from plants or from other animals. Plants need water, air and light to live and grow.

Materials

Plant of choice [(stressed with a pest like caterpillars, aphids, or other biting insects)
*** If available, use a resistant (superpowered) and a susceptible (defenseless) plant variety to highlight the activation of defenses
Milk chocolate
Baking chocolate
Provided worksheets

Engage

Step 1: Engage the students with a discussion on plant defenses by asking the following questions and introducing the plants of choice.

<u>Questions to ask:</u>

- What would you do if someone attacked you?
- Do you think plants get attacked too? By What?

	• What do you think the plant do when they are attacked by caterpillars? • Can they defend themselves? • Can they run away like we human being? "After getting feedback, today we are going to talk about two types of [plants] that caterpillar likes to feed on" – Show students UNDAMAGED plants • Do you think both of these plants could fight off caterpillars?
Explore **The goal is to show that taste aversion protects chocolate from being eaten similar to how plants protect themselves from caterpillars** **Introduce the idea of "unseen differences" between plant types AND chocolate types**	**Step 2**: "We've talked about the caterpillar's favorite food, but what about ours?" Introduce the two different (but visually identical!) chocolate samples. Questions to ask: • Do you like chocolates? *Show the chocolate and ask whether they look same or not • Does anyone want some? "Ok, caterpillars like to eat leaves, and we like to eat chocolate" *Make sure the chocolates look similar; let the students taste them **Step 3:** Get student feedback on the chocolate samples Questions to ask: • Do you like both the chocolates? • Ok, tell us which chocolate you liked and which one you didn't? (It might be helpful to write their experience in one corner of the board: Assign different colors for likes eaten all and dislikes not eaten) (sweetness – green – eaten all) and dislikes (bitter – red – could not be eaten) **Step 4:** Conclude the chocolate experience with a discussion. Questions to ask: • Though these chocolates looked exactly the same, but you are saying that they taste different? How could be the chocolate different? How is that? * They are different from inside, some INVISIBLE SECRET DIFFERENCES. *They were made with different recipe which we don't see from outside.

Remember that ideally, one of the plants is susceptible to insect feeding, while the other is healthy. **Connect "invisible differences" to susceptibility to insect feeding**	**Step 5:** Exploring the secret defenses of plants- Present the two types of plants to the students (insect-damaged and undamaged; or resistant and susceptible) and have them examine the plants closely. Questions to ask: • Can we let some caterpillars eat these similar looking plants and see what happens? • How would we know if one plant defended better than the other? Let's say one of them has superpower than the other. Can you guess what the superpower plant may look like? • And how would the caterpillar eat superpower plant and defenseless plant? **Step 6:** Distribute the supplemental activity sheet to each table. Have students describe what the differences are between 'superpowered' plants and 'defenseless' tomato plant. Questions to ask: • "We did a similar experiment for you. We let the [insects] feed on these two plants separately" Can we tell whether these two similar looking plants are ACTUALLY similar or not? • After few days of feeding it looked like this. Do you see any differences? • Do you see any difference in plants after being fed by caterpillars?
Extend **During this portion of the lesson ask students to think about their observations.**	**Step 7:** Summarize the results of the chocolate and plant activities *Have students put check mark on the sheet when their prediction matches the displayed plants and caterpillars. • Similar to these chocolates, could there be anything that is different between these two plants to fight off the [insects]? Any guess? Let them speculate • Being different from inside may help them defend better than the other one, just like the different tastes for chocolate make them get eaten or not. • They were made with "different recipes" like our two types of chocolates. • Plants and all other living things have a 'kitchen' inside the cell.

	• Superpowered plants have everything needed to defend against the [insect], while the defenseless plants lack the cellular tools to protect themselves. Slide show: pictures of thrones, trichomes and color (pigments like anthocyanins) that plants use to defend insects. • Plants use these structures as a weapon to fight off the insects and they are made from the different type of cellular instructions. • The differences may not show always because they are happening **at the cellular level.**
Extend **Creative expression of concepts identified from the lesson**	**Step 8:** With time remaining, have students come up with their own ideas of 'superpowered plants'- What would yours look like? <u>Questions to ask:</u> • If you were a plant, how would you defend yourself against insects? • What about other types of threats? (No wrong answer!)

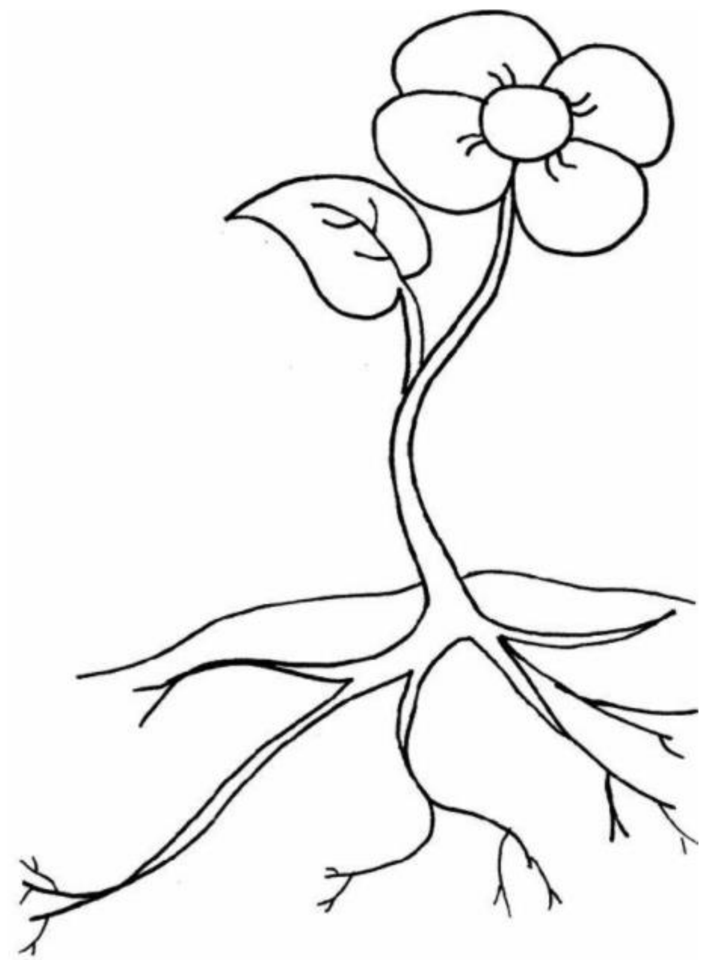
Students examining resistant and susceptible plants

Even Plants Can Fight Back!

Supplemental Materials

Caterpillars on superpowered plants vs. defenseless plants Circle the one that best matches		
	Plant 1 (Superpowered plant)	Plant 2 (defenseless plant)
How does the plant look?		
Leaves shape	Good normal bad	Good normal bad no leaves
Leaf color	Green yellow red	Green Yellow red no leaves
Stem	Good Normal Bad	Good Normal Bad
What about the caterpillars?		
Number	Many Few	Many Few
Size	Small Medium Big	Small Medium Big
Color	Green Yellow Red	Green Yellow Red
Conclusion: Plant ______ is a superpowered plant. Plant ______ is a defenseless plant.		

Draw your own superpowered plant- Use the example plant or design your own!



How Plants Make Food!

Activity Overview

This activity will introduce children to the significance of photosynthesis both to plants and the organisms like us that rely on them for survival. and the means by which water moves through a plant. Students will engage in discussion after playing a board game designed to highlight the importance of environmental conditions to a plant's ability to photosynthesize.

Learning Objectives

At the conclusion of this lesson, students will:

- Be able to describe the necessary inputs and resulting outputs of photosynthesis
- Use a model to describe how the environment of a plant may limit photosynthesis

Next Generation Science Standards

5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Develop a model to describe phenomena.	A system can be described in terms of its components and their interactions.	Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain water and oxygen from the environment.

4-LS1-1. Use observations to describe patterns of what plants and animals need to survive

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Use observations [firsthand or from media] to describe patterns in the natural world.	Patterns in the natural and human designated world can be observed and used as evidence.	All animals need food in order to live and grow. Animals obtain their food from plants or from other animals. Plants need water, air and light to live and grow.

Materials

Provided board game components
Paper and coloring utensils
Gluesticks

Engage

Step 1: Engage students in a lesson about photosynthesis, emphasizing what is required (inputs) and what is produced (outputs). Have them pretend to be plants- What kind of plant are they?

Questions to ask:

- What do you [plants] need to make food?
- What could change how much of those inputs [water, light, CO_2] you have access to?

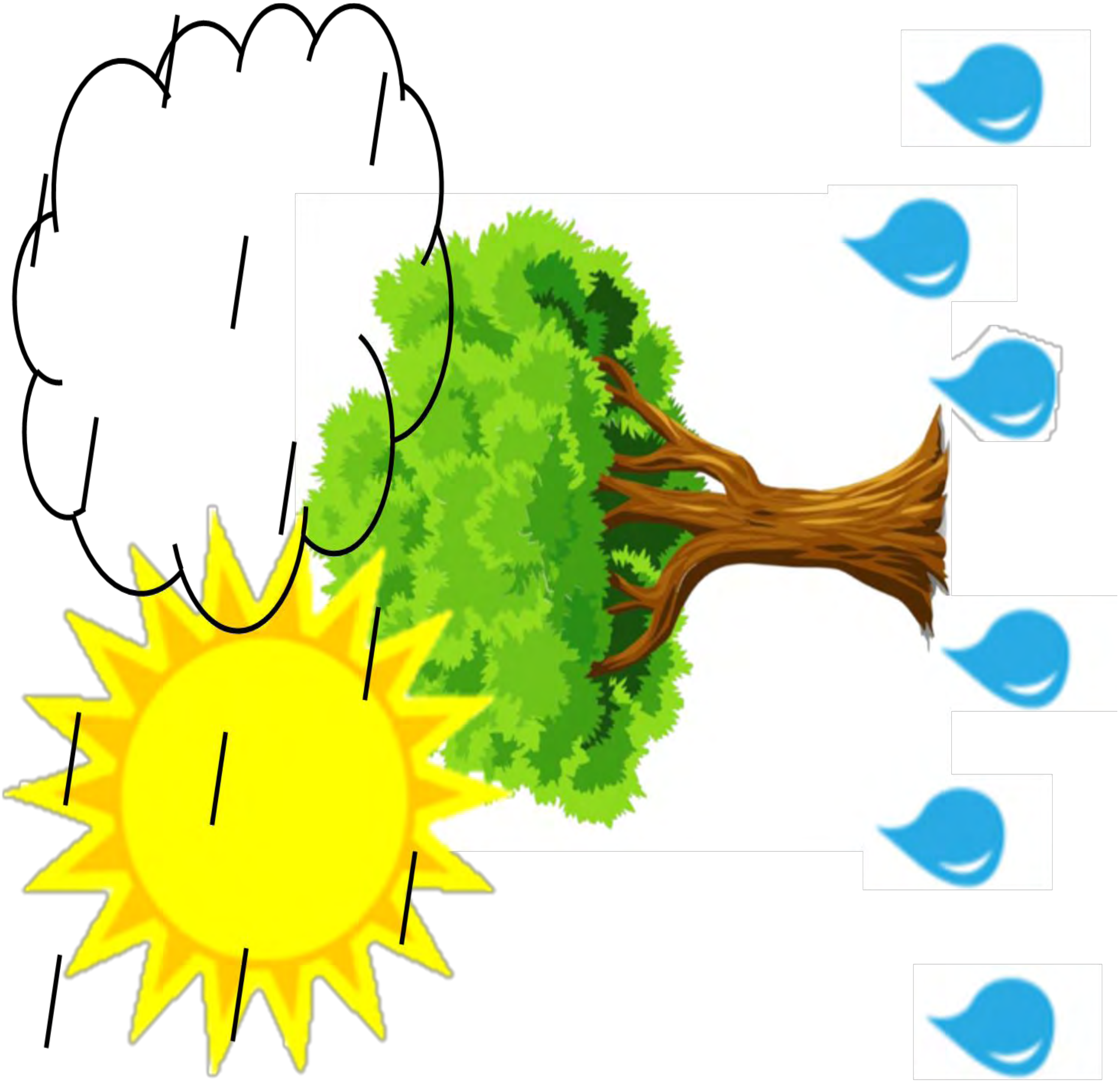
Explore **Students will explore the role of environment in photosynthesis through an interactive board game** **Extend** **Connect photosynthesis back to our reliance on plants**	**Step 2:** Randomly assign groups of students a starting location on the game map (using the provided location cards) and give them the noted starting materials (x # of H_2O, CO_2, and light tokens) <u>Questions to ask:</u> • What do these different starting materials represent? • Can you think of a reason why you might have the specific # of each type of token your location has given you? (no wrong answer) **Step 3:** Shuffle an equal number of each card into its specific individual resource pile and mix an equal number of wildcards into each pile. **Step 4:** The goal of the game is to acquire 6 of each resource, allowing you [the plant] to produce food! In an ordered manner, have students come to the front of the classroom and request a specific type of material they need, selecting a card randomly from the corresponding randomized pile (H_2O, CO_2, and light). The cards will provide 0-1 resources as indicated, but the 'wildcards' shuffled into each deck (the weeds) can provide 1-3 of any resource needed; the wildcards represent elimination of competitions from 'other' plants in your environment! Have the students glue the resources to their game boards to keep track of what they have collected and what they still need. <u>Questions to ask:</u> • Why does removing weeds give you the resources that you [the plant] need? • Is this like the real world outside? Do you always have access to water or sun? What could prevent that from happening? **Step 5:** Once a student has acquired 6 of each resource, the game is over! The best (or luckiest) plant won- but what did they make from all of this resource collection? Make sure to stress the **outputs**. <u>Questions to ask:</u> • How do we take advantage of photosynthesis? • What did you make as a plant that we want as people? • What might happen if photosynthesis can't be performed as well by plants in our environments?

How Plants Make Food!

Supplemental Materials

Game Board [Map]

Game Board [Player Mat]



Starting Environment Cards

The Beach

1 Water
3 Energy

The Road

1 Carbon
3 Energy

The Meadow

1 Water
2 Energy
1 Carbon

The Forest

3 Carbon
1 Water

The River

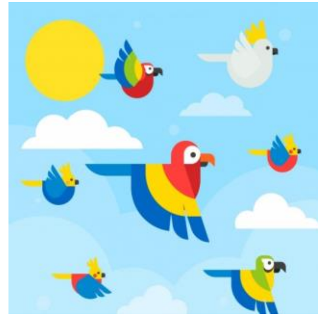
3 Water
2 Energy

Game Pieces

The birds migrate away from the island

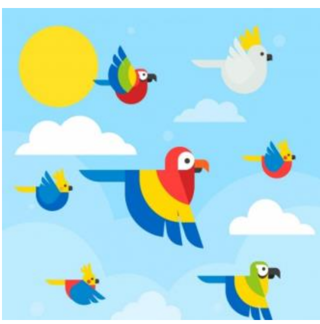
NO CO_2

The birds migrate away from the island



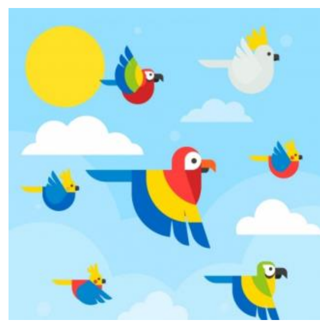
NO CO_2

The birds migrate away from the island



NO CO_2

The birds migrate away from the island



NO CO_2

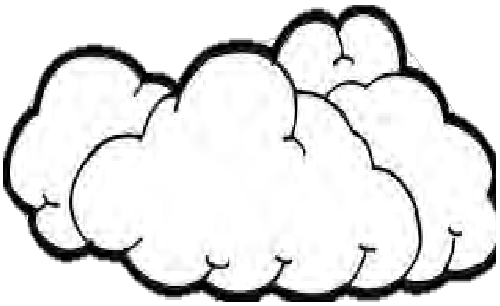
A family of tigers makes a home nearby

+ 1 CO_2

A family of tigers makes a home nearby

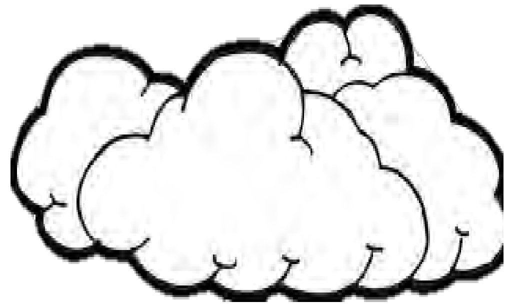
+ 1 CO_2

It's too cloudy for the sun to shine through



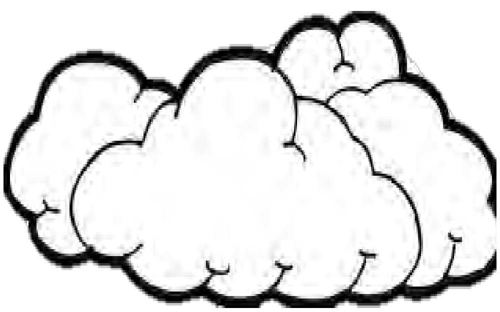
NO Energy

It's too cloudy for the sun to shine through



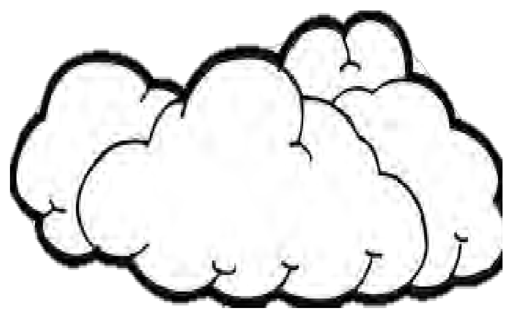
NO Energy

It's too cloudy for the sun to shine through



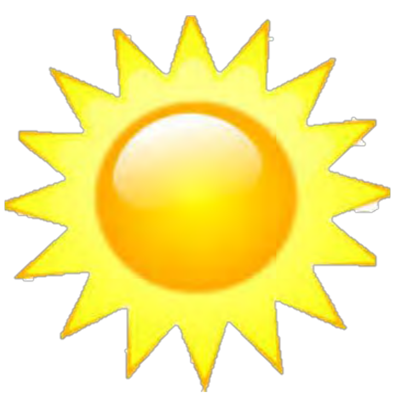
NO Energy

It's too cloudy for the sun to shine through



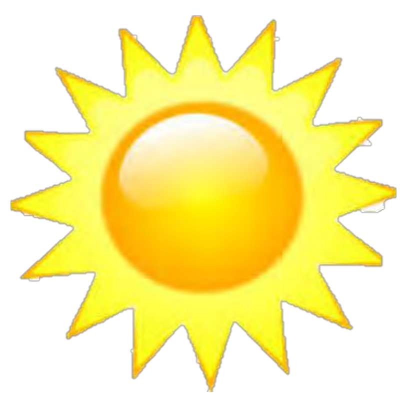
NO Energy

It's a bright sunny day



+ 1 Energy

It's a bright sunny day



+ 1 Energy

It's dry as a desert

NO H_2O

It's dry as a desert

NO H_2O

It's dry as a desert

NO H_2O

It's dry as a desert

NO H_2O

A rainstorm showers you with water

+ 1 H_2O

A rainstorm showers you with water

+ 1 H_2O

A nearby weed is removed

+ 2

A nearby weed is removed

+ 2

A nearby weed is removed

+ 2

A nearby weed is removed

+ 2

A nearby weed is removed

+ 3

A nearby weed is removed

+ 3

CO_2 CO_2 CO_2 CO_2

CO_2 CO_2 CO_2 CO_2

CO_2 CO_2 CO_2 CO_2

CO_2 CO_2 CO_2 CO_2

CO_2 CO_2 CO_2 CO_2

CO_2 CO_2 CO_2 CO_2


Energy

Energy

Energy

Energy


Energy

Energy

Energy

Energy


Energy

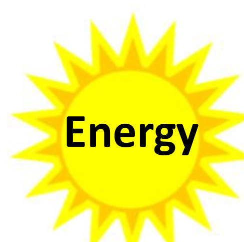
Energy

Energy

Energy


Energy

Energy

Energy

Energy


Energy

Energy

Energy

Energy


H_2O
H_2O
H_2O
H_2O
H_2O
H_2O
H_2O
H_2O
H_2O
H_2O
H_2O
H_2O
H_2O
H_2O
H_2O
H_2O
H_2O
H_2O
H_2O
H_2O
H_2O
H_2O
H_2O
H_2O
H_2O
H_2O
H_2O
H_2O
H_2O
H_2O

Journey into Germination

Activity Overview	Every student should have an idea of what a seed is, but many will likely be unfamiliar with the transition between seed and plant, and the importance of **germination** to that process. In this lesson, students will learn about the different structures within a seed that contribute to germination and reinforce those concepts through several fun activities.
Next Generation Science Standards	**4-LS1-1.** Construct an argument that plants and animals have internal and external structures that function to support survival. Use observations to describe patterns of what plants and animals need to survive.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Construct an argument with evidence, data, and/or a model.	A system can be described in terms of its components and their interactions.	Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.

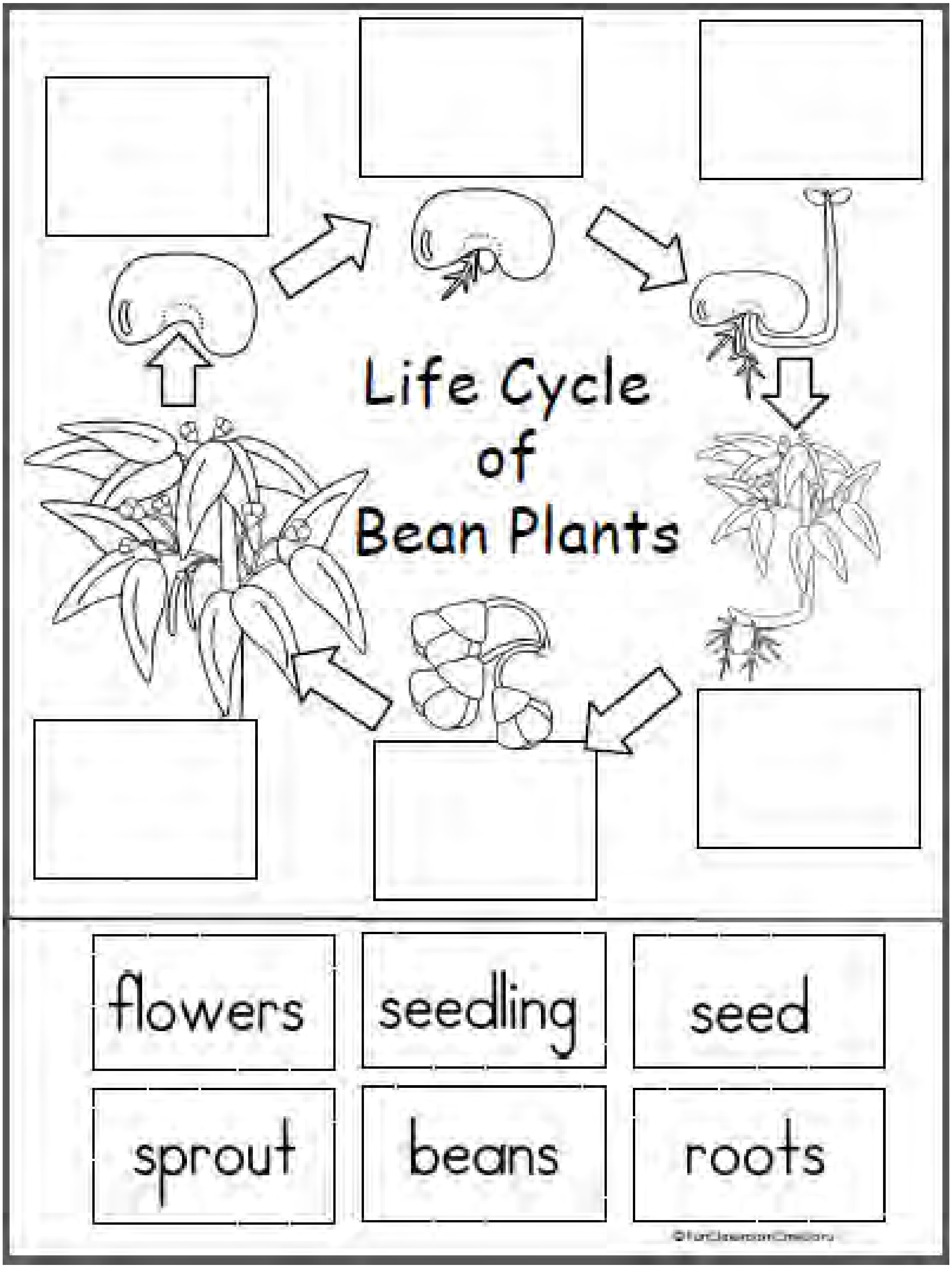
Learning Objectives	At the close of this lesson, students should be able to: 1. Describe the identity and functions of the components of a seed 2. Provide a summary of the transition from seed to adult plant 3. Identify requirements for germination and how it can be influenced by the plant's environment
Materials	Toy foam capsules (any type will do) Bowls of warm water A variety of seeds (many colors, shapes, sizes if possible) Bean seeds [pinto/lima bean] (some dry, some soaked in water for 24 hours) Tool for dissection
Engage	**Step 1**: Engage students in an introductory discussion about seeds, allowing them to examine the variety of seeds. Address the following: • The relationship between seeds and plants (What ARE seeds?) • What might be different between individual seeds/varieties • What does it take to turn a seed into a plant? • Define 'endosperm', 'embryo', 'seed coat', and 'radicle'

Explore **Students will explore the swelling of seeds due to water intake** **Help students identify and think about the functions of seed structures**	**Step 2**: Provide students with the dry and water-soaked pinto/lima beans and ask them to consider the differences between them. Questions to ask: • Why do you think some of these seeds are larger (swollen) compared to the dry seeds? • Are both of these seeds alive? Is the dry one 'asleep'? • What do you think the seed is using this water for? What do we use water for? **Step 3:** Help the students to carefully dissect the swollen seeds and identify the individual seed components that were defined in the initial discussion. Questions to ask: • What do you think [structure] does? What would happen to the seed, and ultimately the plant if [structure] wasn't here? • Why do you think this might happen?
Explore **Use growing foam capsules as a proxy for real-time seed germination**	**Step 4:** Germination of foam capsule 'seeds'. • Show the students a youtube video describing germination, such as: https://www.youtube.com/watch?v=lGCZXx_Pczo • Hand each group of students several capsules and a bowl of warm water- Add capsules to water and have students consider what the natural equivalent of this scenario is. What does the capsule represent? What about the water? • Allow the capsules to grow over the remaining duration of the lesson, having students monitor the progress occasionally. Questions to ask: • Is the capsule swelling in water? How is this like the seeds that we dissected earlier? • What happens when a seed has taken in enough water? Are our 'seeds' doing something similar? • Would this seed grow if it wasn't put in water? Why not?
Explain	**Step 5:** While waiting for foam 'seeds' to germinate, hand out the crossword puzzle and help students to fill it out, reminding them of the earlier discussion in the lesson.

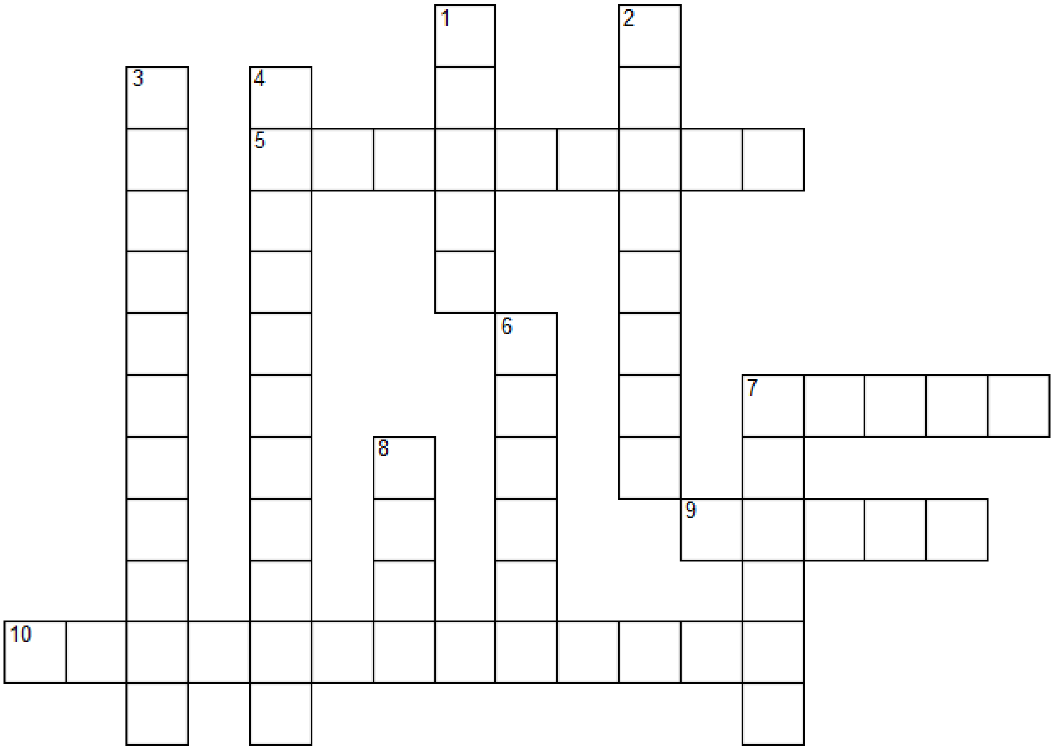
Review the cycle of seed germination	**Step 6:** Complete the life cycle flow chart to review what the students have learned. Questions to ask: • What part of the embryo emerges from the seed first? • Once the seedling reaches the surface, it no longer needs the endosperm- What REALLY important process can the seedling now perform? **Step 7:** Show the student a video discussing germination to reinforce concepts discussed earlier. • https://www.youtube.com/watch?v=lGCZXx_Pczo
Extend **Ask students to apply what they have learned to think about germination in different types of plants**	**Step 8:** Work through the seed and fruit matching activity with students, making sure to stress how different types of plants have different types of seeds, and why that might be the case. Questions to ask: • Why do you think some types of seeds are bigger than others? • What about the different colors? • How do you think seeds can move away from the adult plant? • What kinds of plants have seeds? • Where are the seeds located? • Why are they located in the fruits? What could that help to occur?

Journey into Germination

Supplemental Materials

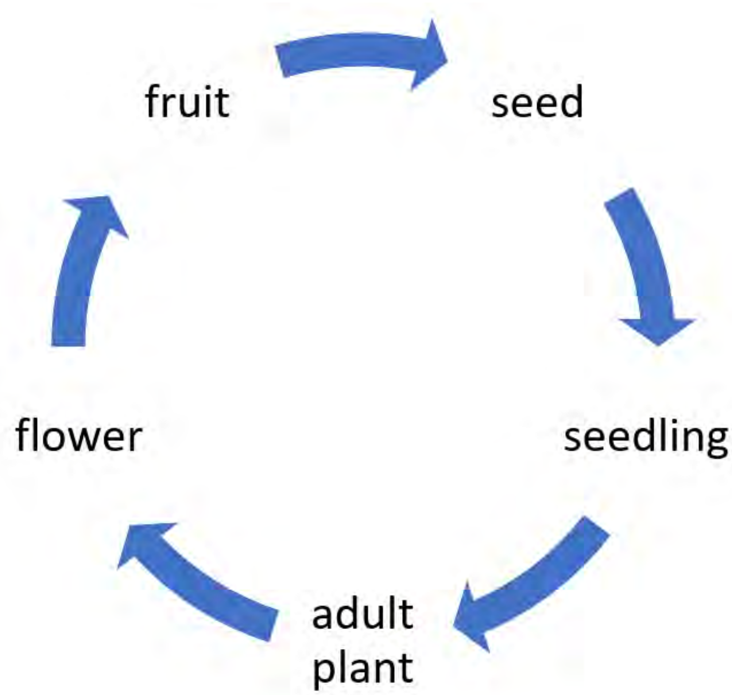

Life Cycle of Bean Plants
flowers
seedling
seed
sprout
beans
roots

Journey in Germination!



ACROSS
5 food source in seed
7 comes from the Sun
9 H2O
10 gas necessary for germination

DOWN
1 plant part that is underground
2 protective coat on outside of seed
3 what a thermometer measures
4 process of seed development
6 tiny plant inside of seed
7 plant part where photosynthesis occurs
8 something that gets planted in the soil



https://www.puzzle-maker.com/CW/

Plants and Nutrients: What Plant Parts do We Eat?

Activity Overview

The focus is on nutrition and plants.

Students know that they eat plants, but what part of the plant are they eating?

Students understand that plants are a major portion of their diet, however, the question is: "What part(s) of the plant do we actually eat?" To answer this question, students will focus on various aspects of plant science:

1. Plant parts: when students think of plants, they often are not aware of the specific portions of each plant – such as leaves, flowers, stem, and roots.
2. Functions of the various parts of the plant: understanding the role of the various parts of a plant in terms of the life of the plant is a critical aspect of plant biology and also provides insight as to why that specific portion of the plant is nutrient rich.
3. Nutrient storage in plants: seeds store nutrients which support the embryonic plant prior to the onset of photosynthesis; tubers [potatoes] store nutrients; roots [roots] also store nutrients; stems or stalks [celery] are also nutrient rich.

Learning Objectives

At the close of this lesson, students will be able to:

- Identify the edible parts of plants
- Match the plant part with a specific function
- Match produce from the grocery with a specific plant part grouping
- Identify plant parts which contribute to a healthy diet.

Next Generation Science Standards

The focus is on the parts of plants and their functions which support survival through growth and reproduction.

1-LS1-1. Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Use materials to design a solution that solves a specific problem.	The shape and stability of structures of natural and designed objects are related to their function.	All organisms have external parts. Plant parts including roots, stems, leaves, flowers, seeds, and fruits are critical to survival of the plant.

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Construct an argument with evidence, data, and/or a model.	A system can be described in terms of its components	Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.

Materials	Plastic knives (for dissecting fruits to see the seeds inside) Fruits & Vegetables: Cherry tomatoes, Apple, Popcorn, Green pepper, Cucumber, Onion, Broccoli, Artichoke, Baby carrots, Radish, Spinach leaves, Asparagus, Celery stalks, and a Potato. T • This is a good variety of fruits and vegetables for sorting (and sampling) purposes. o A pre-made vegetable platter may be useful for this. Normally they contain carrots, celery, tomatoes, broccoli or cauliflower.

Engage
 	
Encourage students to reflect upon the lesson presented last week!
 	
The lesson focused on plant foods, color, and the nutrients within those foods.
 	
This lesson will help students think about what they eat and where those foods actually come from.
	Step 1: Engage children with a discussion focused on healthy eating. Ask students for their thoughts about last week's lesson which was focused on nutrients in plant foods and the relationship of color to nutrient content.
	
	Questions to ask:
	• Why do you remember about our lesson from last week?
	• Does the color of a plant part tell you something about the nutrients it contains?
	  o For instance, carrots and sweet potatoes are orange. Do you remember the important nutrient in these foods? [Hint: Remember golden rice-what nutrient was added that also turned the rice from white to gold?
	• What parts of plants do we typically eat?
	  o Here is a list of plant parts that we eat every day. Can you tell what part of the plant these foods are taken from?
	    ▪ Carrots
	    ▪ Sweet Potatoes
	    ▪ Radishes
	    ▪ Apples
	    ▪ Celery
	    ▪ Lettuce
	    ▪ Tomatoes
	    ▪ Blueberries
	    ▪ Cherries
	• Engage the students with the matching activity [Challenge 1]
	
	• Presenters will implement the PowerPoint presentation at this time.

<table>
<tr>
<td>Explore

The goal of the exploration is to engage students with plants in terms of the foods they eat every day and the nutrients within those plant parts.

The major focus in this lesson is linking the plant foods so common in our diets to specific plant parts.

Also, we can encourage students to think about the function of these various plant parts in terms of survival, growth, and reproduction.</td>
<td>We will begin our exploration with a card sort. The cards are in the white envelopes at your table. Directions for the card sort:

Step 2: Ask students to look at the cards, they will notice that there are all sorts of fruits and vegetables.
<u>Questions to ask</u>:
First ask students to sort the cards into the following groups:
Fruit or Vegetable
Next, challenge students to identify the vegetable as belonging to one of the categories below:
Stem
Leaf
Root
Tuber
Seed
Last, ask the students to indicate if the vegetable is found above or below the ground.
Step 3: Drawing from the nutrition chart provided, ask the students what they think are the major nutrients supplied by each of the fruits and/or vegetables. This question draws from the previous lesson and also emphasizes the link between important nutrients and the vegetables we eat daily.

<u>Questions to ask</u>:
What is the nutrient in carrots and sweet potatoes?
Why should we make sure we eat enough of these foods?
Step 4: Students will now dissect the plant parts provided using plastic knives to conduct the dissection.
<u>Questions to ask</u>:
What did you find inside the cherry tomato you dissected? What do you think the purpose of the tomato might be?
Did you pull the celery stalk apart? What do you think those long string-like strips might be inside the celery? What do you think the purpose of the celery stalk might be?</td>
</tr>
</table>

Explore

Thinking about the foods we eat every day!

Using the student version of the table, help students fill in the missing information.

This is a collaborative activity- invite all students in your group to share their ideas!

Table of Plant Parts – Colors - Nutrients:

Edible Plant Part	**Characteristic**	**Nutrients**	**Edible Plant Part**
Carrot	Plant Part: Root Taste: Sweet Color: Yellow/Orange	Vitamin A	Carrot
Sweet potato	Plant Part: Tuber [Root] Taste: Sweet Color: Orange	Vitamin A	Sweet potato
Kale	Plant Part: Leafy stem Taste: Similar to lettuce Color: Green	Vitamin A & C; Dietary Fiber	Kale
Blueberries	Plant Part: Fruit Taste: Sweet Color: Blue	Anthocyanins (antioxidant)	Blueberries
Broccoli	Plant Part: Stem and Buds Taste: Similar to Brussel Sprouts Color: Green	Vitamin A & C Iron	Broccoli
Popcorn	Plant Part: Seed Taste: Starchy Color: Tan/Yellow	Protein, fats	Popcorn
Almonds, Peanuts	Plant Part: Seed Taste: Nutty Color: Tan	Protein, fats	Almonds, Peanuts
Celery	Plant Part: Stem-like stalk Taste: Wet Color: Green	Vitamins A & C	Celery
Tomato	Plant Part: Fruit Taste: Sweet Color: Red, Yellow, Purple	Vitamin C	Tomato

Extend	**Step 5**: Challenge students to complete the chart shown above, the student version and key are found at the end of the lesson. **Step 6**: Challenge students to plan a meal. The meal will contain a meat (chicken breast) and the vegetables and fruits they would like to add. <u>Questions to ask</u>: • What vegetables or fruits that we investigated today would be good to include in a meal? • Why do you want to include vegetables and fruits in your meal planning?
Explain	**Step 7:** Each student group will share the meals they designed and explain the following: 1. The plant parts included in the meal [roots, leaves, stems, etc.] 2. The nutrients from each plant part. 3. Students will watch the YouTube video which focuses on plant parts and the function of each https://www.youtube.com/watch?v=X6TLFZUC9gI

Graduate and undergraduate lesson leaders discussing plant parts

Background Information:

Stems: connect leaves and roots, and carry water and nutrients throughout the plant. Also provides structural support for the plant. *Examples:* ***Asparagus, White Potato (modified underground stem called a tuber), Cinnamon (bark of a tree), Broccoli (stem AND…??).***

Leaves: Leaves above ground are necessary for **photosynthesis**, which provides food for the plant. A leaf contains **veins**, which carries water and minerals into the leaf, while moving sugars out to the rest of the plant. *Examples:* ***Spinach, Lettuce, Celery (a petiole, which connects the stem of the plant to the leaf), Onion (modified hollow leaves underground).***

Roots are primarily below ground. They provide support so plants don't fall over, and also absorb water and nutrients from the soil. *Examples:* ***Carrots, Radish, Beets.***

Flowers are located above ground, and they act as reproductive structures for the plants. Flowers are designed to attract **pollinators** like bees. *Examples:* ***Broccoli head, Cauliflower head, artichoke.***

Fruits hold the seeds of the plants, and attract animals to eat them and spread the seeds held inside. If a plant part contains seeds, it is a fruit. *Examples:* ***Apple, cucumber, orange, tomato, strawberry.***

Seeds are the final stage in the plant reproductive cycle, and can be planted to grow another plant. *Examples:* ***Popcorn, Peas, Almonds, Peanuts. (Nuts are seeds, but will not be brought into class. Instead, a picture will be shown)***

Why include vegetables in your diet?

Harvard researchers found that people with the highest intake of fruits and vegetables, especially those rich in lutein, had half the risk of macular degeneration as those with the lowest intake.

Lutein—along with several other carotenes—gives summer squash, apricots, peaches, and oranges their yellow to light-orange color. But its richest sources are kale, spinach, and collard greens, in which the yellow pigment is masked by the more abundant green chlorophyll pigments.

Lycopene gives tomatoes their bright red hue and invariably stains our clothes when we indulge in a plate of spaghetti. High intakes may protect against prostate cancer. In a study of men 40 years and older, those who consumed more than 10 servings of tomato products per week had two-thirds the risk of prostate cancer as those who ate less than 1.5 servings weekly

Plants and Nutrients: What Plant Parts do We Eat?

Supplemental Materials

Challenge 1: match the nutrients with the function of each in our bodies.

MATCH UP

Nutrient cards	Function cards
protein	builds and mends muscles and other tissues
carbohydrates	give us energy for work and play
fats	give us energy for work and play
minerals	keep the body healthy
vitamins	keep the body healthy
water	keeps body temperature steady and stops the body from drying out

Vitamins	Function	Food Source	Mineral	Function	Food Source
Vitamin A	Prevents vision problems Immune function Skin health	Kale, Carrots, Pumpkin, Apricots, Peaches, Papayas, Mangos, Grains	Calcium	Vital for strong bones and teeth. Most effective during childhood	Broccoli, dark green leafy vegetables, soybeans.
Vitamin C	Healthy skin, bone, gums, and blood vessels Promotes healing	Citrus fruits, red berries, tomatoes, broccoli, spinach	Iron	Vital for making red blood cells to carry oxygen throughout the body.	Lentils, beans, soybeans, green leafy vegetables, raisins, and grains
Vitamin D	Strengths bones and helps the body to use calcium	Made in skin cells	Magnesium	Critical for muscle and nervous function	Whole grains, nuts, seeds, green leafy vegetables, Beans, bananas, kiwi, broccoli, and chocolate
Vitamin E	Protects cells from damage	Vegetable oils, nuts,	Phosphorus	Critical for healthy bones and teeth also helps the body turn carbohydrates into energy	Found in nearly all food sources.
Vitamin B6	Important for brain and nervous system function	Potatoes, bananas, beans, seeds, and nuts	Potassium	Critical for muscle and nervous system health.	Broccoli, potatoes, green leafy veggies, peas, and lima beans
Vitamin B1 [Thiamin]	Helps the body convert carbohydrates into energy to support muscles and nervous tissue	Whole grains [whole wheat bread]	Zinc	Vital for normal growth and a strong immune system	Nuts, dried beans, soybeans, and whole grains
B2 [Riboflavin]	Helps the body turn food into energy	Peas, lentils, nuts, green leafy veggies, broccoli, asparagus			
B3 [Niacin]	Helps the body turn food into energy	Peanuts			
B9 [Folate}	Helps the body to make red blood cells. Helps the body to make DNA and is very important for developing babies	Legumes and beans, green leafy veggies, asparagus, oranges and other citrus fruits			

Student Page

Edible Plant Part	Characteristic	Nutrients
Carrot	Plant Part: ________________ Taste: Sweet Color: ________________	Vitamin __
Sweet potato	Plant Part: ________________ Taste: Sweet Color: __________________	Vitamin __
Kale	Plant Part: Leafy stem Taste: Similar to lettuce Color: _______________	Vitamin___ & C; Dietary Fiber
Blueberries	Plant Part: ______________ Taste: ________________ Color: Blue	Anthocyanins (antioxidant)
Broccoli	Plant Part: __________________ Taste: Similar to Brussel Sprouts Color: ________________	Vitamin A & ___ Iron
Popcorn	Plant Part: Seed Taste: Starchy Color: Tan/Yellow	_____________, fats
Almonds, Peanuts	Plant Part: Seed Taste: Nutty Color: Tan	Protein, ________________
Celery	Plant Part: Stem-like stalk Taste: Wet Color: Green	Vitamins ___ & ____
Tomato	Plant Part:__________ Taste: Sweet Color: ___________________	Vitamin ___

Key:

Edible Plant Part	Characteristic	Nutrients
Carrot	Plant Part: Root Taste: Sweet Color: Yellow/Orange	Vitamin A
Sweet potato	Plant Part: Tuber [Root] Taste: Sweet Color: Orange	Vitamin A
Kale	Plant Part: Leafy stem Taste: Similar to lettuce Color: Green	Vitamin A & C; Dietary Fiber
Blueberries	Plant Part: Fruit Taste: Sweet Color: Blue	Anthocyanins (antioxidant)
Broccoli	Plant Part: Stem and Buds Taste: Similar to Brussel Sprouts Color: Green	Vitamin A & C Iron
Popcorn	Plant Part: Seed Taste: Starchy Color: Tan/Yellow	Protein, fats
Almonds, Peanuts	Plant Part: Seed Taste: Nutty Color: Tan	Protein, fats
Celery	Plant Part: Stem-like stalk Taste: Wet Color: Green	Vitamins A & C
Tomato	Plant Part: Fruit Taste: Sweet Color: Red, Yellow, Purple	Vitamin C

The envelopes at your table include pictures of fruits and vegetables. These images have been cut into cards which will be sorted by the students.

Step 1:

Sort the fruit and vegetable

Step 2:

Sort vegetable cards by function within the plant

Step 3:

Check either the above ground or below ground column


FRUIT IN ENGLISH
Woodward ENGLISH
apple
apricot
avocado
banana
blackcurrant
blackberry
blueberry
cherry
coconut
fig
grape
kiwi(fruit)
lemon
lime
lychee
mango
nectarine
orange
papaya
passion fruit
peach
pear
pineapple
plum
quince
raspberry
strawberry
watermelon
www.grammar.cl
www.woodwardenglish.com
www.vocabulary.cl


VEGETABLES
Woodward ENGLISH
artichoke
asparagus
beetroot
bell pepper
broccoli
Brussels sprout
cabbage
carrot
cauliflower
celery
corn
cucumber
eggplant
green bean
lettuce
mushroom
onion
pea
potato
pumpkin
radish
sweet potato
tomato
zucchini
www.grammar.cl
www.woodwardenglish.com
www.vocabulary.cl

Card Sort Categories: **[Misconceptions: onions are leaves not roots; Potatoes are tubers not roots]**

<table>
<tr><th>Fruit</th><th colspan="3">Vegetable</th></tr>
<tr><td rowspan="5"></td><td>STEM:</td><td>Above Ground</td><td>Below Ground</td></tr>
<tr><td>LEAF:</td><td>Above Ground</td><td>Below Ground</td></tr>
<tr><td>ROOT:</td><td>Above Ground</td><td>Below Ground</td></tr>
<tr><td>TUBER:</td><td>Above Ground</td><td>Below Ground</td></tr>
<tr><td>SEED:</td><td>Above Ground</td><td>Below Ground</td></tr>
</table>

There's More Than Just Roots Down There!

Activity Overview	It's no surprise that plants are exposed to many different environmental conditions and harmful organisms above the ground that can affect their growth- just look at a flower after a particularly hot and dry spell, or garden vegetable that has been munched on by a pesky rabbit. We know all about how roots work, but we tend to forget that there is another unique ecosystem below our feet where the roots are found! The environment around the plant roots is known as the 'rhizosphere', and the things found there play a big role in the quality of plant growth and development. In this lesson, students will be introduced to the concept of a rhizosphere and how the roots of different plants may be exposed to different environments, and after several fun activities will be able to recognize things below their feet that will be helpful to plants, harmful to plants, or possibly both! Students will learn how scientists work both individually to look at small areas of the world around us, but also how we can generate **big** ideas by bringing our individual data together to make interesting conclusions.
Next Generation Science Standards	**4-LS1-1.** Construct an argument that plants and animals have internal and external structures that function to support survival. Use observations to describe patterns of what plants and animals need to survive.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Construct an argument with evidence, data, and/or a model.	A system can be described in terms of its components and their interactions.	Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.

5-PS1-3. Make observations and measurements to identify materials based upon their properties.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Make observations and measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.	Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.	Measurements of a variety of properties can be used to identify materials.

Materials

Soil
Pipe cleaner flower w/ roots ('healthy' and 'sick' flowers)
Small pots
Various laminated tokens (representations of water, viruses, fungi, bacteria (red and black), plastic bugs, rubber worms etc..)
Drawing activity sheet
Coloring materials
Disposable gloves (latex or nitrile)

	*Prior to the day of the activity, mix together soil and the various laminated tokens (including BLACK bacterium) and pack into small pot in equal numbers; place a 'healthy' flower into each of these *In each pool of pots, prepare one of three possible pots with 'sick' flowers and the following specific soil contents: -RED bacterium instead of BLACK -x2 as many water tokens as the other pots -x0.5 as many water tokens as the other pots -x0.5 as many nutrient tokens as the other pots
Engage **Help students think about what plants are exposed to in environments both above and below ground.**	**Step 1**: Walk through the basics of common plant structure and environment (shoots above ground, roots below) with a picture on the smart board. Questions to ask: • What do plants 'see' above the ground? What sorts of things are in their environment? • What sort of environment is the plant root in? Is this environment the same for every kind of plant? • Are the roots important? What do you think would happen if the plant lost its roots? -Segue into the coloring activity **Step 2:** Hand out the "Draw your own Rhizosphere" coloring sheet and instruct the students to draw their ideas for what a plant root is exposed to in its rhizosphere. Try to let the students propose their own ideas for what they think is lurking in the soil with plant root. After giving some time to think and draw, come together and ask the students what sorts of things they thought would be down where the plant's roots are.
Explore **Students will explore the nature of science through careful thinking and observation.**	**Step 3**: Present each of the students (or group of students) with one of the assembled flower pots. Have them think about what they expect to find inside of the pots, pretending that the area would be similar to what we might find in nature. The students should record their expectations on the 'Predictions' sheet according to what they drew in Step 2 or thought about in discussion. Questions to ask: • Does your plant look healthy or sick?

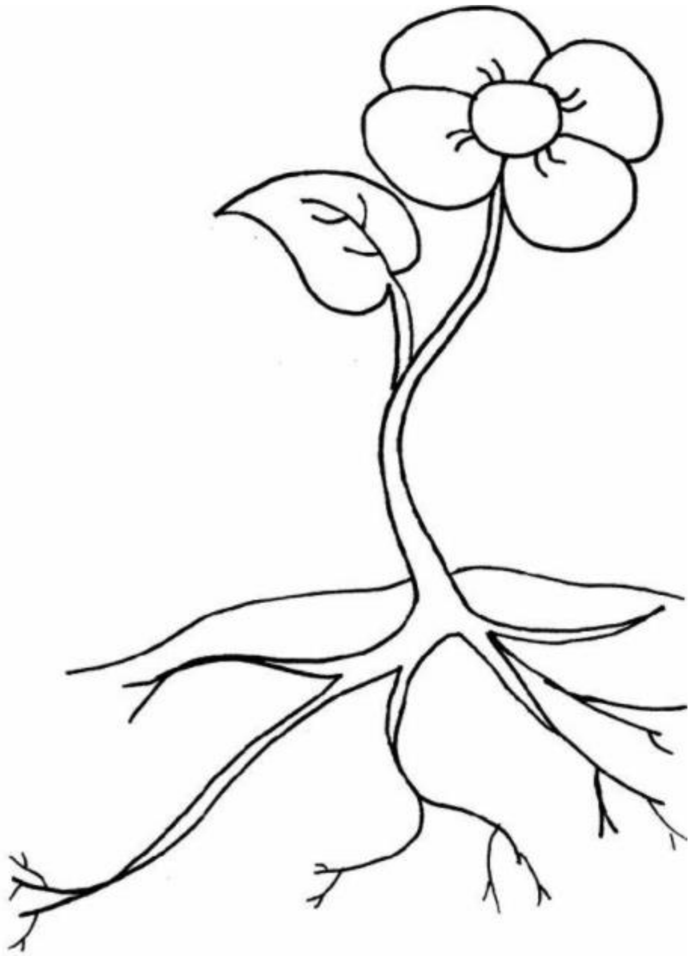
Ask students to think like scientists and make predictions about what they will find 'under ground'	• If the above-ground environments are ideal for these plants, could something be wrong with the underground environment? • What sort of things and down where the roots are? Are they good or bad? [Some are both!] • What are the roots trying to find for the plant? • What will we find inside these pots? **Step 4:** Have the student put on nitrile/latex gloves and begin digging soil out of the pots, recording what they observe on their 'Predictions' sheets. Help the students identify what each token represents if needed (Red and Black bacteria can be just 'bacteria', and relative concentrations of the tokens don't need to be addressed at this point).
Explain **Students will work to contribute their individual findings to a larger dataset to analyze**	**Step 5:** Once the students have excavated all the pots' contents, have them go the front of the class and relay both A) what they found in their pots and B) the condition of the plant (healthy/sick) to one of the teachers at the front of the room; they will record the individual data on a larger chart to summarize all of the students' findings. <u>Items to record:</u> • # of each individual type of token • Color of the individual tokens (Bacteria)
Extend **During this portion of the lesson ask students to think about their observations and generate a model.** **Reflection**	**Step 6:** Work with the students to put together a basic model of what a plant needs to be healthy, and what might make a plant sick. Be sure to highlight that this is how science actually works- many small discoveries adding up to a bigger picture of how the world around us behaves! <u>Questions to ask:</u> • What items do **all** of the healthy plants have down by the roots? • What **amount** of each item do **all** of the healthy plants have? • What thing(s) are different between the healthy roots and the sick roots? • If the above-ground environment was the same for each of these pots, can we make the prediction that the underground environment (rhizosphere) might have determined if the plants are healthy or sick? • Can you think of reasons why these things might have made the plants healthy or sick? (too much water, too little water, beneficial vs. harmful bacteria [gut flora/yogurt as examples of '**good**' bacteria], nutrient deficiency)

Extend **Students will compare and contrast the plant environment from their earlier lesson with these new possibilities.**	• Would we have been able to make these conclusions about what a plant root needs if we all didn't contribute our individual findings? **Step 6:** "Different roots for different plants" activity sheet. *[If time allows]* • Hand out the worksheet for each group • Go through with the students and ask them to consider the following questions in each case: 1) What is the environment that this plant's roots are exposed to? Are they similar to those of other plants or anything that we've talked about? 2) What harmful things are present in this environment? What helpful things? 3) How might the roots of each of these plants have developed to help them grow in their unique environment? [evolution or short-term adaptation is ok]
Reflect	<u>Questions to ask:</u> • What have we learned about the things that plant roots live among in the soil? • Do you think it's important to study how plant roots grow in the soil? • Why do you think healthy plant roots are important? What do we like to get from plants that could be affected if the roots are hurt? • What do you think we could do to help plant roots grow better?

There's More Than Just Roots Down There!

Supplemental Materials

Draw your own Rhizosphere!



Prediction Sheet

What do you think we will find underneath the flower?

What did we find underneath the flower?

Item	**Amount**

Different roots for different plants!

Why so Green? An Activity on Plants and Light

Activity Overview

Everyone knows that the leaves of most plants are green, and most students have probably heard that this is due to a molecule unique to plants and some microbes that we call **chlorophyll**. We also know already that plants use their chlorophyll to take in light from the sun, allowing them to make food and grow. But **WHY** does chlorophyll make plants green? At the end of this activity, the students will understand some basic properties of light (wavelengths and energy) and how that relates to color, and through some fun hands-on activities will see for themselves exactly why we see plants as green, and what the plant is doing to the **other** wavelengths of light that we don't see!

Next Generation Science Standards

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival. Use observations to describe patterns of what plants and animals need to survive.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Construct an argument with evidence, data, and/or a model.	A system can be described in terms of its components and their interactions.	Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.

1-PS4-3. Plan and conduct investigations to determine the effect of placing objects made with different materials in the path of a beam light.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Plan and conduct investigations collaboratively to produce evidence to answer a question.	Simple tests can be designed to gather evidence to support or refute student ideas about causes.	Some materials allow light to pass through them, others allow only some light through and others block all the light and create a dark shadow on the surface behind them, where the light cannot reach. Mirrors can be used to redirect a light beam.

Materials

- Mortars and pestles
- Coloring Utensils
- Dark green leafy tissue
- White Paper
- Strong light sources (flashlights or weak laser pointers)
- Colored filter sheets or cellophane wrapper (Red/Green/Blue)
- Beakers or any other clear glass container
- Rubbing alcohol
- Water for extract dilution

Engage

Refresh student's minds that white light is actually made of many types of light

Step 1: "Did you know that the light around you, that you've seen every day for your entire life is so much more than just white?" Use a rainbow as an example of our brief look at the true nature of light- a mix of many different colors! Have the students perform a coloring activity to think about the different colors that simple white light is actually made of.

Questions to ask:

- What colors of light is the plant getting from the sun?

Introduce students to light properties on a basic level

Step 2: Now that we've established that white light (like the kind in the classroom ceiling) is actually made of multiple 'colors' of light, we can demonstrate this principle be reconstructing white light from different colored light sources. Use the flashlights and colored filter sheets to project red, green, and blue light onto the projector screen individually, and then combine them in various assortments to generate different colors and, ultimately, white light (r +g +b). Ask for student volunteers to control the filters/light sources.

Questions to ask:

- What color of light is being produced from each of these filters?
- How can you make white light from the assorted colors?
- If we can make white light from these colors, do you believe that the white light we see has these colors in it?

Help students think about the components of white light and the concept of absorption/ transmission of different colors of light.

Step 2: Segue into an introduction to the concept of **lightwaves**. We are looking here to impress three main points:

1) There is light we can see with our eyes, and light that we cannot. The light that we can see is made of many different colors of light (energies), which together add up to white.
2) Light is either **absorbed** by an object or it isn't, depending on the object's properties and the color of light.
3) The colors of things we see (like your shirt, your desk) are determined by which parts of the white light are absorbed by the object and which aren't- Our eyes see the colors that aren't absorbed!

Start with video: https://www.youtube.com/watch?v=dH1YH0zEAik

We can make a personal connection here by highlighting students who are wearing different colored shirts, such as in this example:

1."Class what color shirt is Annie wearing? What about Stan?"
2."What color of light is Annie's shirt **NOT** absorbing? What about Stan's?"

Introduce students to photosynthesis and the use of light by plants	3."What is in each of their shirts that makes us see them differently?" (Dyes) 4." Do you think this is how your markers/crayons worked earlier in the lesson?" **Step 3:** Reinforce the lessons from the video with another activity using colored balls/buckets. Have the students try to throw the balls from a 'white light' bucket into a red container. Only allow non-red balls to make it into the container [Carney-style cheating, of course]. "What color is this bucket? Why do we see it as that color?" **Step 4**: Discuss with the students the concept of plants producing food from sunlight, and the tools plants use; Stress that plants can only use light that they can ABSORB. Questions to ask: • What parts of a plant are important for making its food? • Are most leaves green? Do you know why? (Looking for chloroplasts) *Connect to previous lesson by comparing a leaf to a student wearing green shirt; "What kind of light is the leaf and X's shirt not absorbing?"
Explore **Students will conduct a simple experiment to answer a scientific question** **Ask students to think like scientists and make and test predictions about how**	TARGET QUESTION "If we know what color of light the leaf (and chlorophyll), like X's t-shirt, IS NOT absorbing, what color of light do we think it IS absorbing? **** As scientists, we can answer this question with a simple experiment!** **Step 5:** Guide the students in thoroughly grinding several large spinach leaves in ~50mL of rubbing alcohol (You shouldn't have any issues getting them to participate here!). Dilute the lysate (the ground plant mixture) in 4 volumes water. Questions to ask: • What color is this mixture? Is it the same as the intact leaf? • What is in this solution that makes it appear [green]? • Do you think whatever is in this solution could be similar to the dye that colored X's shirt? **Step 6:** Making predictions – After showing the kids the experimental set up [detailed below], ask them to make predictions about what they will see?

light will behave **Students engage in scientific process** **Extend** **During this portion of the lesson ask students to think about their observations.**	• Predict what color light, if any will shine through each solution onto the white paper. o Record hypothesis on 'Predictions Sheet'. <u>Questions to ask:</u> • Why do think this is what we will see? • If we know that a green leaf DOES NOT absorb green light, will it pass through the solution? • Will we see different results between the lysate and clear water? Why? **Step 7:** Perform the experiments, carefully shining the light source through one of the filter sheets (or no sheet), through the beaker of fluid and onto the white piece of paper beyond. • Have the students record what color they see on the sheet for each combination • *Have them try to predict which colors are absorbed by the solution, and which are reflected/transmitted, if any* [could be too advanced, play it by ear] <u>Questions to ask:</u> • Did your hypotheses turn out to be correct? How were the actual results different? • What type of light was absorbed by the plant lysate? What type was not absorbed? How can we tell based on the light color or solution color? • Why did we use the water? [concept of a control]. Do you think controls are important for an experiment? • What do these results tell you about the type of light that plant leaves like to absorb?
Reflection	**Step 8:** Reconvene at the front of the room to talk about the results of the experiment and what we've learned about the type of light that plants absorb. <u>Questions to ask:</u> • What color of light do plant leaves get from the sun? [all colors] What color of light do they absorb? [red/blue] What color of light do they not absorb [green/all others] • What do the plants use to absorb that red light? [chloroplasts] • When we try to grow plants at home, is all light equal? Some people use special light sources to make their plants grow big! What do you think is special about those lights, based on what we learned today?

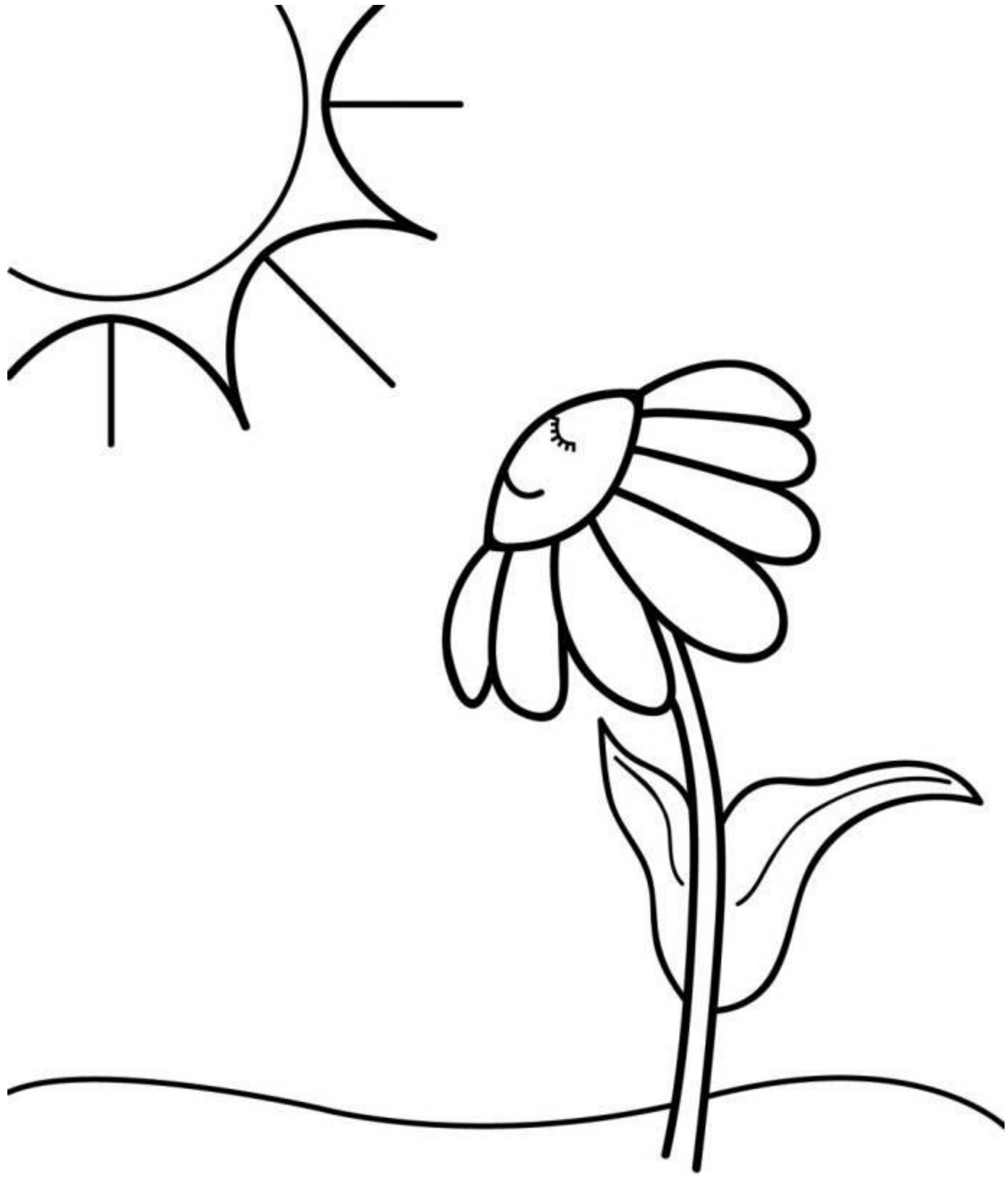
Grinding spinach in rubbing alcohol

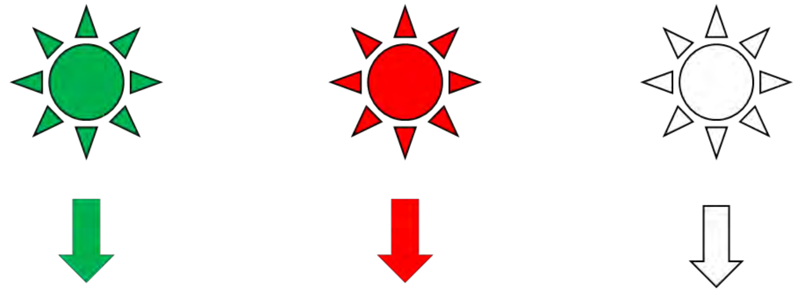
Extracting 'plant juice' is exciting!

Why so Green? An Activity on Plants and Light

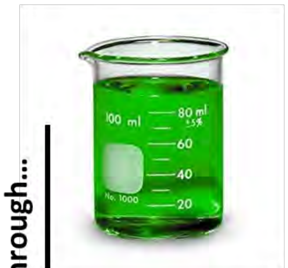
Supplemental Materials

Draw a rainbow made from sunlight, and draw the light that the flower is enjoying!





Light Traveling Through...



What color WILL we see?			
What color DID we see?			

What color WILL we see?			
What color DID we see?			