Soil Solutions

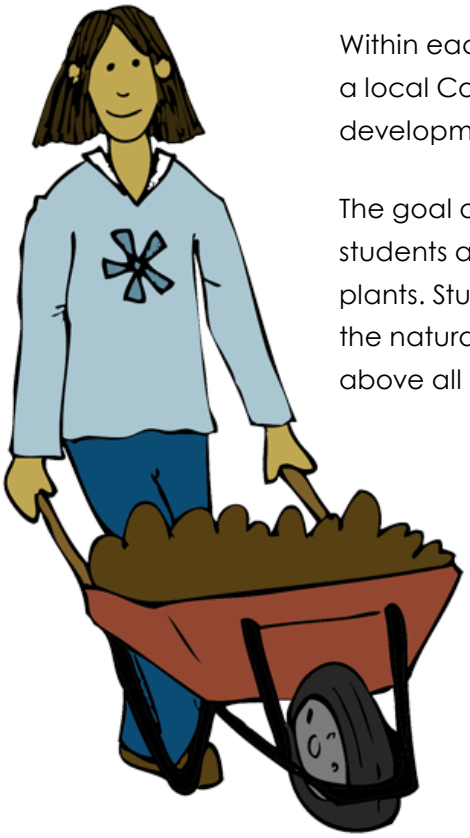
North Carolina State University
4-H Plant and Soil Sciences

Soil Solutions

Introduction

Soil Solutions brims with hands-on science lessons that utilize the local school landscape to connect students to the world of soils and plants in an inviting and relevant way. Students will discover the soil beneath their feet, watch as a basil seed germinates before their eyes and nibble on nutritious and delicious salad greens they have grown themselves. Activities are structured to foster wonder and curiosity and encourage ways to turn student questions into investigations. The teacher's role becomes one of a collaborator and a partner in inquiry with their students. Aligned to meet the North Carolina's third grade science standard course of study in plant and soils, the curriculum draws from current research and knowledge in crops, horticulture and soil sciences.

Each lesson includes background information for teachers, questions to focus student thinking and activities that emphasize observation and problem solving. Using the 4-H Experiential Learning Model as a framework, the curriculum seeks to further life skills like communication, teamwork, critical thinking, and more, by engaging students to learn by doing, sharing their experience with each other, reflecting on their results and generalizing and applying what they know to new situations.

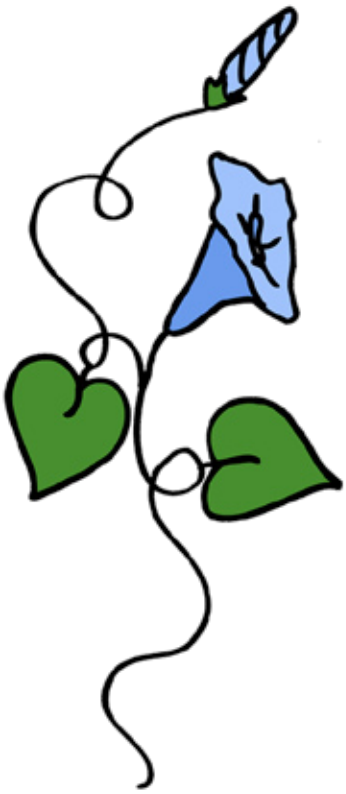


Within each community across the state of North Carolina, there exists a local Cooperative Extension office that can provide content, youth development support and resources to educators.

The goal of Soil Solutions is offer a contextual framework that enables students and teachers to dig deep and uncover the stories of soils and plants. Students will begin to hold a greater appreciation and respect for the natural world, gain confidence in their abilities to solve problems and above all have a lifelong interest and enthusiasm for exploring and learning.

Soil Solutions

Table of Contents



Lesson 1 Soil Properties

Duration: 1.5 hours or two 45-minute sessions

Let's Explore the Soil!

Purpose:

Using skills of observation, comparing, classifying, and communicating, students will discover the different characteristics of soil and how soil properties impact their daily life.

North Carolina Science Competencies:

2.01 Observe and describe the properties of soil color, texture, and capacity to hold water.

2.04 Identify the basic components of soil: sand, clay, silt. and humus.

Life Skills:

Learning to Learn: Is curious, asks questions, learns how to do the process, how to observe, learns by doing.

Problem Solving: Seeks solutions to simple problems and is able to consider a few selected alternatives.

Critical Thinking: Ask questions before, during, and after acquiring information.

Communication: Engages in group discussion.

Cooperation: Has cooperative group experiences.

Leadership: Learns to be a group member, learns to listen when others speak.

Materials (For 30 Students):

- 30 paper cups
- 8 trowels (or soil probes)
- 30 magnifying glasses
- Newspaper (to limit the mess)
- Paper, pencils
- 30 clear, 20-oz. soda bottles
- 2 cups powdered dish detergent
- Rulers
- 1 basketball, 1 golf ball, 1 BB pellet
- 1 water spray bottle
- Funnel
- Masking tape
- Overhead projector & Dissecting Microscopes

Background Information:

Soils are important, from the growing of our food and favorite ornamental plants, to providing the materials to build the houses we live in, filtering impurities out of our water, helping us recycle wastes, and providing recreational activities we enjoy. Soils contain four parts: **weathered minerals**, organic matter, water, and air.

Soil texture refers to proportion of sand, silt, and clay particles. Texture affects many fundamental soil properties, such as fertility, erosion, water-holding capacity, pollution, and **compaction**. Soil color can reflect the different mineral content, **aerobic** or **anaerobic** conditions, and the presence of organic matter.

Humus is the organic part of the soil that results from highly decomposed plant and animal matter. Humus contributes to nutrient exchange with plants and helps bind soil particles into **aggregates**. Humus also holds water well and, therefore, improves drought tolerance.

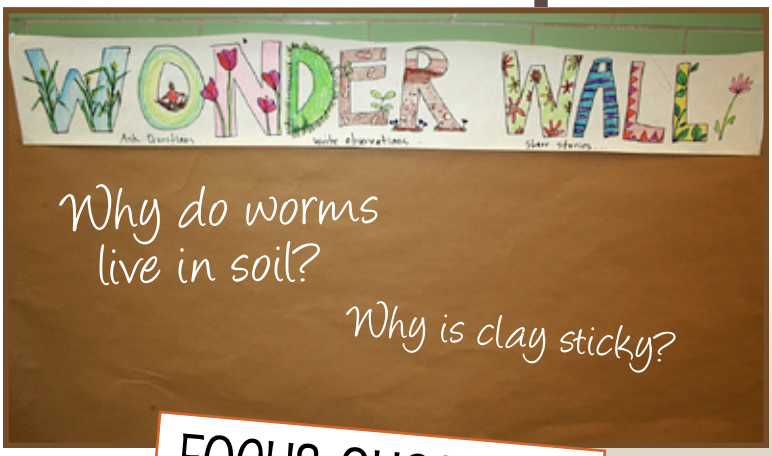
Lesson 1: Soil Properties

Scratching the Surface:

Begin with a brainstorm about soil's importance. Have pairs of students list as many ideas as they can on how soil is important in our daily lives. After a few minutes of cooperative brainstorming, ask for volunteers to voice their ideas.

Collect the ideas by writing them down on a piece of large paper hanging on the wall or a bulletin board. Use this as your "Soil Wonder Wall." Students will use this space to add to their initial list of ideas and as a place to record questions.

Think about engaging students in recognizing their work together as a group. Leading questions might be: Do you think you get more ideas working alone or a group? Why? How did you decide what roles your group members would play? What did you learn about communicating with others?



FOCUS QUESTIONS:

WHY IS SOIL IMPORTANT?
WHAT IS SOIL?
WHAT DOES IT LOOK AND FEEL LIKE?
WHY ARE THERE DIFFERENCES BETWEEN SOILS?

Digging in:

Break the class into teams of three. Go outdoors and ask the students to help you identify three unique spots for soil samples. Ask them why a location may have different soils. You may want to define a unique spot as the edge of the playground where wildflowers grow, a compacted place beneath play equipment, on the soccer field, etc. Demonstrate how to take a soil sample (www.soil.ncsu.edu/publications/Soilfacts/AG-439-30/AG-439-30.pdf).

At each stop, have one teammate fill a paper cup with soil. Bring the samples into the classroom and pour the samples onto pieces of newspaper for observation. (Students may also want to share soil samples brought from home.) Use magnifying glasses and **dissecting microscopes** for a closer look.

Have students record their descriptions and sketches of each soil. What does the soil feel like? What does the soil look like? Is it heavy? What color is it? Is there evidence of plant material or other living materials?

Encourage students to write down questions or interesting things they find in their soil explorations and put it on the Soil Wonder Wall. Take time for reflection about student findings and their questions.

Lesson 1: Soil Properties

Digging Deeper:

Hand Texturing

Hand texturing is a field exercise soil scientists use to determine soil texture, or whether the soil is made up of sand, silt, or clay.

Have students take an egg-sized soil sample, and spray it with water to lightly moisten it. Have them knead the soil. If it is too dry, and completely falls apart, spray more water. Conversely, if it is too wet, add dry soil.

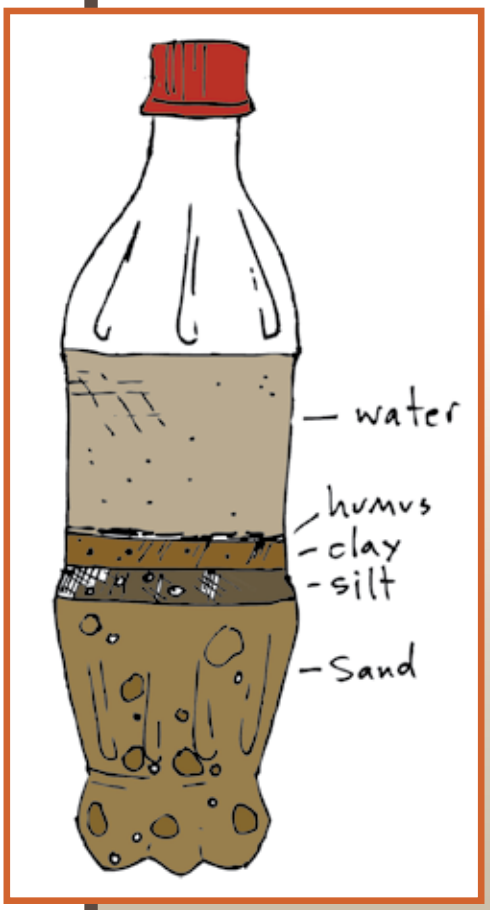
Sand tends to have a gritty texture, like salt or sugar, and it falls apart when squeezed into a ball. Soil with a lot of silt has a silky feel, similar to flour. Clay tends to be sticky and greasy, and it easily forms a ball. Most soils have varying amounts of these particles, and will have a combination of the properties. Once you have a moist soil ball, gently press your thumb and push the soil over your forefinger into a ribbon.

The longer you can make your ribbon, the higher the clay content. Clayey soil can ribbon out or three-fourths of an inch or greater. If your ribbon is short (less than three-fourths of an inch) and cracks, the soil is considered to have a loamy texture (usually containing varying amounts of sand, silt, and clay).

Project the soil texture key (found at the end of the lesson) onto the overhead.

As a whole class, work together to figure out the soil texture. Does it match with previous finding? Why is soil texture important?

Rarely are soils ever composed of one size of soil particle, but if a teacher has access to separate samples of sand, silt, clay, and humus, the students can further their soil sample observations by feeling and looking closely. Students should record any descriptions and sketches they make.



Soils are composed of particles of different sizes:

- **Sand** (.05 to 2 mm)
- **Silt** (.002 to .05 mm)
- **Clay** (smaller than .002 mm)
- **Humus** (decomposed organic matter)

What does the soil feel like?

Lesson 1: Soil Properties

The Soil Shimmy

1. To determine what soil particles make up the collected samples, have students use a funnel to put at least a half cup of soil into clear 20-ounce plastic soda bottles. You may want to have them put their name on a piece of masking tape and adhere it to the bottle.

2. Have them add a tablespoon of powdered dish detergent in with the soil, and fill the bottle with water. (Dish detergent clings to the soil particles, helping to separate them.)

3. Secure the bottle cap, and have the students dance around and shake the bottle vigorously for at least two minutes.

4. Have them place their bottles in a location where they can sit undisturbed for 24 hours. The soil should settle out from bottom to top in layers of sand, silt, clay, and organic matter, respectively.

5. Ask the students what they observe. Which layer has the most? Which layer has the least? How does this compare to when you hand textured? Why is some water still murky?

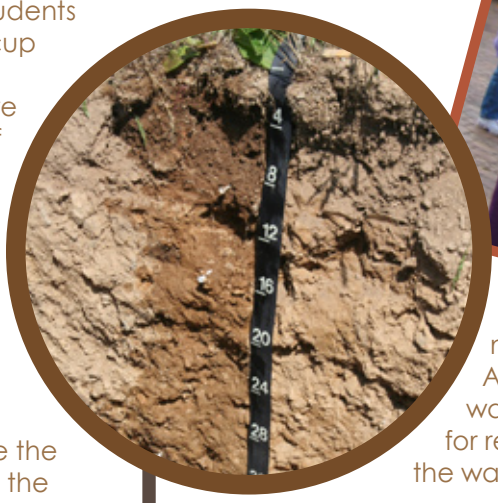
Soil Particle Play

Each soil particle is a different size. To show the differences between a sand particle, silt particle, and a clay particle, start with a basketball, golf ball, and a BB pellet. Tell students that the basketball represents a sand particle, the golf ball symbolizes the silt, and the BB denotes a clay particle.

1. To illustrate the relationship between particle size and the pore spaces or places between the soil particles, tell the students they will be performing in the great Soil Particle Play!

2. Begin by having the students stand up in a cluster and spread their arms out and position themselves fingertip to fingertip. Have the students drop their arms and tell them that they are sand particles. Explain that all the room in between them is occupied by air, which allows plants and animals to thrive and also allows water to travel through soil.

3. Set the scene and tell students that you, as the gardener, need to water the soil and



must pick a student to be a water drop. Ask the student volunteer to wind his or her way through the students. Ask the students for responses on how easy or hard it was for the water drop to make its way through the soil.

4. Next, have the students spread themselves out elbow to elbow and then drop their arms. This scenario shows the smaller spaces between silt particles. Ask the students what they observed and how this might be important. Have the water drop, wind his or her way through again.

5. Finally, the students should stand almost shoulder to shoulder, showing clay particle spacing. One can notice that water would have to move much slower to make it through the pore spaces and that clay creates a challenging situation for plant roots to grow.

As a final act in the Soil Particle Play, divide the students into groups based on the average soil particle findings from the Soil Shimmy exercise. For example, if most of the soil was three-fourths sand, take three-fourths of the students and assign them to be sand particles.

The remaining particle percentage might have been one-eighth clay, one-eighth silt. Divide the remaining students accordingly. Have the students space themselves and make comments on the arrangement. Is there space for roots to grow? Will the plants get enough air?

You may decide to do other scenarios, like demonstrating compacted soil or how compost can help soil structure. (Compost creates clumps or aggregates of soil with space between.)

Ask students what they learned through this activity. Why was this a fun way to learn about soils? How does having fun help you learn?

To summarize the soil properties exercise, reflect with students on the experience. Why is it important to know about soils? How have soils been important in your life? What did you learn from this activity that you didn't know before? What made this a good activity? How can the things you learned be use in other situations? What other ways could you apply the skills you gained in this activity?

Lesson 1: Soil Properties

Assessment:
Soil Wonder Wall Questions

Student-generated questions allow you to make judgments about the number, quality, and range of questions produced. Questions reveal student understanding about the topic. They show what students are interested in knowing more about, and they also reveal the level of thinking required to ask the question. Encouraging students to write down individual and group questions on the wonder wall gives you a permanent record of their thoughts. You may also include the questions they ask out loud.

Using Bloom's taxonomy, questions can be separated into categories from simple basic information questions to higher-level wonderment questions. Basic information questions include knowledge or factual questions, which usually only require a recall of information and are often closed questions, usually based on an observation they made. Questions like, "Why is this soil red?" are basic information questions.

Procedural questions seek clarification about how a given task or procedure was carried out (Chin, et al, 2002). Examples might include: How do I take a soil sample? How do I set up the Soil Shimmy?

Wonderment questions are pitched at a conceptually higher level. According to Chin, (et al., 2002), "They require an application or extension of taught ideas, and focus on predictions, explanations, and causes instead of facts, or on resolving discrepancies and gaps in knowledge." These questions fall into Bloom's categories of comprehension, application, analysis, synthesis, and evaluation.

Why is it important to know about soils?

When trying to evaluate the questions, use the following:

- Comprehension questions typically seek explanations of things not understood (Chin, et al, 2002). Example: Why is clay stickier than sand?
- Application questions use previously learned information in new and concrete situations to solve problems that have single or best answers (Krumme, 2003). Example: If sand doesn't hold much water, how does it support plant growth?
- Analysis questions break down and organize information into its component parts and develop conclusions by recognizing patterns and finding evidence to support generalizations. Example: I know clay soils can be hard for plants to grow in, yet plants still do. Are there plants for clay soils?
- Synthesis questions creatively apply existing knowledge and skills to produce an original whole.
- Evaluation questions judge the value of material based on personal opinions and values.

Questions can reveal student understandings and curiosity and can play a significant role in encouraging further scientific discovery.

Beyond the Garden Gate:

Activities to try at home

Dirt Shirts

Find a clean, washed, white t-shirt that you won't get you into trouble when you dye it with dirt. Gather enough soil to fill the bottom of a bucket. Red clay works very well, but you may want to try other soils, like a humus-rich black or gray soil. Make a mud slurry by adding some water to your soil in the bucket. You want it to be a little thinner than a mud pie.

To make a tie-dyed dirt shirt, tie rubber bands tightly onto the shirt. Put your shirt into the mud-pie mixture, and mix it in really well. Let it soak for at least four hours or even overnight. Take your shirt out of the bucket and wash it off, preferably outside using a garden hose. Let your shirt dry outside, and then rinse it again in cold water. Dry the shirt in a hot dryer to set the color. The color will fade over time, but you should end up with a glorious shirt from the garden!

Soil Crayons

Soils across the country and even in the state of North Carolina come in different colors. Some Native American cultures used colorful soil for pottery, makeup, and paint pigments. You can create your own artistic expressions with soil crayons. The U.S. Natural Resources Conservation Service has created a procedure that is easy to follow with an adult's help. Visit this Web site: www.soils.usda.gov/education/resources/k_12/lessons/crayons/.

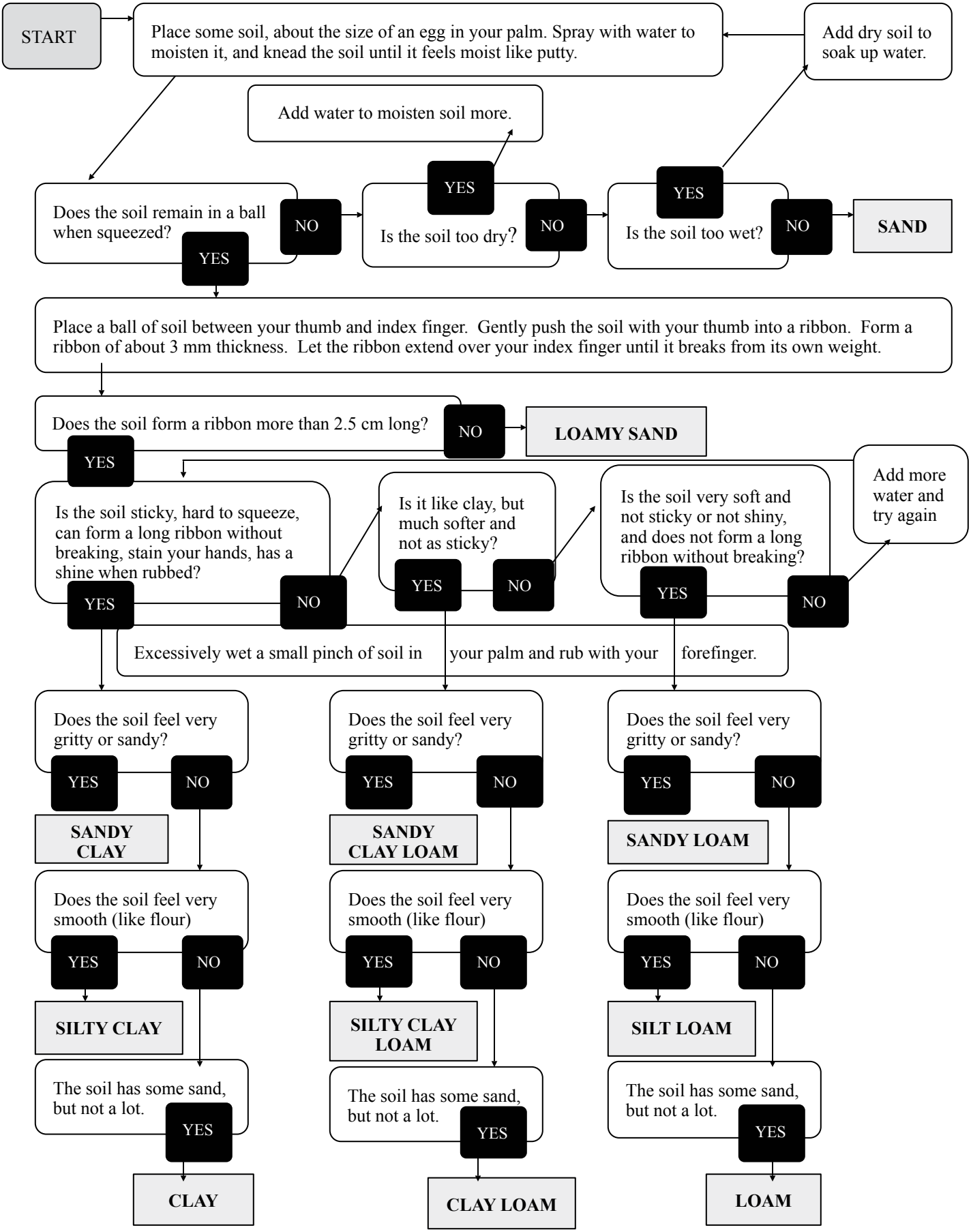
Soil Observation Record

Group Names:_____

Date:_____

Soil Location:	Soil Sketch:
Describe what the soil looks like: (Color, size, other)	
What does it feel like? (Smooth, silky, gritty, sticky, etc.)	
Give your soil a sniff. What does it smell like?	
What other observations can you make about your soil?	
What questions do you have about your soil?	

Soil Texture by Feel Key



Adapted from Modified from S.J. Thien. 1979. *A flow diagram for teaching texture by feel analysis.* Journal of Agronomic Education. 8:54-55 & http://soils.usda.gov/education/resources/k_12/lessons/texture/

Lesson 2 Soil and Water Relationships

Duration: 45 minutes. Two-week preparation time.

Let's Explore the Soil!

Purpose:

Students will see how a soil's properties affect its capacity to hold water.

North Carolina Science Competencies:

2.02 Investigate and observe that different soils absorb water at different rates.

Life Skills:

Learning to Learn: Is curious, asks questions, learns how to do the process, how to observe, learns by doing.

Problem Solving: Seeks solutions to simple problems and is able to consider a few selected alternatives.

Critical Thinking: Ask questions before, during, and after acquiring information.

Communication: Engages in group discussion.

Cooperation: Has cooperative group experiences.

Materials (For 30 Students):

- 30 empty, rinsed 20 oz. clear soda bottles* (top cut off and holes drilled in the bottom)
- 30 cups marked with ¼, ½, ¾, and 1-cup measurements
- Different soils, enough to partly fill each soda bottle container
- 30 plastic cups marked with a 1-cup line
- 1 clock or stopwatch
- 1 sponge
- Clear bowl filled with water

*Soil Drainage Container: Take your empty 20-ounce soda bottle, and cut off the top just above the shoulder of the bottle. Drill about five holes of the same size in the bottom. For fine soils like dry sand, you may need to nestle cheesecloth or a fine mesh fabric in the bottom of the bottle. Alternatively, you may use empty tennis ball containers and drill holes in the bottom.

Background Information:

Soils have different porosity levels, which depend on soil structure (aggregation) and texture (particle size). Typically, the larger the particle, like sand, the larger the pore space and the easier it is for water to drain through. The smaller the particle, like clay, the longer it takes for water to drain through. Plants depend on water in order to grow.

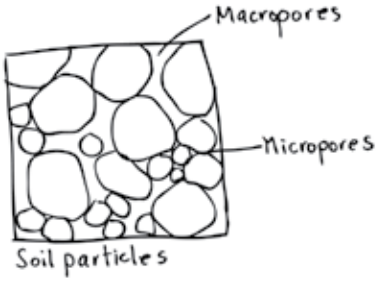
The soil that a plant is growing in will control the amount of water that is available to plants. Soils that have been disturbed or compacted will tend to have smaller pore spaces. Humus (decomposed organic material) is important in soils because it helps soil aggregate or clump, which allows air and water to pass through. Certain plants have adapted to grow well in particular soils. For example, native plants growing on the coast can tolerate the dry sandy soils found there.

Lesson 2: Soil and Water Relationships

Scratching the Surface:

Ask the students to recall the soil particle play. Remind them that the spaces between the soil particles are filled with a mixture of water and air depending on the environmental conditions. Use a sponge as an example. Hold up a large dry sponge and ask the students what is in all the holes? They should answer air. Dunk the sponge into the water and squeeze; the student should see air bubbles come to the surface.

Lift the sponge out of the water and tell the students the sponge represents soil saturated with water, like right after a rain.



Ask students why there is standing water in some yards after it rains? Some soils have slow infiltration rates of water.

Lift the sponge out of the water and let it drain on its own. The water that drains out is in the macropores and represents the water available to plants. Gently squeeze out most of this water. This is the water that fills the medium-sized pore spaces.

Pass the sponge around and ask if it is still wet. The water still present in the sponge represents the soil micropores, smaller spaces between the soil particles. This water drains out more slowly and is somewhat available to plants. As the soil dries out, however, it becomes harder for the roots to take up water.

FOCUS QUESTIONS:

HOW WELL DO DIFFERENT SOILS HOLD WATER?
HOW DOES WATER IN THE SOIL IMPACT PLANT GROWTH?
WHY ARE SOME SOILS MORE LIKELY TO FLOOD?

Digging in:

To test the differences in water infiltration and permeability by the soil, begin with clear soda bottles (or similar plastic containers) with holes drilled into the bottoms. Divide the class into teams of three, and give each student a cup of different soil. Use soils collected from the schoolyard, or work with your local county Extension agent to obtain different soil samples. Soil samples should be dry. To dry soil, lay them out on a tray on a sunny windowsill for a week or two. Each student sample should be different.

continued on next page

Digging in: (continued)

For example, in a group of three, one member may have a clayey soil, another the sandy soil, and the third a loamy or silty soil. Have the students put the same amount of soil (about 2 cups or more) into a bottle and then fill their glass with a cup of water to the one-cup mark. Using the soil and water drainage sheet, ask the guiding question, "how does water drain through different soils?" Have the students write down a hypothesis about what they think will happen. Next have students make a hypothesis about which soil water will travel through the fastest.

Using a classroom clock or stopwatch, start at the same time and have students simultaneously pour their water into the three soils and observe how fast the water drains. After 30 seconds, observe how much water drained into the cup. Have students record their measurement on their work sheet. Continue observing the water drain through the soil. Measure at 30-second intervals until most of the water has drained.

Have groups discuss with each other some of the following points: Which soil drained the fastest? Which drained the slowest? What does the water look like from the drained soils? What happens if we use compacted soil? What if the soil is already wet? Can we change the structure of the soil? How? What is the relationship of water drainage in soil to plant growth? Compare the total water quantity that drained with the amount added. Which soil retained the most water after drainage stopped? Why? Which soil has the most total porosity?

Assessment:

Soil Water Concept Sentencing

Give students key words or pictures on cards that they will use with words of their own choosing to create sentences about the relationship between soil and water. Have the entire class generate a consolidating conversation on soil and water relationships. Use the resulting conversation to assess their learning.
(NC Language Arts Competency: 4.02)

If you have not done concept sentencing before, begin with a simple topic and demonstrate concept sentencing to your class. You may want to use an overhead projector and pieces of acetate printed with the words.

For example, start with the topic of plant growth.

Sample Words

Grow	*Short*	*Tall*	*Climb*	*Slowly*
Quickly	*It*	*Will*	*Does not*	*With*
A lot of	*The*	*Stunted*	*Large*	*Small*

Sample Sentence:

The plant will grow quickly with a lot of sunlight.

The students come up with the words plant and sunlight. The students can also help you come up with words that can be used in the concept sentencing. To assess soil and water relationships, print the work sheet from the end of this lesson.

Lesson 2: Soil and Water Relationships

Beyond the Garden Gate:

Activities to try at home

Soil Filtering

Soil acts as a natural filter, removing pollutants from the ground water, keeping our water supply clean. Do you think there is a type of soil that may be a more effective filter than others? Find samples of sand, loam, and clay. Take three plastic bottles with holes drilled in the bottom and fill with equal amounts, one with sand, one with loam, and the last with clay.

Take 3 separate cups of water and fill each with ¾ cup of water. Add a tablespoon of a colored powdered drink (like Kool-aid) to each cup, and stir until the drink is dissolved. Add the water to the soil, and watch until the water filters through. What is the color of the water that filters through the soil? Is the water darkly colored? Clear? Why?

Soil and Water Drainage

Group Names: _____

Date: _____

Question: How does water drain through different soils?

Hypothesis: Which soil do you think water will drain through the fastest?

Collect Data:

Time	Type of Soil	Amount of Added Water	Amount of Drained Water	Difference (Amount of water held in the soil)
30 Seconds				
60 Seconds				
90 Seconds				
120 Seconds				
150 Seconds				
180 Seconds				
210 Seconds				

What if the soil was already wet? Would water drain faster or slower?

What does the drained water look like? Is it clear, murky? Why?

How will water drain through compacted soil? How can you compact soil?

What other questions do you have about soil and water drainage?

Soil and Water

Group Names: _____

Date: _____

George made a sentence using the cards below.

Do you agree with his ideas?

You can change his sentence if you want to. Make some sentences of your own. You can use the words as many times as you like. You can also add words of your own!

drains	filters
quickly	when
rains	a lot
slowly	measure
does not	will
stops	trickles

Lesson 3 Soil & Plant Growth

Duration: 1 hour

Purpose:

Plant growth is related to the soil that it grows in. North Carolina's broad range of soils have the ability to grow many of our food and fiber crops. Students will determine how well local soil can support plant growth.

North Carolina Science Competencies:

2.03 Determine the ability of soil to support the growth of many plants, including those important to our food supply.

Life Skills:

Learning to Learn: Is curious, asks questions, learns how to do the process, how to observe, learns by doing.

Problem Solving: Seeks solutions to simple problems and is able to consider a few selected alternatives.

Critical Thinking: Ask questions before, during, and after acquiring information.

Communication: Engages in group discussion.

Cooperation: Has cooperative group experiences.

Leadership: Learns to be a group member, learns to listen when others speak.

Materials (For 30 Students):

- Seeds: peanuts, cotton, corn, wheat, soybean, and tomato
- Soil: collected from the school or from home
- 12 6-inch pots
- Pot labels
- Rulers that measure centimeters
- 1 package pH paper (may order from Carolina Biological Supply)
- Nutrient test for nitrogen, phosphorous, and potassium (available from local garden or science supply store)
- Soil Sample Box (available for free through county Extension Service)

See additional materials in the following lessons:

- Soil Properties
- Soil and Water Relationships

Background Information:

Agriculture remains one of North Carolina's most important industries. Throughout the state a number of different **agronomic** crops like corn, cotton, soybeans, and wheat are grown. So are a diverse number of horticultural crops like apples, pecans, blueberries, strawberries, grapes, cucumbers, melons, okra, landscape ornamental shrubs, annual and perennial flowers, and even Christmas trees. Different parts of the state have environmental conditions suitable for growing specific plants. Much of the variation in the crops grown can be traced to the different types of soils – sandy loams of the coastal plains, organic soils in eastern parts of the state, the more clayey texture of the piedmont, and the varying types of soils in the mountains. Other environmental conditions that play a role in plant growth include amount of light, nutrients, moisture level, and temperature.

Scratching the Surface:

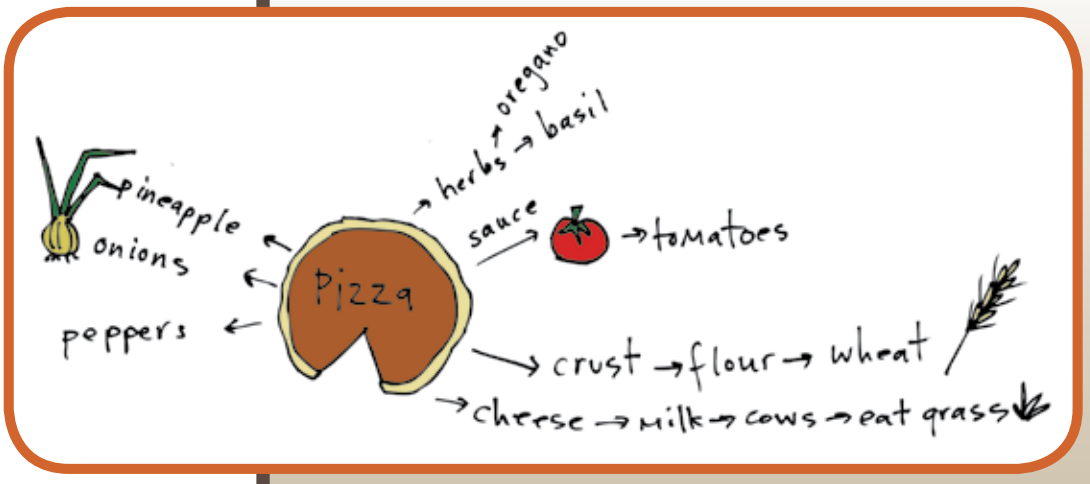
Ask the students what they had (or are going to have) for lunch. Ask them if they knew that soil was responsible for everything they eat. Invite the music teacher (or do it yourself) to teach students the song "Dirt made my lunch" by the Banana Slug String Band. For the lyrics, visit http://ces.ncsu.edu/4hplantandsoils/soilsolutions. (Buy and download the song from Apple iTunes http://www.apple.com/itunes/). Invite the students to create imaginative movements with their bodies. After dancing and singing, have them reflect on the experience. Ask questions like, "In the song, what do we eat that comes from the soil? What did you like about the song? How did it make you feel?"

As a whole group, brainstorm some of their favorite foods and trace the foods back to the plants that make the ingredients. For example, a student might say pizza is a favorite food. Ask the students to tell what plants we must grow in order to make pizza: peppers, tomatoes, herbs, wheat, forage grasses for cows, etc.

Once you have generated a good list, ask the students how many of these plants grow in North Carolina. Circle the North Carolina-grown plants. How many are grown in your county? Visit the North Carolina Department of Agriculture and Consumer Service Web site (http://www.ncagr.com/stats/) to find out which crops are grown in your county. Put a square around these plants. Show students the North Carolina agriculture map at the end of this lesson. Point out that while many food crops are grown throughout North Carolina, some grow only in specific areas of the state. Have them make observations about what they find.

Ask questions like, "Why do potatoes grow best in the east? Why do apples grow mainly in the mountains? What is it about the soils in the area that support certain plants but not others? Why can some crops grow all over the state? When do we grow these plants? What other environmental factors may play role?"

Why do potatoes grow best in the east?



Why can some crops grow all over the state?

Lesson 3: Soil & Plant Growth

Digging in:

Ask students how we might find out what plants will grow well in their area. Collect enough local soil to fill 12 6-inch pots. You may consider using the same soil you tested in lesson 1&2. Have the students investigate the soil to determine how the soil characteristics might influence plant growth. Then have them fill the 6-inch pots.

Perform some simple soil tests and record your findings on Soil and Plant Growth Scientific Report (found at the end of this lesson):

- Soil texture. Have students perform hand-texturing tests and the soil shimmy (learned in Lesson 1: Soil Properties) to determine the kind of soil you have.
- Drainage test. Have students perform the tests they learned in Lesson 2: Soil and Water Relationship to determine how well their soil drains and retains water.
- Nutrient availability. To find out if nutrients are available for plant uptake, measure the soil pH. pH is a measurement of the acidity or alkalinity of a soil. pH determines whether nutrients can be released to the plants. Most plants prefer to grow in soil with a pH range from 6 to 7. If your soil has a pH of 4, for example, your plant may grow poorly and the adult plant may be stunted because it cannot get the nutrients from the soil that it needs to grow.

  Obtain **pH paper** from a science supply store. Dip the paper into moist soil; the pH paper will change color. Compare the color of your pH paper to the colored chart included with the package. Each color aligns with a different pH.

- Nitrogen, potassium, and phosphorous are common nutrients needed by plants. By performing a soil nutrient test, students can determine the amounts of these nutrients that are present. The pH level determines if they are available. If any of these nutrients are present in low amounts, it could cause the plant to not grow well. Obtain a soil nutrient testing kit from a local garden center or commercial science education supply store (like Carolina Biological Supply).
- Send a soil sample in to the local North Carolina county Extension Center to be analyzed for free by the North Carolina Department of Agriculture. The results give recommendations for fertilizer and lime treatments. Download a guide from the NC State University Soil Science Department (http://www.soil.ncsu.edu/publications/Soilfacts/AG-439-30/AG-439-30.pdf) on properly collecting soil samples. Your local county Extension agent can help interpret the results.

FOCUS QUESTIONS:

HOW DOES SOIL INFLUENCE PLANT GROWTH?

WHY DO CERTAIN PLANTS GROW BETTER IN SOME SOILS THAN OTHERS?

Digging Deeper:

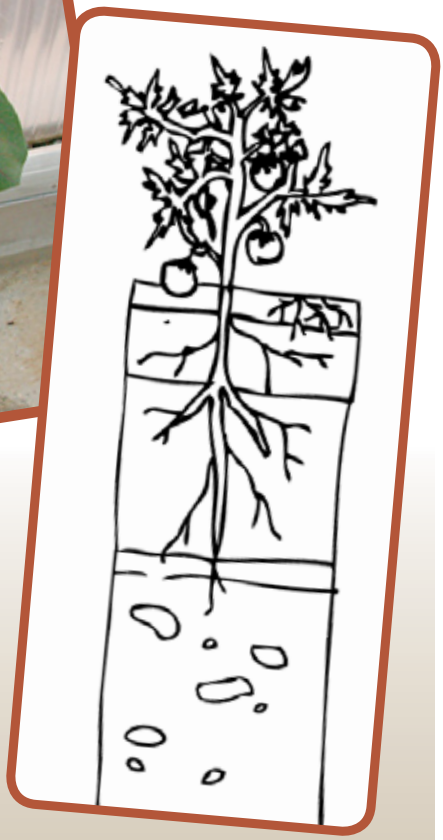
Have students ask your local county Extension agent for recommendations on what crops to grow and where they might find seeds. Students may consider growing:

Corn	Tomatoes	Eggplants
Wheat	Peppers	Radish
Soybeans	Lettuce	Greens
Peanuts	Melons	Cucumbers

Have the group choose six different plants to grow. Divide the class into six groups, assigning each group a type of plant. Each group should work together to plant two pots of their agricultural crop. Place plants in a sunny spot or under a grow light. Continuing with the Soil and Plant Growth Scientific Report work sheet, have them record a hypothesis. Do they think their plants will grow well? Why or why not? Groups can also follow up with further research on their plants and include what they learned on the work sheet.

Students should make weekly observations on the plant growth. They might sketch and write down descriptive details. After the plants have grown for eight weeks (or longer) start a summary discussion on the plant performance. Ask questions like, "How well did the crops grow? Why did the plants grow well or poorly? What properties of soil contributed to growth? How might we change the soil so plants could grow better?" Have students complete their group's report of their scientific investigation on their work sheet.

Conclude the experiment by helping the group to reflect on the experience. Ask questions like, "What did you do to plan and conduct the experiment? What did you learn about conducting an experiment? What did you learn about making decisions? Where can you go to find resources to help you make further decisions about what plants you might like to grow? How will your new skills help you at home?"



Assessment:

Scientific Report:

A scientific report allows students to follow the scientific method and outline their understanding of the soil and plant growth process. It permits you to see areas of strength and challenge and help direct further scientific inquiries. Tell students that a scientific report is the same written document that scientists create to let other people know their findings. (They've been filling it out all along.)

Beyond the Garden Gate:

Activities to try at home

Peanut Butter

2 cups roasted shelled peanuts

1 tablespoon peanut oil

Salt to taste

With help from an adult, combine peanuts and oil in a food processor fitted with a metal blade. Process for two to three minutes, stopping to scrape down the sides with a spatula. Add salt to taste. Store in an airtight container in the refrigerator. If oil rises to the top, simply stir before eating.

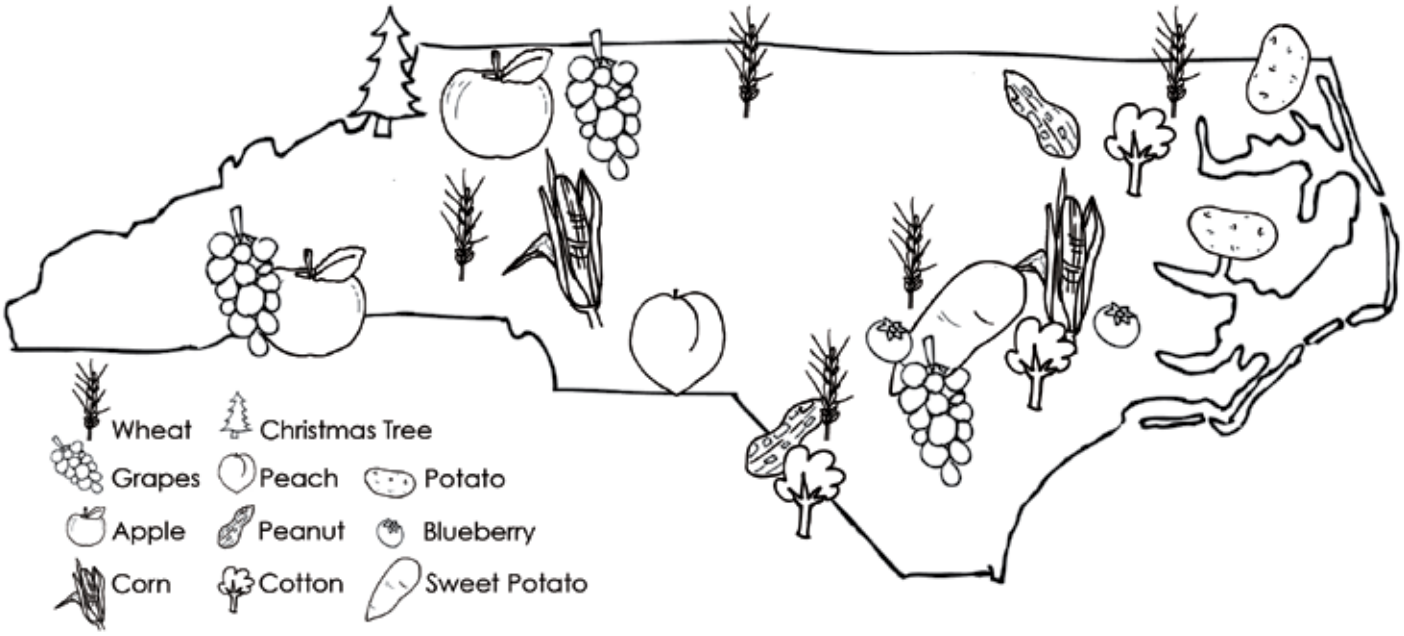
Finger Spinning Cotton

Before cotton is made into clothing, it must first be spun. Machines usually do the spinning, but you can use your fingers to form a rough thread. Ask your local Extension agent for a cotton boll (from a cotton plant), or you can work with a cotton ball. (The actual cotton boll works better.) Carefully spread the cotton into a fluffy cloud, removing the seeds. Keep your cloud in one piece, and hold it in your left hand or whichever hand feels most comfortable.

To spin into the thread, pinch a bit of the cotton between your finger and thumb, and gently twist it. Continue twisting in the same direction, slowly pulling away from the cotton cloud. Pull more cotton, continually twisting, and you should see the thread start to form. Keep a firm grip on the twist, to prevent it from unwinding. This is hard. You may need to tape it down. If you end up with a nice thread, wind it onto a skewer, chopstick, or pencil.

Resources: North Carolina Department of Agriculture Crop Summaries by county (http://www.ncagr.com/stats/cntysumm/index.htm).

North Carolina Agriculture Map



Notes:

Soil and Plant Growth Scientific Report

Group Names:_____

Date:_____

A scientist records findings from experiments into a scientific report.
Answer the questions below based on your observations of your plant's growth.

Ask a Question:

1. What were you trying to find out?

Research:

2. Record information about your soil tests and about your plant.

Make a Hypothesis:

3. How do you think your plant will grow?

Design Your Experiment:

4. What did you do to set up your experiment? Write down the steps you followed.

Collect Data:

5. Record information on your plant's growth.

Type of Plant:

Date	Plant Height (centimeters)	Other Observations

Explain Data:

6. How did your plant grow? Write down some of your observations. Why do you think your plant grew the way that it did?

Ask New Questions:

7. What new questions do you have about soils and plant growth?

Life Skills Questions:

1. Why is it important to know what crops are grown in North Carolina?

2. What are these plants used for in our everyday life?

3. If you were going to grow plants again, what would you do differently?

4. What did your learn about yourself through this activity?

Lesson 4 Seed Germination Experiment

Duration: 1 hour for initial lesson, followed by 5-10 minutes each day for observation

Purpose:

Students will understand the function of seeds and the different environmental requirements for seed germination.

North Carolina Science Competencies:

1.06 Observe, describe, and record properties of germinating seeds.

Life Skills:

Learning to Learn: Is curious, asks questions, learns how to do the process, how to observe, learns by doing.

Problem Solving: Seeks solutions to simple problems and is able to consider a few selected alternatives.

Critical Thinking: Ask questions before, during and after acquiring information.

Communication: Engages in group discussion.

Cooperation: Has cooperative group experiences.

Leadership: Learns to be a group member, learns to listen when others speak.

Materials (For 30 Students):

- 5 6-inch pots
- Peat-based potting media
- 50 morning glory seeds
- 5 labels
- Sandpaper
- Hot water
- Vinegar
- 1 plastic sandwich bag
- 30 small craft plastic bags
- 30 cotton balls
- Basil seeds
- 30 black bean seeds (from the grocery store)
- String or yarn
- 1 hole punch
- Video clip

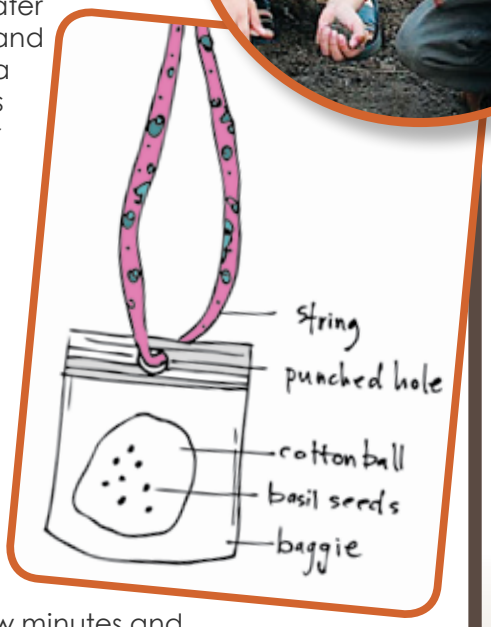
Background Information:

Seeds are the ripened and fertilized **ovules** of a plant. In flowering plants, seeds are found within the mature **ovary**, commonly called the ripe fruit. The type of fruit provides opportunities for seeds to disperse by means of wind, water, animals, or explosion. A fertilized seed contains the **embryo** from which a new plant will begin to grow. Seeds need proper temperature, adequate moisture, and oxygen to germinate.

Lesson 4: Seed Germination Experiment

Scratching the Surface:

Give each student a pinch of basil seeds and ask, "What is seed germination?" Having them still hold the seeds, watch a short video clip of a black bean germinating. http://www.ces.ncsu.edu/4hplantandsoils/soilsolutions.html What did the students observe? What do they think seeds need in order to grow? List their ideas. Take a water dropper and squeeze a few drops onto their seeds.



Wait a few minutes and the seed coat should start to break down and form what looks like mucus. Tell the students that the basil seeds are starting to germinate.

To observe the process of seed germination, make a germination necklace. Give each student a small craft plastic bag with a hole punched in the top, a cotton ball, and a string. Demonstrate dipping the cotton ball into water, gently squeezing the excess water, and putting the basil seeds on the ball and slipping it inside the baggie. Thread the string through and tie around the neck. The germination necklaces will let students observe the basil seed growth. Dried beans also work very well for this exercise. They are readily available at a grocery store and are big enough to observe easily.

Digging in:

Seeds must be given adequate moisture, oxygen, and a proper temperature for germination to occur. **Viable** seeds that do not germinate are considered **dormant**. One type of seed dormancy is found in plants that have hard seed coats, which protect them from germinating in unfavorable conditions. In order for the seeds to germinate, the hard seed coat must be weakened, so water may be **imbibed** or taken in by the seed. Gases are also exchanged through the weakened seed coat. The process of removing the hard seed coat is called **scarification**. In nature, this can happen through freezing temperatures, **microbes** in the soil, and passing through an animal's digestive system.

Begin by telling the students that horticulturists use different scarification methods including soaking seeds in hot water, submerging them in an acid, using sandpaper, or even striking them against a hard surface. The students will set up a scarification experiment to determine the best way to encourage morning glory seed germination. Divide the class into five groups. Each group will be responsible for one scarification treatment. Give each group 10 seeds, one 6-inch pot filled with potting media, and a label. Students will also need the supplies for their individual treatments listed on the next page. After performing the scarification treatment, students will plant the 10 seeds, evenly spaced in the pot. Have them make a hole with their finger about 2-3 cm deep and place the seed inside. Cover gently with soil and water the pot with a sprinkling can.

Lesson 4: Seed Germination Experiment

Digging in: (continued)

Scarification Treatments

Treatment 1: **Control**	To determine how well the scarification methods work, it is important to first find out how morning glory seeds will germinate without any treatment This is the control.
Treatment 2: **Sandpaper**	Sandpaper mechanically or physically removes part of the seed coat. (This can also be done with a metal file). Have the students lay the sandpaper on a desk and rub the morning glory seeds across a few times. They should just make a nick into the seed coat, not wear it down entirely. Too much sanding might injury the seed embryo inside.
Treatment 3: **Percussion**	Percussion is the process of taking seedlings and striking them against a hard surface repeatedly. The idea is to nick part of the seed coat. Put the morning glory seeds into a plastic baggie and have the students strike it against the desk.
Treatment 4: **Hot Water**	Hot water will soften the seed coat, making it more permeable to water and gases. Heat a mug of water in the microwave for about 3 minutes (almost boiling). Put the seeds in the hot water and allow them to soak overnight.
Treatment 5: **Vinegar**	Vinegar is an acid that chemically breaks down the seed coat. Have students put their seeds into a cup of vinegar and allow them to soak for an hour.

Note: TreatmentS 4 and 5 should either be done ahead of class—or if the students begin the treatment, they will have to come back and finish their planting at a later time.

Use the attached student sheet to make a hypothesis regarding the results of the experiment. Have the students check on their seeds every day. Every time a change is observed, include a sketch, and record the number of seeds that have germinated, height, and any other details.

Digging Deeper:

What happened to the seeds in each treatment? How did your hypothesis compare with what you observed? Make a bar graph of seed germination for each treatment. Which treatments had the most seeds germinate? The least? (NC Math Competency 3.02)

Many other seeds have hard seed coats that require scarification. Try this experiment with canna seeds, Kentucky coffee bean, honey locust or black locust seeds. (Contact your local horticulture extension agent for seed supply ideas.)

What other factors might affect seed germination? What is the evolutionary value to the seed for not germinating in the absence or overabundance of water? At low temperatures? Seeds have evolved with survival mechanisms that will inhibit seed germination when the conditions are not favorable. Explore the effects of plant density, planting depth, light (lettuce seeds require red light), or dormancy temperature requirements (**stratification**). What is the value to the plant for having these limitations?

Have the students think about how seed germination relates to their own lives. How does knowing about the process of seed germination help you? When would you have had to know about seed germination before? Where can you go to get more information about seed germination? How could the things you learned today be used in other situations?

Lesson 4: Seed Germination Experiment

Assessment:

Comic Strip Sequence

A cartoon strip sequence allows students to fill in their ideas about the sequence of events in seed germination. Students should fill in the blank squares with drawings and annotations of the seed germination process. The finished assessment sheets allow you to see the nature and depth of the student's understanding. Comic strip sequencing helps learners clarify their thoughts and think about what evidence they have to support their ideas as well as areas in which they are uncertain.

FOCUS QUESTIONS:

WHAT DOES A SEED NEED IN ORDER TO GROW?

WHAT IS SEED GERMINATION?

DO ALL SEEDS HAVE THE SAME REQUIREMENTS FOR GERMINATION?

CAN PLANTS GROW IN OTHER WAYS BESIDES FROM A SEED?

How does having fun help you learn?

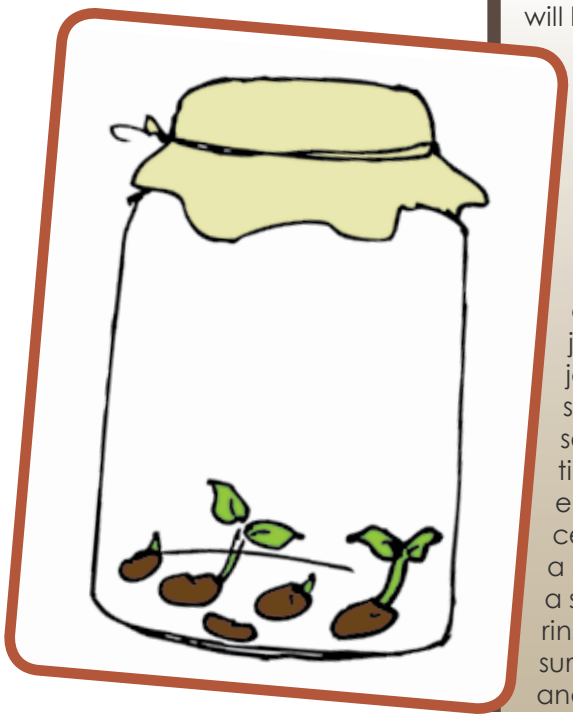
Lesson 4: Seed Germination Experiment

Beyond the Garden Gate:

Activities to try at home

Seed Viability Experiment

In 1879, William James Beal, a professor of botany at what was then Michigan Agricultural College (now Michigan State University) began an experiment to test how long weed seeds could remain viable or alive. Dr. Beal filled glass jars full of a mixture of dry sand and seeds and then buried them in secret locations around campus. Every few years he would unearth a jar and plant the seeds to see if they would grow. Today, scientists continue to carry on his experiment and have found that over 100 years later, two types of weed seeds still germinate! Ask students why might this be important. Encourage them to do their own seed experiment and bury a glass jar filled with favorite seeds and sand in their yards or at school. Ask questions like "How many types of seeds will you try? How many seeds will you bury? When will you try to germinate them? Every month? Every year? Every 5 years? What do you think will happen?"



Sprouting a Sandwich

Some seeds grow very quickly and easily and can actually be eaten! Make a sprout jar and try different seeds to find out which are the tastiest and how well they grow. Select from the follow seeds: lentils, fenugreek, alfalfa, chickpeas, broccoli, cabbage, and pea. Most of these seeds you can purchase at a health food store. Rinse the seeds thoroughly in a strainer and drain. Put 1 to 3 tablespoons of seeds into a wide-mouth jar, and cover it with a mesh like cheesecloth secured with the jar ring or a rubber band. Add 1 cup of cool water, and let the seeds soak overnight. The next day, drain the water, rinse the seeds, and lay the jar on its side. Rinse the seeds two or three times a day, and place the jar out of direct sunlight. You may enjoy the sprouts in three to five days when they grow 2 to 4 centimeters long. After they are ready to eat, cover the jar with a lid or plastic wrap and keep in the refrigerator. Add sprouts to a salad, a sandwich, or just eat from the jar. It is very important to rinse the sprouts as they are growing. Keep a close watch to make sure mold doesn't develop. Mold likes light, warm temperatures, and moisture. If mold grows, throw the seeds away and try again!

Seed Scarification Experiment

Name: _____

1. **Question:** What is the best scarification method for morning glory seed germination?

2. **Research:**
   - Morning glory seeds have a hard seed coat.
   - Morning glory seeds germinate in about 7 days.
   - Seeds must have water to germinate.

3. **Hypothesis:**
   I think morning glory seeds will germinate best with (circle one):

   Control Sandpaper Percussion Hot water Vinegar

4. **Experiment:** Describe how you set up the experiment.

_____

_____

_____

_____

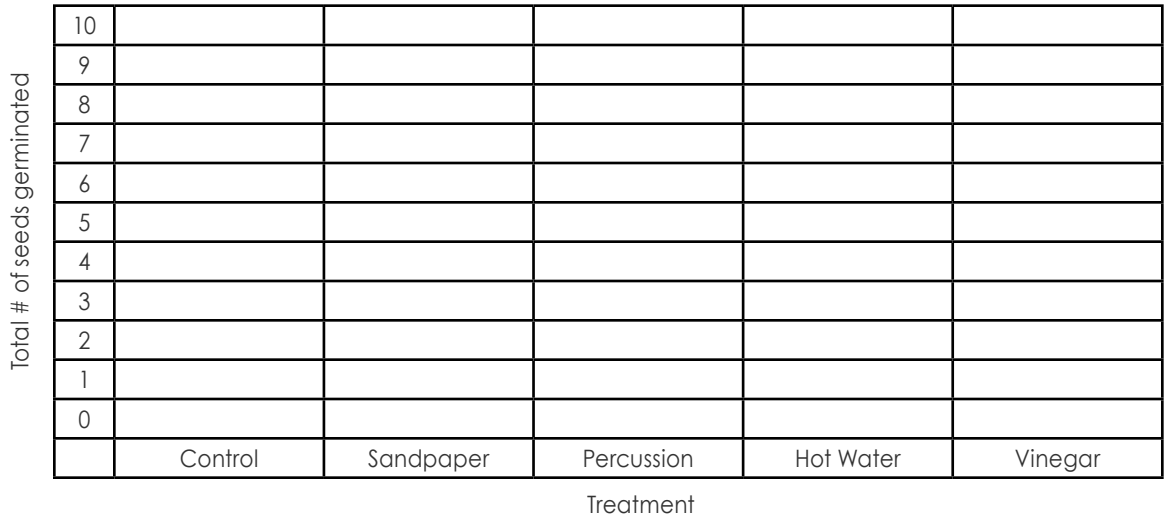
_____

5. **Collect Data:** Record the number of seeds that germinate.

Number of Seeds Germinated						
Date	Days	Control	Sandpaper	Percussion	Hot Water	Vinegar
	1					
	2					
	3					
	4					
	5					
	6					
	7					
	8					
	9					
	10					
	11					
	12					
	13					
	14					
	Total					

Write down any observations about your seeds:

6. **Explain Data:** Create a bar graph that shows the total germination for each treatment.



Does your data support your hypothesis? Why or why not?

7. **Ask New Questions:** What new questions do you have about seed germination?

SEED GERMINATION

Draw a set of pictures to show what the steps of seed germination looks like. Add words to show what the seeds need to grow.

Lesson 5 Pollination Partners

Duration: 45 minutes to 1 hour

Purpose:

Students will learn the function of the flower, including the processes of pollination and fertilization. Students will explore the relationship between the shape of the flower and the way it is pollinated. They will understand the flower as it relates to fruit and seed production.

North Carolina Science Competencies:

1.04 Explain why the number of seeds a plant produces depends on variables like light, water, nutrients and pollination.

1.05 Observe and discuss how bees pollinate flowers.

Life Skills:

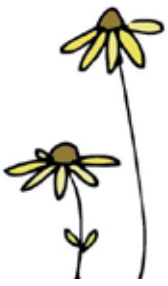
Learning to Learn: Is curious, asks questions, learns how to do the process, how to observe, learns by doing.

Problem Solving: Seeks solutions to simple problems and is able to consider a few selected alternatives.

Critical Thinking: Ask questions before, during, and after acquiring information.

Communication: Engages in group discussion.

Leadership: Learns to be a group member, learns to listen when others speak.



Materials (For 30 Students):

- Different types of flowers collected from a garden, nursery, flower shop
- 30 magnifying glasses
- Sketching paper and pencils
- 2 paper blowouts (uncurls when you blow)
- Hand-crafted flowers (see below)
- Hand-crafted bee puppet
- Yellow sticky tape
- Musky cologne
- Construction paper
- paper plate
- 5, 1-oz. plastic cups

Optional

- Butterfly wings and antenna (hand crafted or store-bought)
- Dissecting or stereo microscope
- Slide microscope

Background Information:

Seed production occurs in plants as the result of different methods of pollination. Bees, hummingbirds, bats, beetles, wind, water, flies, moths, and butterflies transfer pollen from one flower to another. The flower contains the pollen-producing male organ, the **stamen**, and the pollen-receptive female organ, the **pistil**. Flowers have adapted their shape, scent, and color to attract specific pollinators. As the pollinators seek out **nectar** and **pollen** to feed themselves, they enable plants to produce fruits and seeds. Bees, the most important and productive pollinators, pollinate over 1/3 of the food crops we consume.

Lesson 5: Pollination Partners

Scratching the Surface:

Close your eyes and imagine that you are in the middle of a flower garden. Sunflowers tower over you, daisies are tickling you, and you can smell the spiciness of the chive flowers.

What do you see? Perhaps insects are buzzing around, and birds are chirping. What do the flowers look like? Can someone describe what his or her favorite flower looks like? Maybe you imagine the long bugles of a trumpet vine, or the unfurled spiral of a rose.

Is there anything visiting the flowers? What? Butterflies, bees, birds? What are they finding in the flower? They might be finding nectar and pollen for food. Why is this important?

Have the students discuss with their neighbor why pollination is important for the flowers and the pollinator. Encourage a few students to share their ideas with the group.

Digging in:

If you have access to a garden, begin by letting the students collect two to four flowers. Encourage them to collect flowers that have different shapes and colors. If your school doesn't have a garden, look for weeds that have begun to flower or ask your local florist for leftovers. Consider collecting flowers that are perfect (with pistil and stamen), male flowers that just have a stamen, and female flowers that just have a pistil. (See chart to the left.) You might also contact your county Extension center and see if they know of a local nursery that may let you "deadhead" their flowers.

Let each student have a flower to briefly examine and ask them to share what they observe. What parts can they identify? Sketch on the board each part they name. During the discussion, ask the students to describe the role of each flower part as they name it. What is the purpose of the petals? The pollen?

Lead into a conversation about pollination, and what the different pollinators are, and

Common Flowers for Observation and Dissection

Perfect flowers (Contain stamen and pistil)	Plants with separate male and female flowers
• Petunia	• Begonia
• Snapdragon	• Daisies
• Lilies	• Many trees (birches, oak, sycamore, maple)
• Iris	• Squash
• Alstromeria	
• Tulip	
• Rose	

Digging in: (continued)

how it relates to the **morphology** or shape of the flower. Use the interactive demonstrations described below to illustrate the relationship of the pollinator to the shape, smell, and color of the flower:

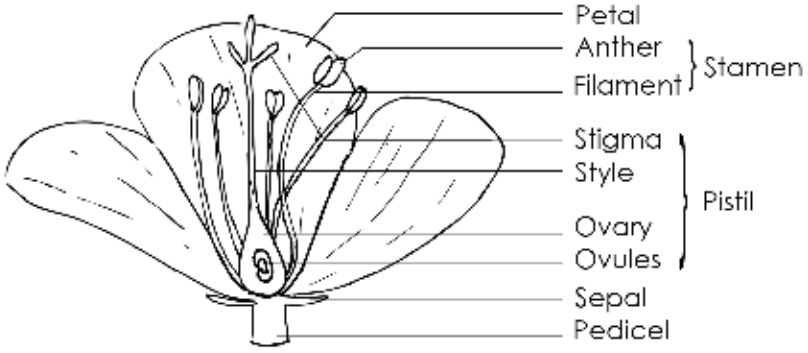
- **Flowers pollinated by bees**

  Bees prefer flowers that have landing surfaces. Landing surfaces can be the petals of a daisy flower or the lip of a snapdragon. To make a daisy flower, glue yellow petals around the edge of a heavy-duty paper plate. Glue 1-ounce plastic cups onto the plate to simulate the individual flowers that make up a daisy. Crumple up yellow tape, sticky side out, and stick to rim of cups. Give a student volunteer a bee hand puppet (homemade from a black stretchy glove or store-bought). Have them pretend to get nectar from the cups by sticking their fingers in the cup and as they make the motion, the sticky tape "pollen" should adhere to the puppet (you may have to "help" the pollen adhere). Bees have short tongues, or **proboscis**, to collect nectar as they visit flowers.

FOCUS QUESTIONS:

- What is the function of the flower?
- What are the different ways a flower is pollinated?
- What are the parts of a flower important for pollination by bees?

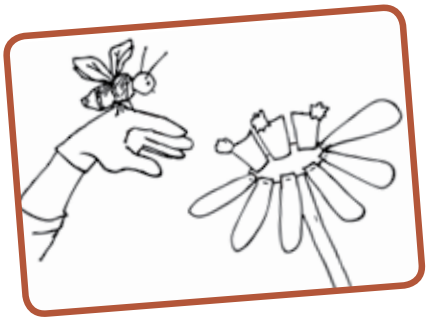
Flower Part	Purpose
Petal	Attracts pollinators, or aids in pollination with color & shape.
Sepals	Protects the unopened flower bud.
Stamen	Male part of the flower; includes the anther at the end of the filament.
Anther	End of the stamen; produces pollen.
Filament	Part of the stamen that supports the anther.
Pistil	Female part of the flower; includes collectively the stigma, style and ovary.
Stigma	Sticky end of the pistil where the pollen from the anthers must land for pollination and fertilization to occur.
Style	Part of the pistil that is a long stalk that holds up the stigma.
Ovary	Part of the pistil, usually found at the base of the style (but not always). The ovary matures into a fruit once fertilization occurs. Contains the ovules, or developing seeds.
Ovules	Seeds that grow into new plants.



The pollen clings to their legs and as they move to other flowers, some of the pollen will rub off onto the flower's stigma. Bees often intentionally collect pollen, making

Digging in: (continued)

Have you ever seen bees crawl into a flower?



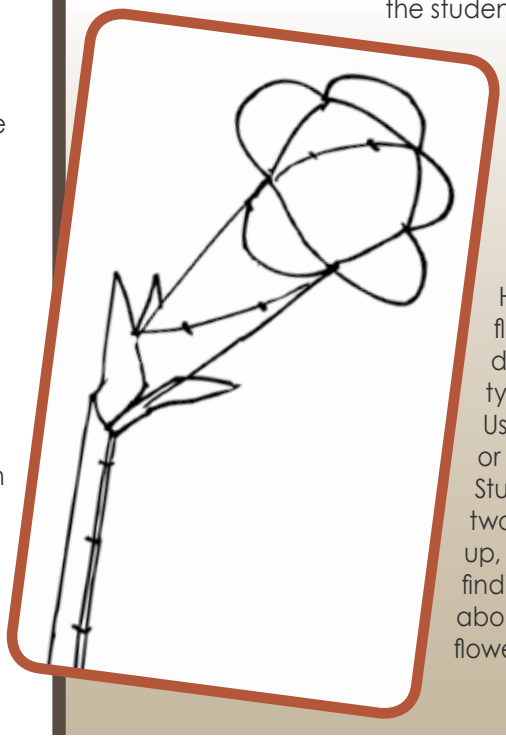
them the most efficient pollinator. Why do the bees need nectar and pollen? Nectar provides food or energy for the adult insects and the pollen is a food source for the young bees or larva in the hive. Follow up by showing real examples of flowers like the snapdragon, foxglove, or other flowers that bees crawl into and pollinate. Ask the students if they have ever seen bees crawl into a flower in nature or in a garden.

- **Flowers pollinated by butterflies:**

  Create a long, tubular, orange (or red) flower out of construction paper. Have one student be the "flower" and hold it out to the student volunteering to be the "butterfly." Give the butterfly student a paper blowout proboscis to gather nectar from the bottom of the flower. To show how a butterfly helps with pollen, stick yellow tape "pollen" to their leg and mention that pollen transfer tends to be more accidental for butterflies as they are simply looking for nectar and not pollen. Butterflies are, therefore less, effective than bees. Follow up by showing a real flower that butterflies would pollinate, such as flower from lantana, pentas, verbena, or butterfly bush.

- **Flowers pollinated by moths:**

  Moths prefer long, tubular flowers that allow their long proboscis to unfurl into and reach the nectaries nestled at the end. Most moths are active at night, so they prefer white flowers that attract them with a heavy musky scent. Create a similar tubular flower out of white paper. Turn off most of the lights and hold up the white flower and the orange flower. Ask the students which one is most visible.



Next, spray a musky cologne lightly into the air and tell them that at night, moths rely primarily on their sense of smell. Have a volunteer student demonstrate pollinating the white flower.

Have the students dissect their flowers, encouraging them to find the different parts and to wonder what type of pollinator visits the flower. Use the dissecting microscope and/or a magnifying glass to look closely. Students should sketch and describe two or three different flowers. To wrap up, ask the students to share their findings and guide the discussion about the relationship of their flower to the pollinator.

Lesson 5: Pollination Partners

Digging Deeper:

1. Students can press petunias or another flower that has both the male and female parts. Have them carefully open the flower and press it flat onto the inside of a folded sheet of paper. Students should write their name on the paper, fold it closed, and then put it into a plant press. After the flower has dried, students can label the different parts and laminate it as a guide for further study. Some plants have male and female flowers. Students can also find and press these flowers.

2. Students can collect pollen, and transfer it to a glass slide. Put a drop or two of water (or iodine to stain) on the pollen and gently top with a cover slip. Under a compound microscope, they can see the pollen grains. Small stigmas and petals might also be examined under a microscope.
3. Catch a honeybee or bumblebee. Put it in a freezer. Once it is frozen, take it out and push a pin (insect pins work best, but dressmaker's pins will be fine) through the thorax. Stick the pinned insect on a piece of Styrofoam or cardboard. Let students examine it closely with a hand lens. Ask questions like, "Can you see the hairs on the leg? Why is it good for a bee to have hair? Is there any pollen on the bee? Can you see its proboscis? What is this used for?"

Can you see hairs on the leg?

Additional Activities:

Insects pollinate most of the world's flowering plants. Many have evolved to have special relationships with a specific insect pollinator. Other animals, like birds, bats, and even a few mammals, can also play a role in pollination. Some plants use wind or water to aid in pollination, and some even pollinate themselves. Visit http://www.ces.ncsu.edu/4hplantandsoils/ to download images that show the special relationships between a flower and its pollinator. Show students the photos, and engage them in a discussion on what they observe.

Special Pollinator Stories

Bees are the most productive pollinators because they intentionally collect pollen for their larvea. Their legs have bristles that act as a pollen brush. The first two pairs of legs brush pollen from the body and the third pair forms a pollen comb that collects pollen from bristles. The comb forces pollen into the pollen baskets on the legs. Bees have a sucking tongue (shorter than the butterfly's and moth's) that sips nectar. Then bees regurgitate into honey, which is food for the rest of the hive.

Many plants have developed complex paths that force pollinators to follow a certain route into and out of the flower. This ensures that the anther and the stigma come into contact with the pollinator and in the proper order. The lady's slipper orchid is an example of this.

Lesson 5: Pollination Partners

Information adapted from Biology of Plants (6th edition, 1999)

Pollinator	Flower Characteristics	Examples	Insect Characteristics
Bees	Usually blue or yellow in color and have "honey guides" that act like airplane runway markings, leading the bee to the nectar. Flowers have showy, brightly colored petals that are never pure red. The nectary is usually found at the base of the flower, which tends to be specialized for the mouthparts of bees. Flowers give a sweet odor and have a landing platform.	Orchids, foxglove, snapdragon, clover, daisies	See UV light as a color (honey guides are usually UV in color). They cannot perceive red. Are the most important group of pollinators. Suck nectar and collect pollen from the flowers.
Beetles	Flowers are usually bourn singly or are a flat aggregate flower. They tend to have a dull color but a strong odor that can be fruity, spicy, or similar to the foul odors of fermentation.	Stapelia, magnolias, wild roses, some lilies, sprirea, members of the parsley family	Active day and night. Have a highly developed sense of smell. Chew petals, pollen, and sometimes even nectar.
Butterflies & diurnal moths	Long flower (corolla) tube, usually red and orange, sweet scent to attract insects.	Milkweed, butterfly weed, butterfly bush, pentas, lantana	Sip nectar from flower. Active in day. Some can perceive the color red.
Moths	Long flower tube is white or a pale color. Flowers release a heavy, sweet fragrance after sunset.	Nicotiana, yucca, moonflower, evening primrose	Nocturnal. Long proboscis (sucking mouthpart) to reach nectar.
Birds	Produce large amounts of nectar and are often red and odorless. Provide visual stimuli and hold lots of nectar.	Columbine, fuschia, banana, cactus, hibiscus	Mostly hummingbirds, who respond to the visual stimuli.
Bats	Produce a lot of nectar. Have dull colors, and strong musty, fermenting, or fruit-like odors. The flowers open at night.	Found in the tropics, organ-pipe cactus	Attracted through sense of smell. Eat pollen and other flower parts. Carry pollen in their fur. Obtain much of their protein from pollen.
Wind	Produce no nectar, have dull colors and are relatively odorless. Small or absent petals, sexes often separated on the same plant. Inefficient; pollen lands close to parent. Exposed stamens, large exposed stigmas with feather outgrowths to intercept pollen.	Grasses including corn, many trees like birches, pines, and maples	Not applicable.
Water	Pollen is transported underwater or floats from one plant to another.	Eel Grass (Vallisneria)	Not applicable.

Lesson 5: Pollination Partners

The Ophrys orchid resembles a female bee, wasp, or fly. The males of this insect species emerge in the spring before the females. The orchid's blooming coincides with the emergence of the male insects. The male insects are tricked by the flower's appearance and scent into mating with the orchid flowers. During the visit to the flower, the pollen rubs onto the insect's body. When the insect visits another orchid, the pollen is deposited, thereby pollinating and fertilizing the flower. The female insects emerges slightly later, mates, and lays her fertilized eggs.

In a spirited tale of symbiotic relationships, the yucca moths are the only pollinator for the yucca flower. The female moth rolls a tight ball of pollen from one yucca flower, flies to another flower, and packs the sticky pollen into the stigma, fertilizing the flower. She then lays her eggs in the ovary wall. The moth larvae and seeds develop simultaneously with the larvae eating some of the seeds.

The hawkmoth is a moth that hovers above the flower, inserting its long mouthparts into the floral tube to reach the nectar at the bottom. Hawkmoth-pollinated flowers don't have landing platforms, traps, or other specialized adaptations.

Hummingbird-pollinated flowers tend to produce a certain amount of nectar that is drained by the birds. After the bird leaves to hunt for more nectar the flowers will refill with more nectar, to attract more birds and ensure successful pollination.

Assessment:

Flower-Pollinator Whatzit Cube Game

Adapted from Whatzit tic-tac-toe (Tishman, Andrade, 1997), this assessment encourages students to use analogies, evaluate important features of flowers, and think creatively about pollination. Cut out and assemble (or have students do this) dice, and make copies of the Whatzit work sheet at the end of this lesson.

Divide the class into partners or small groups, and have them work through the whatzit game. Students should fill out the work sheet as they are completing the game. Use the work sheets to find areas of strength and uncertainty in students.

Beyond the Garden Gate:

Activities to try at home

Flower Pounding

Flower pounding is a crafty way to preserve different types of flowers. Place a paper towel. Cover it with a piece of muslin cloth. Place thin flowers or petals on the cloth. Cover with another paper towel. Finally, cover with a sound-absorbing material, like a phone book. Hammer the flowers into the muslin, and carefully peel off the paper towel. Experiment with different flowers. Some preserve perfectly, like pansies, marigolds, verbena, and geraniums. Others leave very different effects, like the watery impression of impatiens or the dark veins from some leaves.

Edible Flowers

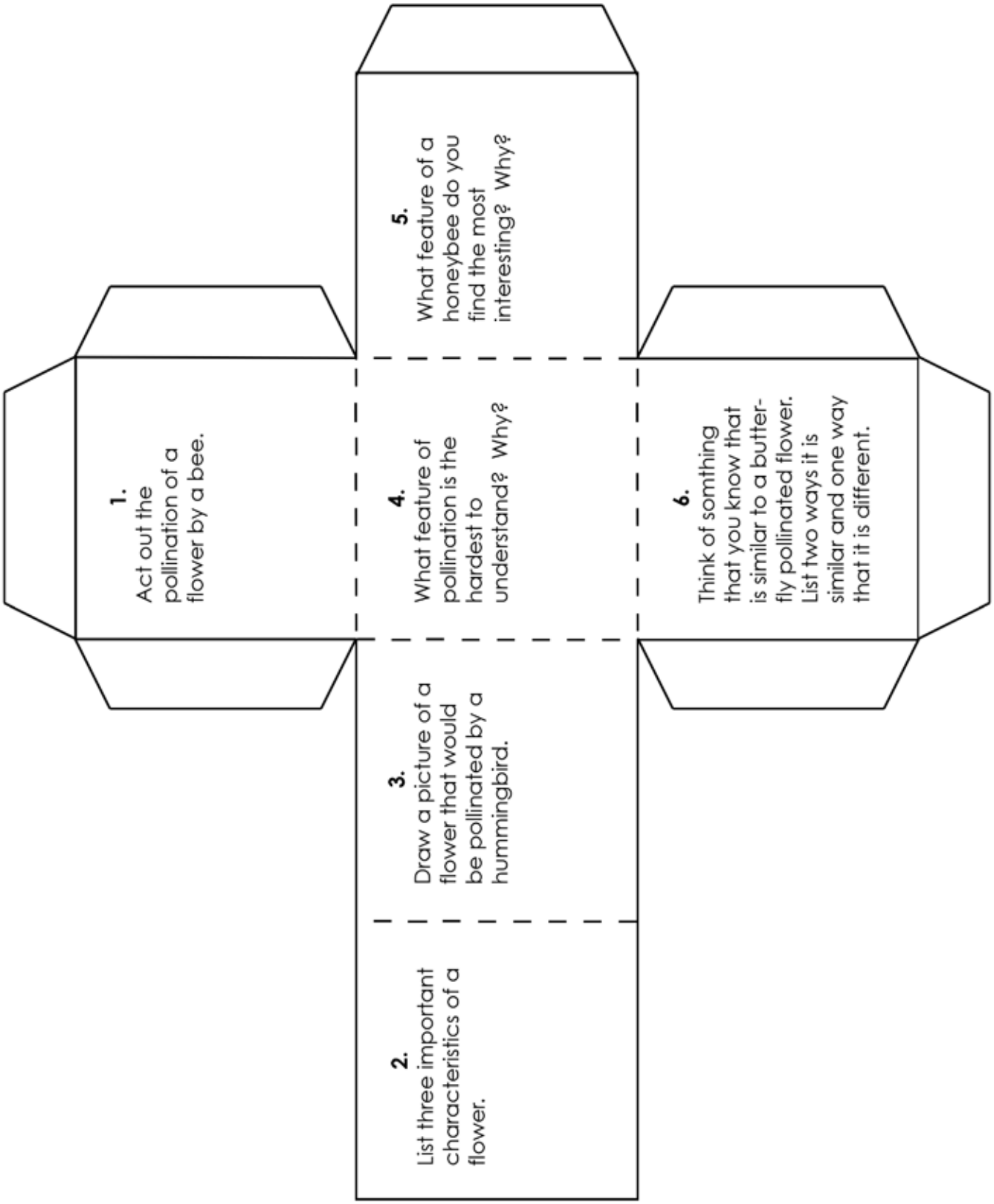
A number of tasty edible flowers provide delightful nibbling snacks. Borage, begonias, rose petals, pansies, calendula, chive blossoms, dianthus, and bee balm are all edible. For a complete list of edible flowers, download the Garden Grazing Guide at http://www.ces.ncsu.edu/4hplantandsoils/.

Edible Flower Ice Cubes

For a marvelous addition to your favorite drink, make flower ice cubes. Simply fill an empty ice cube tray with your favorite edible petals or flowers. Gently cover with water, and place it in the freezer. After a few hours, plunk the ice cubes into your glass and enjoy!

Flower/Pollinator Whatzit Cube Piece

Cut along the solid lines and fold along the dotted lines.
Tape the edges together to form a cube.



Flower & Pollination Whatzit Response Sheet

Group Names:_____

Date:_____

Challenge 1:

Act out the pollination of a flower by a bee. Describe what you did.

Challenge 2:

List three important characteristics of a flower.

Challenge 3:

Draw a picture of a flower that would be pollinated by a hummingbird.

Challenge 4:

What feature of pollination is the hardest to understand? Why?

Challenge 5:

What feature of a honeybee do you find the most interesting? Why?

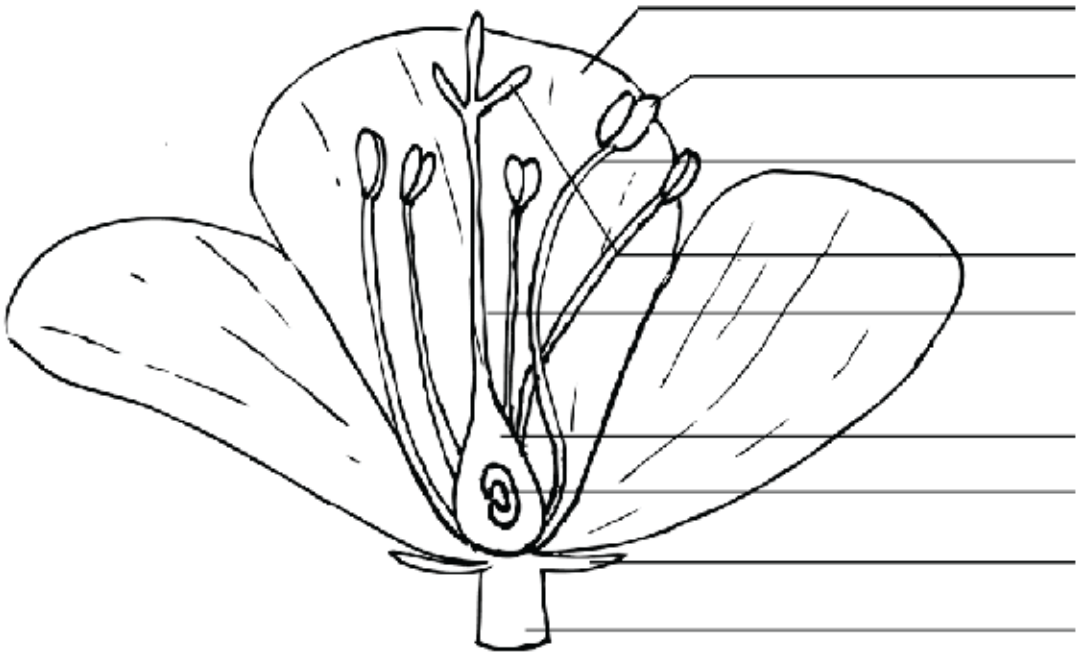
Challenge 6:

Think of something that you know that is similar to a butterfly-pollinated flower. What is it? List two ways it is similar to a butterfly-pollinated flower and one way that it is different.

Name:_____

Flower Dissection

Can you label the parts of the flower below?

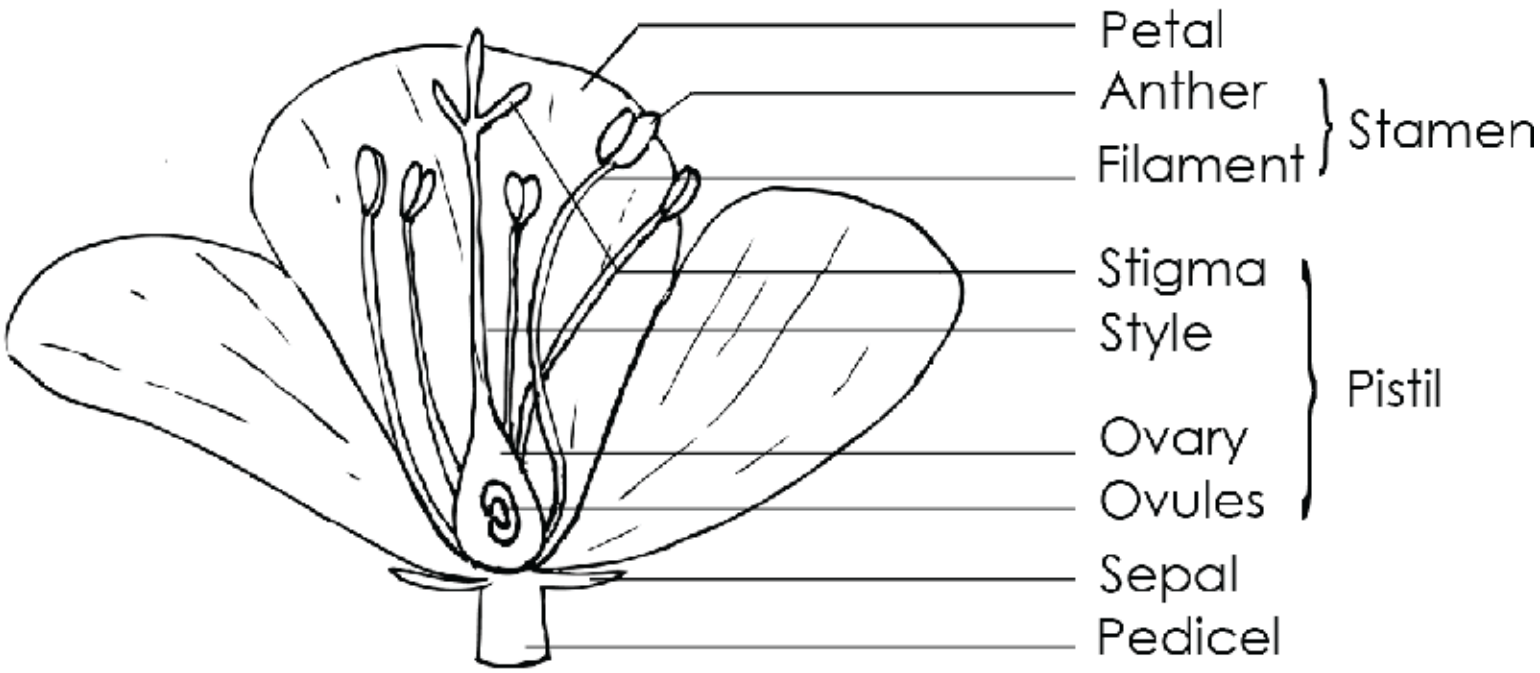


Draw the flowers you dissected below. Label the flower parts you can find. How do you think your flowers are pollinated?

Name:_____

Flower Dissection

Can you label the parts of the flower below?



Draw the flowers you dissected below. Label the flower parts you can find. How do you think your flowers are pollinated?

Lesson 6 Plant Growth Experiment: A Nutrient Study

Duration: 1.5 hours for initial experiment design, followed by 10 minutes 2-3 times a week for observation

Purpose:

Students will observe the different stages of a plant life cycle and determine the requirements needed for each step. Students will measure the effects on growth and specifically seed development when environmental variables are **manipulated**. They will create questions and identify methods of collecting data to gather answers. The students will analyze their findings and compile summarizing conclusions.

North Carolina Science Competencies:

1.01 Observe and measure how the quantities of nutrients, light, and water in the environment affect plant growth.

1.03 Investigate and describe how plants pass through distinct stages in their life cycle including growth, survival, and reproduction.

1.04 Explain why the number of seeds a plant produces depends on variables like light, water, nutrients, and pollination.

Life Skills:

Learning to Learn: Is curious, asks questions, learns how to do the process, how to observe, learns by doing.

Problem Solving: Seeks solutions to simple problems and is able to consider a few selected alternatives.

Critical Thinking: Ask questions before, during and after acquiring information.

Communication: Engages in group discussion.

Cooperation: Has cooperative group experiences.

Leadership: Learns to be a group member, learns to listen when others speak.

Social Skills: Has interactions that revolve around play, learns from and with others in small groups.

Materials (For 30 Students):

- 1 packet, Standard Wisconsin Fast Plant Seeds
- 1 Fast Plant Growing System, including reservoir, wicking mat, wicks, styrofoam cells
- Pelleted slow-release fertilizer (like Osmocote)
- 1 ruler with centimeters, per group
- 2-3 water droppers
- Q-tip or paintbrush to transfer pollen, or purchase bee abdomen with Fast Plant Kit

Background Information:

Plant growth, development, and reproduction are the result of the interaction between a plant's genetics and environmental conditions. Depending on the growing environment, the amount of light, water, and nutrients vary, creating differences on how a plant might thrive. For example, a cactus has genetics that are well suited to live in a desert climate of full sun, little water, and minimal nutrients, whereas a fern (shade-loving, moisture-rich environment dweller) would have a hard time even surviving. By changing the environmental conditions for plant growth, students can observe changes in plant development for a particular species.

Students studying the variables affecting plant growth can develop **authentic inquiry** experiments using Fast Plants. Fast Plants were developed by scientists at the University of Wisconsin for specific use in a classroom environment. They are plants in the mustard family and are easy to grow. They are bred to grow in a styrofoam, self-watering **wicking** system and can be adapted to explore different questions. Questions might include nutrition studies, **genetics**, or light requirements. Fast plants complete their life cycle in only 28-36 days.

Lesson 6: Plant Growth Experiment: A Nutrient Study

Scratching the Surface:

Place the Fast Plant life cycle steps on the board (pictures at the end of this lesson). Have the students to place the pictures in order and tell you what the plant needs in order to grow into the next stage, survive, and reproduce.

Schoolyard Survey

For students to understand the steps of the plant growth process, encourage them to look for examples of each stage of a plant's life cycle in the schoolyard. Have them bring their science journals to sketch or press each stage they find. If your school doesn't have a garden, investigate the wild places between cracks in the sidewalk or at the edge of the playground for good sampling. Small weeds can be easily found, showing the seedling stage and often will be flowering. Many grasses might also be flowering and setting seeds. Large trees might have produced fruit like maple helicopters or pines with cones. Students might consider contrasting the type or quantity of plants they find in different environments (wet, shady, sunny spots) across the schoolyard.

FOCUS QUESTIONS:

WHAT IS A FAST PLANT?

HOW IS IT DIFFERENT THAN OTHER PLANTS?

DESCRIBE THE LIFE CYCLE OF A FAST PLANT. HOW LONG DO LIFE CYCLES LAST?

WHAT DO PLANTS REQUIRE TO COMPLETE A LIFE CYCLE?

HOW DO PLANTS GROW IF THEY DON'T GET ENOUGH OR TOO MUCH OF WHAT THEY NEED TO GROW?

After the observing the different stages of the plant growth in the schoolyard, tell the students they will be growing unique plants called Wisconsin Fast Plants. They provide a wonderful way to observe the entire process of plant growth, from seed to seed in about 28-36 days. Give students the enclosed handout (at the end of this lesson) illustrating Fast Plant growth and what they can expect when growing them. Show the growing system that they will be planting in, explaining that the plastic shoebox container provides continuous water that is wicked into the soil by the felt and paper wicks. Tell students that they each will share one growing cube, called a quad, which has 4 growing cells.

Lesson 6: Plant Growth Experiment: A Nutrient Study

Digging In:

There are numerous experiments a class could conduct with Fast Plants. This lesson will focus on the plant's requirement of nutrients. Begin by asking students what they themselves need in order to grow and be strong. Many replies might suggest food, water, shelter, and space. Ask students why food is important. Food gives us not only the energy we need, but also important vitamins and minerals that help our bodies function. Plants also require nutrients to grow and develop properly. Nutrients can be found naturally in the soil, through compost (decomposed organic matter), or through manufactured means like commercial fertilizer. We will be using a commercial fertilizer that can be found in pelleted form at a local nursery, which slowly releases nutrients to the plant over time. The pelleted fertilizer is easy to handle and count.

Ask the students to help you design an experiment that will demonstrate how nutrients contribute to plant growth. How much fertilizer should we use? What is our control? Your specific experiment may differ, but include treatments that have no fertilizer, some fertilizer and a lot of fertilizer. One Fast Plant kit includes eight quads, which leaves room for eight treatments. Treatments (treatment number is listed in parentheses) might range from using (1) zero fertilizer pellets, (2) two pellets, (3) four pellets, (4) six pellets, (5) eight pellets (6) ten pellets, (7) twelve pellets and (8) fourteen pellets. Other nutrient options might be to use a compost mixture or different types of fertilizers, chemical and organic.

Divide the class into groups of four and assign each group a nutrient treatment.

To start your Fast Plant system, begin by putting the given wicks (included in kit) into the holes at the base of the styrofoam quads. If you run out of wicks, you may also use felt scraps. Fill the quad with a potting mix (be sure to find one without nutrients added) halfway, placing the fertilizer pellets in the soil. An easy way to disseminate fertilizer pellets and seeds is to take a piece of masking tape and stick the fertilizer and seeds on the tape and let the students roll off what they need. Finish filling the cell with potting mix and gently place 2-3 seeds on the top of the soil in each section of the quad. Each student might be responsible for planting one cell within the quad. Take a pencil and gently push the seed under the soil, burying only slightly. Fast plants are designed to grow the best under continuous florescent lights, like on a grow cart. Fast plants will do okay under less optimal conditions, but place them in a sunny location.

The students should write down what they did to set up the experiment (materials and methods) and determine how often and what they would like to collect data on. Data could include (but not limited to):

- Number of seeds germinated
- Height
- Number of leaves (Hint: when counting leaves, mark the counted leaf with a marker, easy to track newly unfurled leaves.)
- Number of flowers
- Leaf width
- Number of fruit pods
- General observations (Are there holes or dots in the leaves?)

As the plants grow, students should carefully observe and record their observations in a science journal. See the data collection sheet that cam with the Fast Plant Kit for more specific ideas.

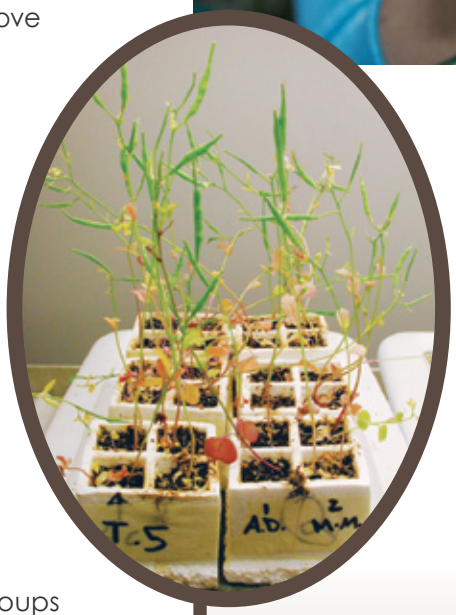
Impact of Pollination on Seed Production

The number of seeds produced by a plant is directly related to the number of flowers a plant produces (flower

Lesson 6: Plant Growth Experiment: A Nutrient Study

Digging In (continued):

production is determined by environmental conditions, nutrients, light quality, moisture levels, temperature), and how the flowers are pollinated. When the plants flower, the students can play the role of the pollinator and transfer pollen from one flower's stamens to another flower's pistil. Set aside a group of plants that will not be pollinated and count the number of seeds produced. Often even without intentional pollinating, flowers will rub against each other and spread pollen. If you want to prevent this, try to separate plants as much as possible. Plant scientists will actually remove stamens to prevent pollination. Compare the number of seeds from pollinated flowers to the unpollinated flowers. Relate this back to the Plants and Pollinators lesson and ask students how pollination occurs in nature and how plants attract pollinators to ensure seed development.



Digging Deeper:

Once the experiments are completed, project a transparency of the filled out data collection chart for the class. Tell the students they will be working together in their groups to compare what they found. Start with the first few questions on the Plant Growth Experiment "Explain Data" work sheet as examples. Have the students complete the remaining questions and once they have finished, ask each group to present its findings to the whole class and encourage discussion of how the results might impact how they would grow plants in their own garden. Follow up with additional questions to encourage students to examine their experience. What did you learn today that you will be able to use at school? At home? What did you learn about your own skill in communicating with others? What are some other situations when you will need to use the skills you learned today?

Follow-up Lesson

Have the students act out the life cycle of a plant. The teacher can be the gardener and pretend to water the seeds and call out directives for growth. Begin by having each student pretending to be the seed of their favorite plant. Have a few students volunteer what they are. Create a storyline as you go. The rain is falling (plants grow), the sun is shining (more growth), blooms unfurl (time for them to pollinate each other), the temperature is dropping, a frost comes along (some plants may die, others live through another year).

Assessment:

Journal Entries for a Scientist

Journal entries are a creative way for students to summarize the findings of their experiment. It enables you to assess the accuracy and completeness of their ideas. It is more informal than a traditional scientific report and allows the students to combine their creative thinking with scientific understanding.

Have the students complete the Plant Growth Journal work sheet to give to students. Students with less fluent writing skills may prefer to do a 'Captain's Log' and include shorter sentences, so their ideas are judged, not their writing ability. Encourage students to include drawings and rich descriptions of their experiment.

Lesson 6: Plant Growth Experiment: A Nutrient Study

Beyond the Garden Gate:

Activities to try at home

Try this fun activity at home!

Track the arrival of wildflowers around your home, beginning in spring and finishing in the fall. Keep a small notebook and as you go on hikes through the woods and meadows, note the flowers that emerge. Are the same plants flowering in the woods during the spring, also flowering in the late summer? Why do you think some plants grow better at different times of the year?

Date: _____

Plant Growth Experiment: Nutrients

Group Names: _____

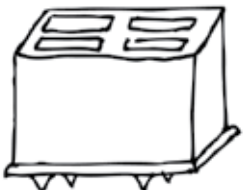
_____

_____

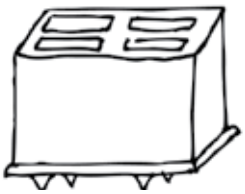
_____

Question: How do different amounts of nutrients change the way a plant grows?

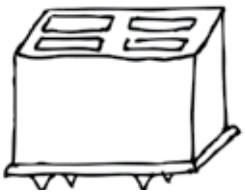
Hypothesis: How do you think plants will grow with different amounts of nutrients? Draw a plant and show what you think will happen if plants receive no nutrients, some (6 pellets) nutrients or a lot of nutrients (12 pellets).



0 PELLETS



6 PELLETS



12 PELLETS

Describe your drawings in the space below.

Plant Growth Experiment

Group Data Collection Sheet:

Name:_____ Date:_____

Treatment: How many fertilizer pellets did you use:

	Number Seeds Germinated	Plant Height (cm)	Number of Leaves	Number of Flowers	Number of Seeds
Days					
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					

Plant Growth Experiment

Explain Data:

Name:_____

As a group, answer the following questions:

Which treatment had the tallest plants? _____

What was the height of the tallest plant? _____

What was the height of the shortest plant? _____

Which treatment had the most leaves? _____

Which treatment had the most flowers? _____

Which treatment had the most seeds? _____

How many seeds? _____

Which treatment had the least amount of seeds? _____

How many seeds? _____

What was the strangest thing you observed? _____

Why do you think this happened? _____

Reflection

What did it feel like to work as a member of a group? _____

_____

What did you like best about this experiment? _____

_____

What new questions do you have about plant growth? _____

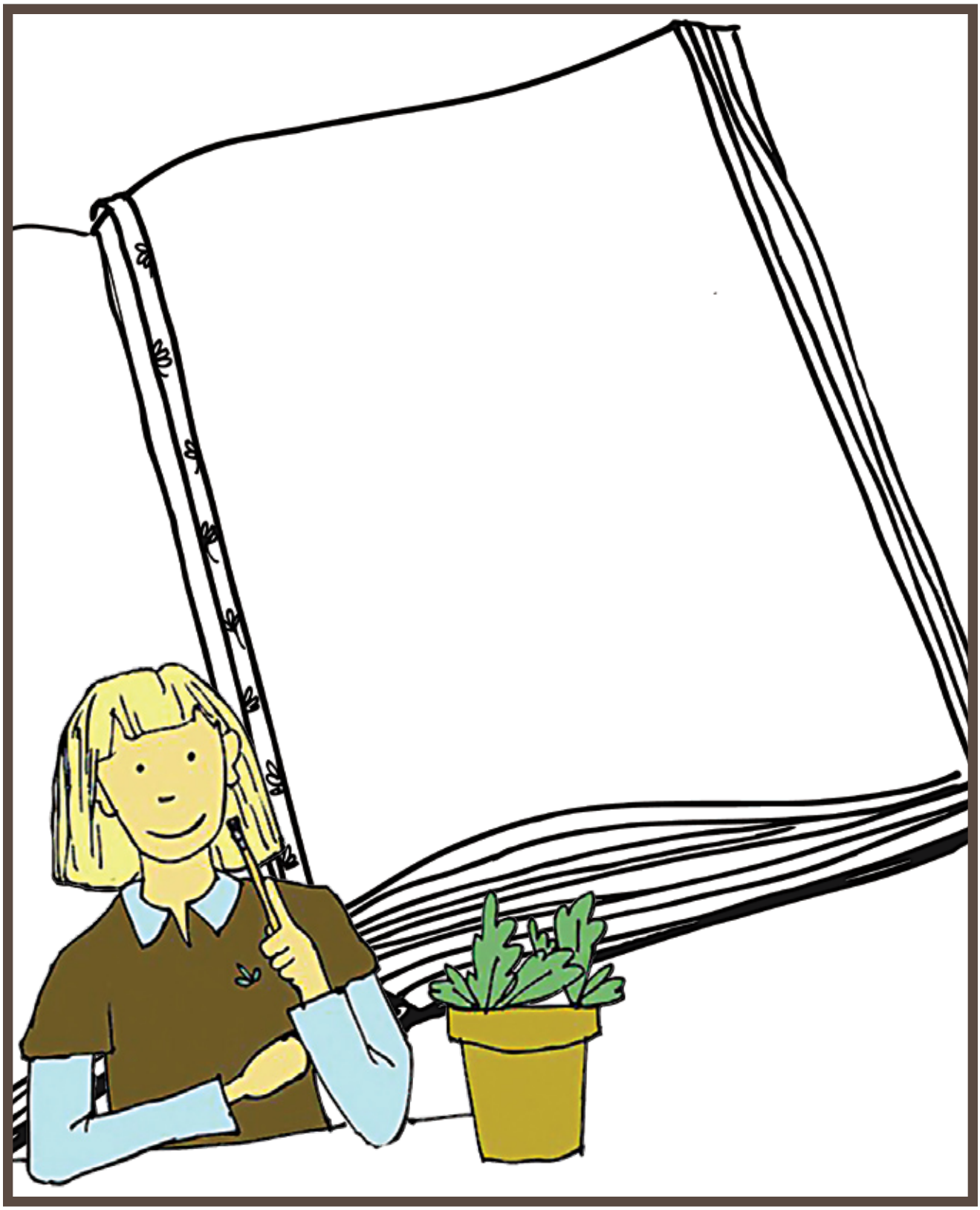
_____

How did your group decide who would to perform which experiment? _____

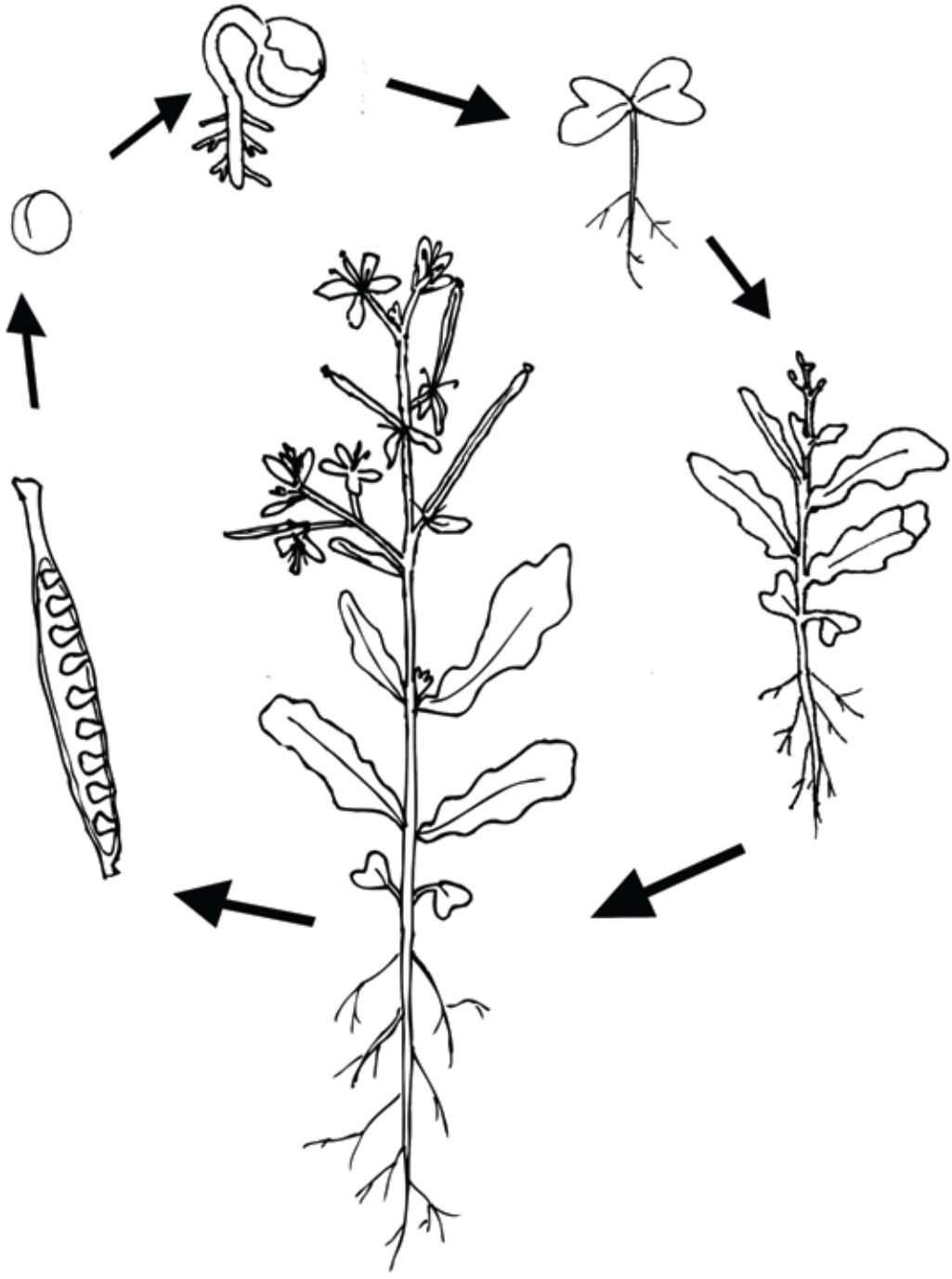
_____

Plant Growth Journal

Name: _____



Fast Plant Life Cycle



As you observe your Fast Plants growing, fill in the number of days it takes to get to the different stages of the life cycle.

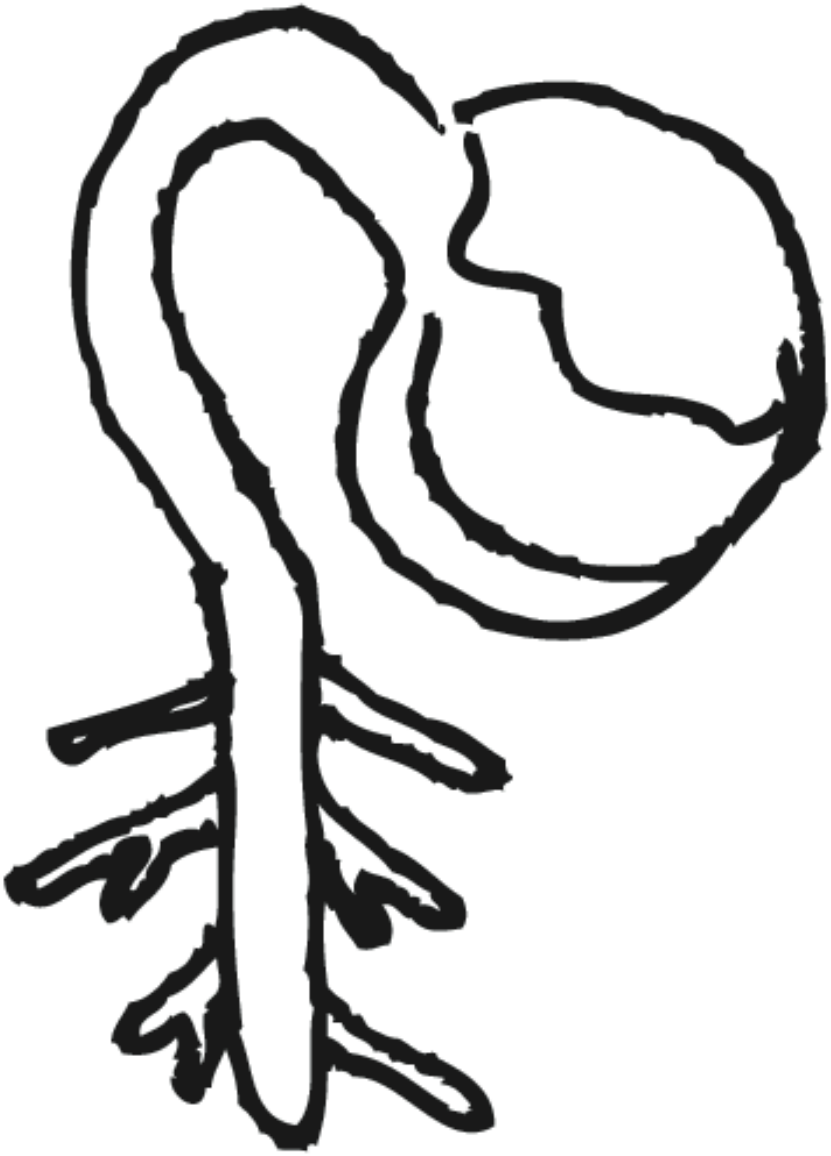
Drawn by Liz Driscoll, adapted from Fast Plants Manual

Fast Plant Individual Life Cycle Steps

Seed

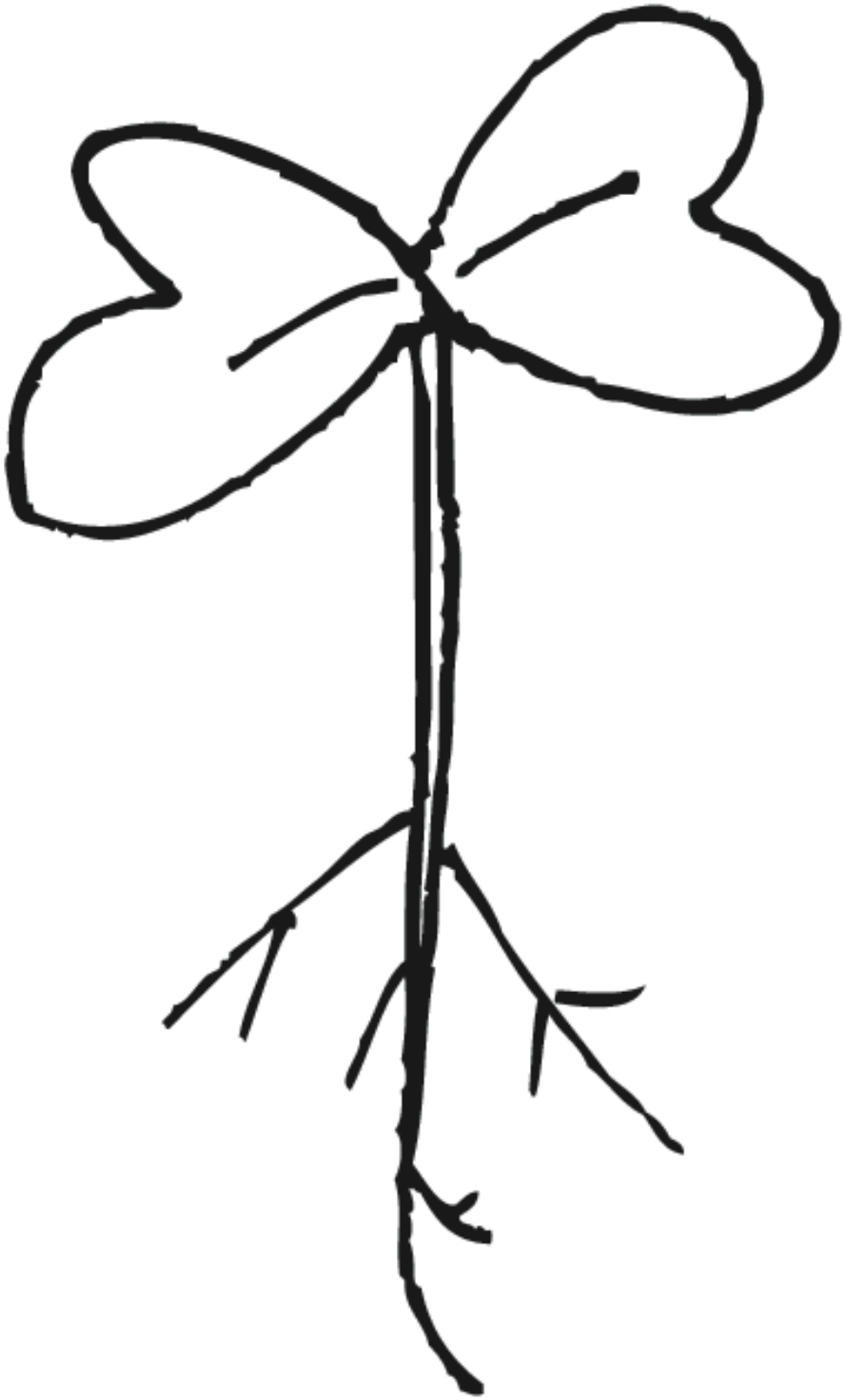
Fast Plant Individual Life Cycle Steps

Germinating Seed



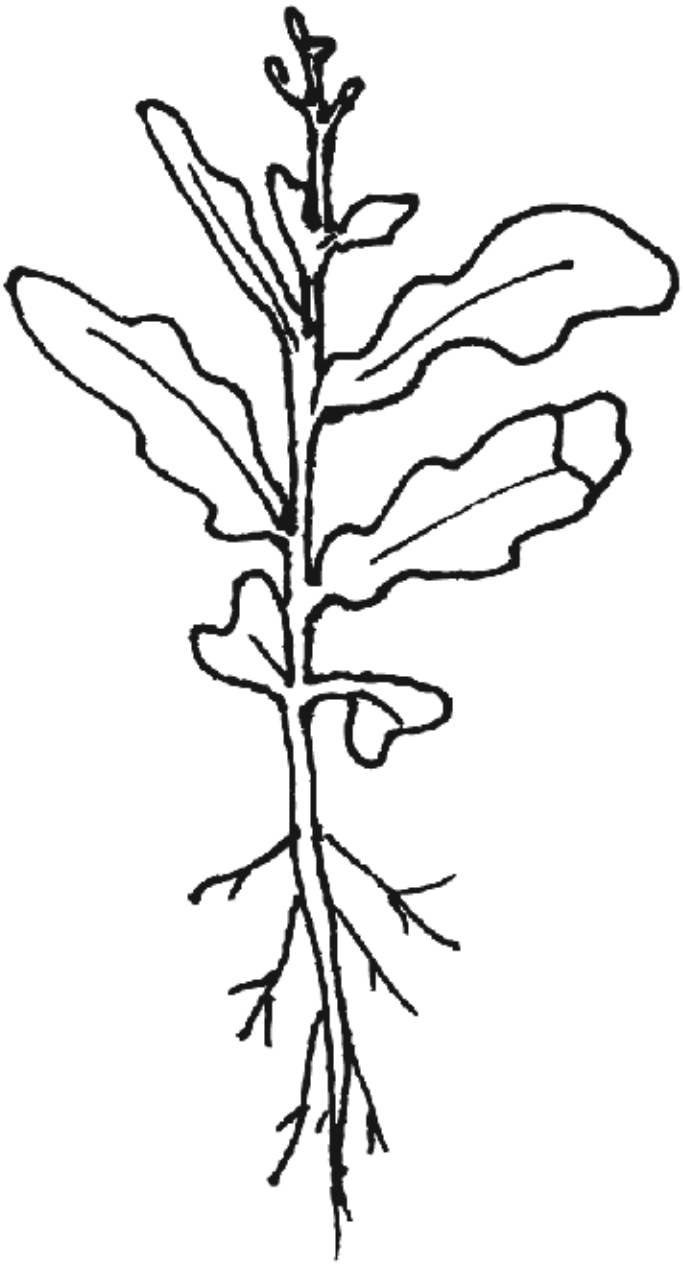
Fast Plant Individual Life Cycle Steps

Seedling



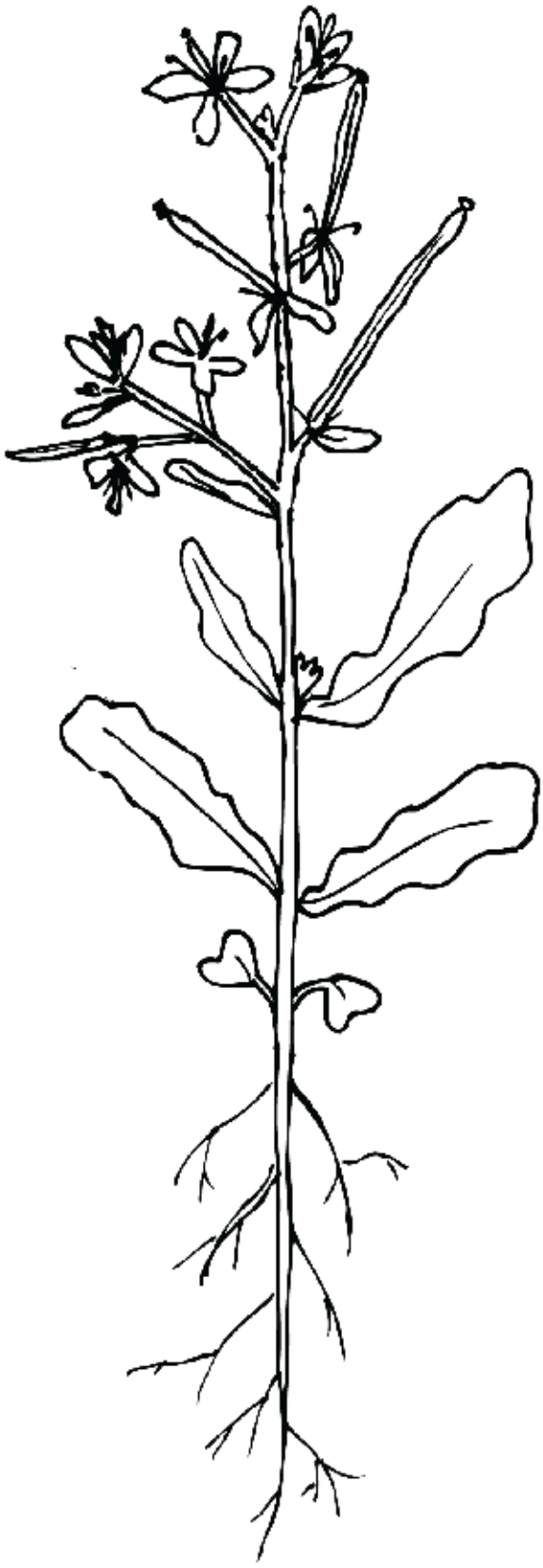
Fast Plant Individual Life Cycle Steps

Young Plant, flower buds present



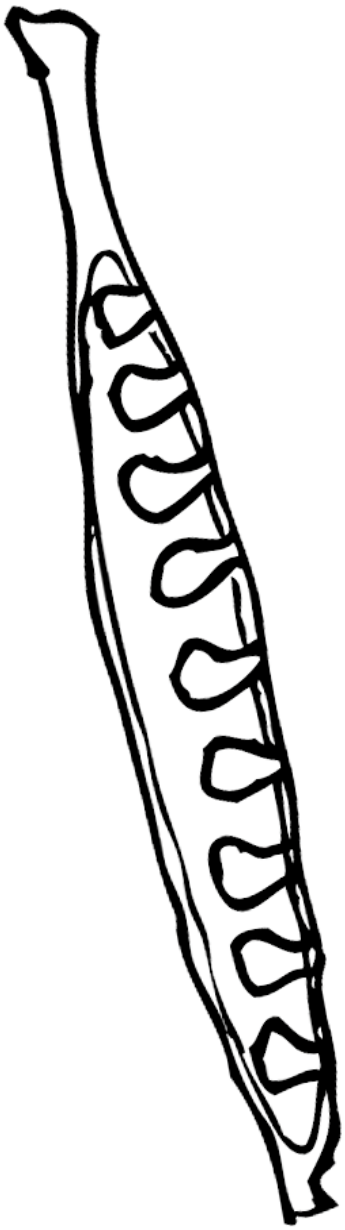
Fast Plant Individual Life Cycle Steps

Adult Flowering Plant



Fast Plant Individual Life Cycle Steps

Fruit with Developing Seeds Inside



Lesson 7 Salad Bowl Experiment

Duration: 1 to 1.5 hours, followed by 10 minutes once a week for data collection

Purpose:

Students will learn what plants need in order to grow and how to measure growth **quantitatively**, by collecting numerical data and **qualitatively**, through using their personal justifications. They will determine the "best" salad greens to grown in their classroom, based on their observations of plant performance in known environmental conditions.

North Carolina Science Competencies:

1.02 Observe and describe how environmental conditions determine how well plants survive and grow in a particular environment.

Life Skills:

Learning to Learn: Is curious, asks questions, learns how to do the process, how to observe, learns by doing

Problem Solving: Seeks solutions to simple problems and is able to consider a few selected alternatives.

Critical Thinking: Ask questions before, during and after acquiring information

Communication: Engages in group discussion

Cooperation: Has cooperative group experiences

Leadership: Learns to be a group member, learns to listen when others speak

Materials (For 30 Students):

- 6 different varieties of salad greens. Try to include lettuce, as well as other greens like kale, collards, chard, beet greens, and Asian greens like tatsoi, pac choi, mizuna. (Some favorites are Mizuna 'Kyona', Arugula, Kale 'Red Russian', Lettuce 'Freckles,' 'Rouge D'Hiver,' and 'Tango'.)
- 6 6-inch pots
- Peat-based potting media
- 6 Labels
- 1 light bank (optional, but preferable)
- School garden bed for planting (optional)
- Thermometer
- Ruler with centimeters

Background Information:

A tremendous number of salad greens can be easily grown in a minimum amount of time. Different salad greens have unique characteristics. Some have red leaves, some have a bitter taste, some are disease resistant, and some have freckles. They also have a number of nutritional qualities. This is an evaluation experiment to see how the different varieties perform based on given environmental conditions.

Lesson 7: Salad Bowl Experiment

Scratching the Surface:

Begin the Salad Bowl Experiment by posing the following scenario: "News Flash: Kids will no longer have to eat smelly school lunches. They will be able to graze from the garden and dine on gourmet salad greens they have grown themselves!" Ask students if they were to grow salad greens, what would they like to grow? Brainstorm characteristics that the students would like to find in their salad greens. Characteristics might include:

- Texture: crunchy, slimy, crisp
- Taste: spicy, sour, bland
- Pest resistant
- Disease resistant
- Shade tolerant
- Fastest growing
- Goes well with other veggies

FOCUS QUESTIONS:

WHAT IS A SALAD GREEN?

WHAT DOES IT NEED TO GROW?

WHAT ARE THE ENVIRONMENTAL FACTORS IN OUR CLASSROOM?

WHAT ARE THE ENVIRONMENTAL FACTORS OUTSIDE IN OUR GARDEN?

HOW CAN WE DETERMINE "THE BEST" SALAD GREEN TO GROW AND EAT?

Digging in:

Introduce the students to the different types of greens they will be growing by writing their names on the board. Based on your selection, use the seed packet information to tell students what is special about each green. For example, Arugula is really spicy and Asian greens can be sweet and 'Tango' lettuce might make you want to dance! Try to include different salad greens like, arugula, kale, mizuna, other Asian greens, etc. For seed source recommendations, contact your local county horticulture Extension agent (or refer to the Resource appendix).

Tell the students that plant growth depends on the environmental conditions in which they are grown. As a group, discuss how environmental conditions inside the classroom or in a school garden might affect the salad greens' growth. Write these ideas on the board. Ask them for suggestions on how to measure temperature, light, water, and nutrients. You might consider using the following methods:

- **Temperature:** Use a thermometer to determine temperature.
- **Light Quantity:** It is okay to use a rough estimate of shade, part shade, or full sun. Plant scientists use a special instrument to measure light.

Lesson 7: Salad Bowl Experiment

Digging In (continued):

- **Moisture:** If growing salad greens in the classroom, monitor water input. For the outdoor garden, measure precipitation by using a rain gauge.
- **Nutrients:** Refer to the Soil & Plant Growth lesson to determine how to measure soil nutrients.

Have the students write down a personal hypothesis about how they think the salad greens will grow given the existing environmental conditions. For example, which lettuce will grow the fastest, which will have the best color, texture, resist the most pests, etc.

Example Hypotheses:

- I think 'tango' lettuce will grow the fastest.
- I think that collards will have the best texture.
- I think kale will have most interesting color.

Digging Deeper:

After seedlings emerge, qualitative and quantitative data should be recorded. Ask students what information or data should be collected to determine the "best" lettuce. Students may consider measuring the following:

- Plant height
- Leaf number
- Leaf shape
- General observations
- Amount of germinated seeds
- Number of flowers
- Number of insects
- Leaf color

Data should be recorded once a week through the duration of the experiment. You can grow salad greens for as long as you like, but typically plants can be ready to harvest in about 6-8 weeks. Sample data collection sheets are included in the appendix. You may also download them from the 4-H Plant and Soil web site, so you can adjust them according to the data your class is collecting and the plants you end up growing. Sample data sheets can be found at the end of the this lesson.

On the final data collection students get to enjoy a salad bonanza! Harvest the salad greens by allowing students to use scissors to cut just above the growing point (about ½" above the soil) of the plants. The salad

Lesson 7: Salad Bowl Experiment

Digging Deeper (continued):

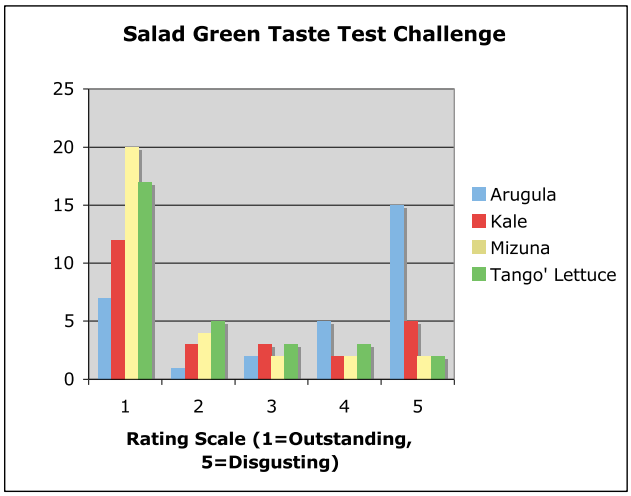
greens will grow back if they are not cut all the way down. Arrange the students into groups of six, with each type of salad green in each group. To record the taste-test data, establish a 5-point rating scale. For example:

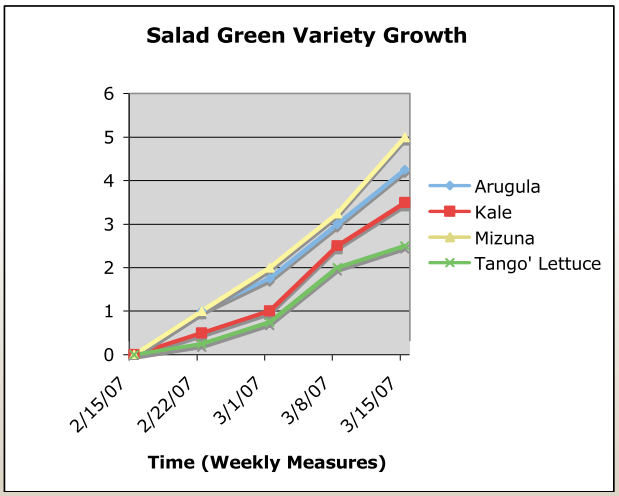
1. **Outstanding!** This (fill-in-the-blank) salad green is absolutely delicious; I will graze on it at every opportunity.
2. **Good.** This (fill-in-the-blank) is pretty good. I could eat this again (maybe with a little ranch dressing).
3. **Average.** This (fill-in-the-blank) green is just okay. I don't love it, but I don't hate it.
4. **Poor.** This (fill-in-the-blank) is not tasty, but I am tough so I tried it.
5. **Unacceptable!** This (fill-in-the-blank) is totally disgusting. I cannot stand it and cannot see myself eating it again!

Chart the taste ratings for each green as an entire class into a bar graph. Talk about what the graph shows. Which greens tasted the best? The worst? What was the average taste rating for each variety?

Another important graph to make would be the measure of plant growth over time. Create your horizontal x-axis as time (number of days) and your vertical y-axis as height (in centimeters). Ask students to call out data for each point that you are graphing. Use a different color marker to chart each salad green. Which variety grew the fastest? The slowest? Why? How do you think environmental conditions changed how the plants grew? Graph any other information as appropriate. From these graphs draw conclusions by having each student identify his/her favorite green and justify their selection. Their rationale might be based on taste, plant growth, or the characteristic they were most interested in seeing in their salad green. (North Carolina Math Competency: 4.01) How did you decide what to choose? What steps did you go through before you made your decision? What was the most difficult part of the experiment? How will learning about experimental design help you in other situations? What are some ways that you like to learn? What would you do differently if you did this experiment again?

What would you do differently if you did this experiment again?





Follow up Lesson:

Ask students how the environmental conditions played a role in the growth of the plants. How would the salad greens perform under different environmental conditions? Refer to previous experiments (Soil & Plant Growth, Fast Plant Growth Experiments) for support. How would it grow outside in a school garden or under a **cold frame**?

Lesson 7: Salad Bowl Experiment

Assessment:

Salad Green Consumer Report

A consumer report is a creative way to communicate the student findings from their salad green scientific inquiry. It shows the observations students made and the conclusions they drew. A report will also help students share information in a meaningful and relevant way. They can present their finished report to the school garden committee or home garden groups, recommending their favorite varieties. (NC Language Arts Competency: 4.02)

Divide students into groups based on the salad green variety they grew. Have the students record their findings in the Consumer Report Outline (at the end of this lesson) and present it to the class. Encourage them to "sell" their variety, attesting to the positive features and perhaps giving warnings of some of the "challenges" of the variety.

Beyond the Garden Gate:

Activities to try at home

Salad Square Foot Gardening

Grow your own salad green garden in just one square foot! The concept of square foot gardening comes from a gardener named Mel Bartholomew. He encourages beginning gardeners to start out simple by building raised beds and planting in square foot sections. Have an adult help you make a 12-inch square mini-raised garden from non-treated wood that is 6 inches deep.

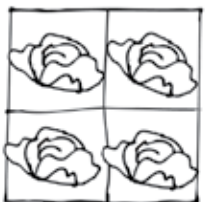
You could also find a pot, preferably a square one that measures about 12 inches across. Put weed cloth on the bottom of your square and set in your yard or patio.

Fill your square or pot with a soil mix of 1/3 good compost, 1/3 peat, and 1/3 vermiculite. Mix in water thoroughly, and add more of your soil mix if needed. For plant spacing, use the diagrams to the left. Once your plants are ready, harvest, enjoy, and plant again!

Square Foot Garden Plant Spacing

1 plant per square:

Broccoli
Cabbage
Pepper

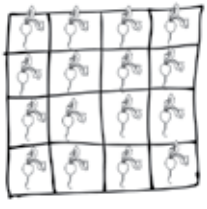


4 plants per square:

Lettuce
Swiss Chard
Parsley

9 plants per square:

Beets
Spinach
Turnips
Most Salad Greens



16 plants per square:

Radish
Carrots
Onions

Salad Bowl Experiment

Collect Data (Sample 1)

Group Names: _____ Date:_____

_____

_____

Teacher Instructions: Use this template to collect data from a group of six students, measuring their data for each salad green variety collectively.

1. Record Plant Height

a. In the first line, include the salad green varieties you chose.

b. Measure in centimeters the height of the salad greens.

c. Make copies of this page each time you make a measurement. This data sheet is for one day of data collection. Note the space to record the date is below the group names.

	1 - Kale	2 - Mizuna	3 – 'Tango'	4 – 'Integrata Red'	5 – Arugula	6 - 'Freckles'
Plant Height (centimeters)						

2. Leaf Data

a. Record additional data measurements below. Change the categories as appropriate. Students may want to collect measurements on color, texture, number of seeds germinated, etc.

	1 - Kale	2 - Mizuna	3 – 'Tango'	4 – 'Integrata Red'	5 – Arugula	6 - 'Freckles'
Number of Leaves						
Sketch Leaf						
Appearance						
Other Observations						

Salad Bowl Experiment

Collect Data (Sample 2)

Name:_____

Teacher Instructions: Use this data sheet for individual students making measurements on one type of salad green. You may want to change the data collection categories to fit the information you are trying to uncover. For example instead of other observations, you may want to be specific and count the number of seeds germinated, leaf width, number of insects, etc.

Name of salad green: _____

Date	Plant height (centimeters)	Number of Leaves	Leaf Color	Sketch Leaf	Other Observations

Salad Bowl Experiment

Final Data Collection

Group Names: _____ Date:_____

_____

_____

Teacher Instructions: This data sheet marks the final data collection. Record the plant height and make a final evaluation of leaf appearance by assigning it a numerical rating on a 1-5 scale. Also use the same 1-5 scale to rate the taste of the different salad greens. Graph the results to compare the growth of the different salad greens, appearance, and taste.

1. Record Final Plant Height

	1 - Kale	2 - Mizuna	3 – 'Tango'	4 – 'Integrata Red'	5 – Arugula	6 - 'Freckles'
Plant Height (centimeters)						

2. Leaf Data

In the table below evaluate each of the lettuce cultivars on their overall leaf appearance. Assign a number 1-5 for each of the cultivars. You may think all six of the cultivars are outstanding and give them all 5's or you may assign a range of numbers.

	1 - Kale	2 - Mizuna	3 – 'Tango'	4 – 'Integrata Red'	5 – Arugula	6 - 'Freckles'
Appearance						

3. Taste Evaluation

Taste a portion of a leaf for each salad green and assign each a number according to the following scale:

1. **Outstanding!** This (fill-in-the-blank) salad green is absolutely delicious. I will graze on it at every opportunity.
2. **Good**. This (fill-in-the-blank) is pretty good. I could eat this again (maybe with a little ranch dressing).
3. **Average**. This (fill-in-the-blank) green is just okay. I don't love it, but I don't hate it. I am tough; I tried it.
4. **Poor**. This (fill-in-the-blank) is not tasty. Ewww!
5. **Unacceptable!** This (fill-in-the-blank) is totally disgusting, I cannot stand it, and I will never eat it again!

	1 - Kale	2 - Mizuna	3 – 'Tango'	4 – 'Integrata Red'	5 – Arugula	6 - 'Freckles'
Taste Rating						

Salad Green Consumer Report

Group Names: _____ Date:_____

_____

_____

Salad Green Variety: _____

1. Write down reasons why someone would want to grow your salad green variety.

2. What are some challenges in growing this variety of salad green?

3. How did your salad green grow in comparison to the other varieties?

4. Would you recommend your salad green variety for someone else to grow? Why?

Lesson 8 Composting

Duration: 45 minutes to 1 hour

Let's Explore the Soil!

Purpose:

Composting is a way to turn kitchen and waste materials into a rich amendment for the garden. Composting is also a great opportunity to practice environmental stewardship of the land by improving the structure of the soil, providing plants with nutrients, controlling weeds, reducing the need for watering, and keeping waste out of landfills.

North Carolina Science Competencies:

2.05 Determine how composting can be used to recycle discarded plant and animal material.

2.06 Determine the relationship between heat and decaying plant matter in a compost pile.

Life Skills:

Learning to Learn: Is curious, asks questions, learns how to do the process, how to observe, learns by doing.

Problem Solving: Seeks solutions to simple problems and is able to consider a few selected alternatives.

Critical Thinking: Ask questions before, during, and after acquiring information.

Communication: Engages in group discussion.

Materials (For 30 Students):

- Compost
- 30 hand lens (3x or 10x)
- 2 trash bins
- Newspaper
- Paper bag or tongs
- Compostable and noncompostable materials (see list of ingredients on next page)
- 3 wooden palettes (or another type of compost bin)
- Nails and hammer (to build the bin)
- Water hose
- Composting thermometer (or digital thermometer with a wire probe)
- Compost starter

Background Information:

Composting is the speeding up of the **decomposition** process of **organic** materials by naturally present microorganisms. It is a way to turn kitchen and yard wastes into a substance that, when added to soil, improves the soil's physical properties and increases plant nutrients. Microorganisms (bacteria, fungi, and actinomycetes) use the carbon, nitrogen, and other elements in the waste materials, which results in the decomposition of material. There are three main types of composting bacteria: those that start the process, those that take over from the starter bacteria, and those that finish the job. Each operates in a different temperature range.

As carbon compounds are digested, heat is given off. Fungi and **actinomycetes** break down tougher plant fibers like **lignin** and **cellulose**, as well as proteins and starches. Earthworms also play a role by ingesting, digesting, and excreting organic matter as nutrient-rich **castings** that are used by plants.

Lesson 8: Composting

Background (continued)

The ingredients for a compost pile can vary. An overall rule of thumb is to create a pile that is moist but not soggy, has sufficient **aeration**, and has at least a third to a half more carbon than nitrogen materials.

- Carbon materials include dead leaves, ashes, sawdust, newspaper, coffee grounds, and hay.
- Nitrogen ingredients consist of kitchen scraps like banana peels, apple cores, etc, grass clippings, and farm animal manure.
- Add a handful of compost to provide the microorganisms that decompose the materials.
- Avoid charcoal, diseased plants, colored paper, meat, oils, dairy products, pet waste and **non-biodegradable** materials (plastics, synthetic clothing, etc).

For more information, read Composting, a North Carolina Cooperative Extension Service publication online http://www.ces.ncsu.edu/depts/hort/hil/pdf/ag-467.pdf.

Scratching the Surface:

Place small piles of compost on newspaper on the desks in front of the students. Pose a few questions, like "What is the stuff in front of you? Why is it important?"

Briefly explain the composting process of decomposition of living (or once living) materials into a soil amendment. What is it made of? How is it made? Take a small trash can and fill it with real materials that could be composted and those that cannot (see list of materials below). Put compostable food scraps in a paper bag to easily and safely handle (or use tongs). Tell the students that often we tend to throw away items that we could easily recycle through composting.

Dump the trash can contents onto a table covered by protective material (newspaper). Ask students to come up and decide whether to put a material in a bin labeled "organic" and destined for the compost pile or a bin labeled "trash" that will end up in the landfill. After they have finished sorting, see how much actual trash is left. Compare it with the original pile.

Ask the students to reflect on the activity. How did they decide what to choose? What happened during the activity? Ask questions like, "Why do you think students had different ideas about what is trash and what is recyclable? How does having fun help you learn? Why is learning with others sometimes more fun than learning alone?" Tell the students they are going to apply the information they just learned by making a compost pile.

FOCUS QUESTIONS:

WHAT IS COMPOST?

HOW IS IT DIFFERENT FROM SOIL?

HOW DOES COMPOSTING WORK?

WHY IS GOOD FOR THE GARDEN?

Lesson 8: Composting

Digging in:

Compost piles can be very easy to create and maintain, and they offer many rewards for students. Have your bin ready to use but show the students how it is put together.

To build the compost bin, salvage three wooden palettes from a shipping company or a local recycling station. (You could also make a simple chicken wire bin with metal poles.) Nail the three palettes together to form a U-shape, leaving an open side to add recyclables. The compost pile itself is similar to a layer cake.

Have the students help by placing a layer of carbon-rich dead leaves and grass on the bottom. Then add a handful of soil or compost (which is full of good composting-starting bacteria). Next comes a smaller layer of nitrogen-rich ingredients, like vegetable scraps, fresh leaves, and farm animal manure. (Do not use dog droppings.) The smaller the pieces, the faster they will compost.

Students can rip and shred ingredients before they add it to the pile. Add alternating layers with the material you have. A good rule of thumb is to use two parts carbon or "brown" material to one part nitrogen or "green" material. Use a water hose to moisten the pile, making it not too soggy and not too dry.

Compost Ingredient List:

Carbon Ingredients
(Brown Ingredients)

- Hay or straw
- Sawdust
- Chopped twigs
- Ashes
- Dried leaves & grass
- Shredded paper
- Old potting soil

Nitrogen Ingredients
(Green Ingredients)

- Vegetable peelings
- Fruit scraps
- Coffee grounds
- Garden trimmings
- Egg and nut shells
- Manure
- Fresh grass clippings

Ingredients to Avoid

- Pet waste
- Dairy products
- Ingredients with fats or oils
- Meat or fish scraps
- Weeds with seed heads
- Diseased plants

As the bacteria begin to decompose the materials, they give off heat. On cool mornings, students may observe steam rising from the pile. Stick a long compost thermometer (or digital thermometer with a wire probe) in the middle of the pile, and keep track of the internal compost temperature as well as the outdoor temperature. Use this data to create a graph.

Depending on how active of a composter you are, you could see compost in anywhere from a few months to a year. Finished compost has a dark color and smells like the earth. Dig the compost into the school garden to provide nutrients for plants and build the soil structure.

Ask students questions like, "What happens to the original materials in the compost pile? How long does it take for an apple core to compost versus collard greens? How does the temperature of the compost pile vary as the outdoor temperature fluctuates?"

Lesson 8: Composting

Digging Deeper:

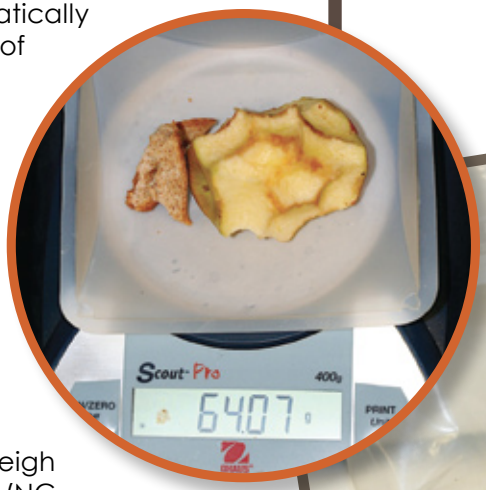
Composting can be hard to understand, since students cannot see the microbes that break down organic matter. If you have access to a compound microscope, show students how to make slides of the compost. Carefully put a small amount of compost on the slide. Using a water dropper put one or two drops of sterile water on the compost.

Make sure you create a thin layer so the light can pass through and illuminate the microorganisms. Apply the cover slip and start observations on low power, working to higher magnifications. Larger invertebrates can be identified, including nematodes and flatworms. The smaller microbes like fungi and bacteria will be a bit fuzzy.

Additional Activities:

Weighing Compost

Compost can dramatically reduce the amount of material going into the landfill, but how much? Record the amount of materials the students throw away at lunch for one week. After the composting lesson, have them keep track of what they put in the compost pile and weigh the remaining trash. (NC Math Competency: 2.02).



Ask students questions like, "What is the difference in weight? How could you further reduce the amount of waste being thrown away? Do you bring your lunch in reusable bags? Can you pack your food in reusable plastic containers?

Brainstorm ways to involve the entire school in a composting effort. For a schoolwide project to eliminate waste, consider composting in the cafeteria. For more information, visit the Web site http://www.bae.ncsu.edu/topic/vermicomposting/pubs/worms.html.

Compost in a Bag

Composting in a bag lets every student closely observe the composting process. Have each student bring in a gallon, resealable bag filled with compostable kitchen scraps like vegetable and fruit peelings, bread crusts, coffee grounds, or tea bags. Encourage them to bring in yard scraps, as well, like grass clippings and dry leaves. You may want to bring in extra ingredients to supplement. (See the compost ingredient list). Add compost starter in the form of a handful of compost, alfalfa meal, or commercially available compost starter from a local garden store. Have the students put their ingredients on a piece of newspaper and tear the ingredients into small pieces.

They should put the small pieces back in the bag. Be sure to have a rough ratio of two parts brown (carbon) to one part green (nitrogen) ingredients. Add about two tablespoons of water and seal the bag. Students should massage their bags every day to speed up the decomposition process by further breaking down the materials. Open the bags each day for a few hours to allow oxygen to filter into the compost. The composting process should be completed in four to six weeks. Have students add their finished compost to a garden or indoor potted plants.

Lesson 8: Composting

Beyond the Garden Gate:
Activities to try at home

Soda Bio-Reactor

Cornell University developed a lesson on small-scale composting. By using soda bottles students can design their own experiments manipulating variables like ingredients, temperature, and moisture to find out the effects on composting rates. Visit Cornell's Web site http://compost.css.cornell.edu/soda.html for a complete lesson.

Worm Bin

Special worms called 'red wigglers' are also great at making compost. They love to eat your rotting lettuce and leftover apple cores. Visit the NC 4-H Web site http://www.nc4h.org/teachers/enrichment/wildlife/9-12-worms.pdf to download instructions on building a worm bin.

Compost Gin

Compost Gin is a fun card game that you can play to learn more about how to compost and the ingredients needed to make compost. Created by Stan Slaughter, buy it at Compost Gin http://www.stanslaughter.com/products.html.

Assesment:

Compost Card Sort

Divide students into small discussion groups and have them organize cards into two categories: compostable and non-compostable. You may have them further subdivide the compostable ingredients into Carbon ingredients and Nitrogen ingredients.

Have the students share with the whole group their justification for separating each card into a specific category. Create a chart on the chalkboard for the whole group to follow along. Students may also come up with additional ingredients. Areas of disagreement tend to evolve into good conversations and teaching opportunities. (NC Language Arts Compentency: 4.02)

Other Resources:

North Carolina State University
http://www.ces.ncsu.edu/depts/hort/hil/hil-8100.html

Cornell Composting in Schools
http://www.ces.ncsu.edu/depts/hort/hil/pdf/ag-467.pdf

Compost Card Sort

Make copies for each group and cut out the cards on the dotted lines. Have students sort them into two piles: ingredients that can be composted and those ingredients that should go into the trash.

Dead Leaves

Coffee Grounds

Newspaper

Weeds

Fish

Eggshells

Manure

Ashes

Lint

Pet Waste

Cat Litter

Diseased Plants

Cheese

Meat

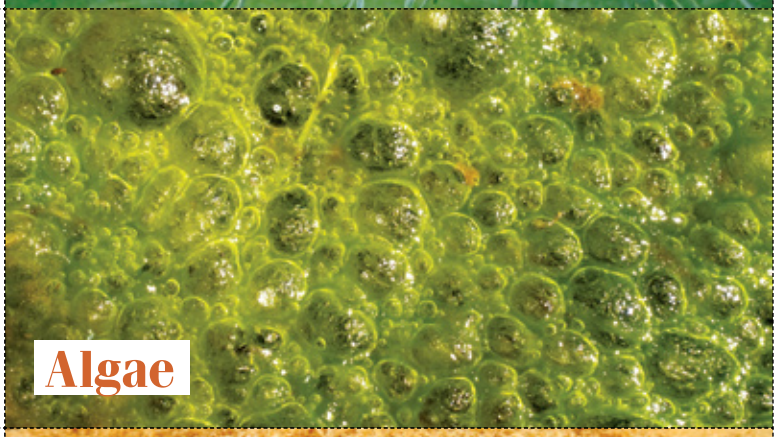
Yogurt

Milk

Potato Chips

Pine Needles

Hair



Algae

Cardboard

Sawdust

Soil Solutions Glossary

Actinomycetes: Soil-dwelling bacteria that decompose organic materials.

Aeration: The process of air being circulated through a substance, in this instance, compost. Compost must have sufficient amounts of oxygen in order for the decomposition process to occur.

Aerobic: The presence of oxygen, specifically in reference to soil.

Aggregates: Clumps of soil particles massed together.

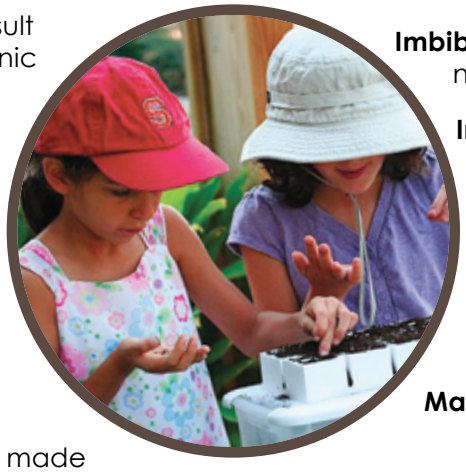
Agronomic: Referring to the science of field crop production. Agronomic crops are generally grown in large-scale production like corn, soybean, cotton, peanuts, wheat, rye, barley, oats, and forage crops.

Amendment: The addition of compost to the soil to promote healthy plant growth by improving soil structure, moisture retention, nutrient amount and availability.

Anaerobic: Without oxygen. As related to soil, anaerobic conditions occur in wet soils and are sometimes related to compaction.

Authentic Inquiry: To perform the same or similar activities and experiments that actual plant scientists do.

Castings: Worm manure, the result of the breakdown of organic materials by certain species of worms. Can be used like compost, as a soil amendment to improve soil structure, fertility, and water retention.



Cellulose: A complex carbohydrate found in the cell walls of plants.

Cold Frame: A structure, usually made of a wood frame covered with plastic, that extends the growing season for plants by allowing the sun's rays to raise the temperature inside the cold frame.

Compaction: What occurs when soil particles have been compressed and the pore space between them reduced. Some causes include driving heavy machinery over the soil and over tillage.

Decomposition: The breakdown or decay of organic or once-living materials.

Dissecting Microscope: A kind of microscope that enables users to closely examine the surface of various specimens, like flowers, leaves, or insects.

Dormancy: A stage in plant development when the plant rests or the stopping of growth until favorable environmental conditions are available.

Embryo: The young plant contained within the seed.

Genetics: The study of differences and similarities between organisms due to genes and the influence of the environment.

Germination: The process of a seed starting to sprout and grow.

Imbibe: To soak up and absorb water. Seeds need to imbibe water to germinate.

Invertebrates: Describes any animal without a spinal column, and includes organisms that aid in the composting process like worms and insects.

Lignin: Fibers found in woody plant tissue usually in connection with cellulose. Lignin strengthens the cell walls of plants.

Manipulate: To change. In the case of Fast Plants, to vary the amount of what plants need to grow in order to observe a difference in plant development.

Microbes: Small organisms like bacteria.

Nectar: Sugar-rich liquid found in many flowers to attract pollinators. Pollinators use nectar as a source of energy or food.

Soil Solutions Glossary (continued)

Nectary: Glands in the flowers that produce nectar.

Non-biodegradable: Materials that cannot be decomposed by living organisms. For example, plastic and Styrofoam are non-biodegradable materials.

Organic: Referring to the materials of once-living organisms (like plants, animals, or fungi).

Ovary: The ovary holds the ovules and mature into fruit once fertilization has happened.

Ovule: The eggs or female gamete of the plant. The ovules are contained within the ovary and mature into seeds or plant embryos once fertilization from pollen has occurred.

Pistil: The female reproductive structure of the plant, made up of the stigma, the style, the ovary, and the ovules.

Pollen: The male gamete of a plant. Pollen originates within the male reproductive structure of the stamen, specifically in the anther.

Pollination: The transfer process of the pollen from the male stamen to the female pistil, which contains the eggs. Occurs in the flower.

Proboscis: The sucking mouthpart of an insect. Butterflies, moths, and bees commonly use a proboscis to suck nectar from a flower.

Qualitative: A research method (for our purposes) that is based on personal reasoning and understanding.

Quantitative: Research from which the data is based on numerical measurements, like plant height, number of leaves, width of flowers, etc.

Radicle: The primary root of a germinating seed.

Scarification: The process of physically removing part of the seed coat in order to promote seed germination. Methods of scarification are performed on seeds with hard coats and include soaking in water, the use of acid, sandpaper, or a file.

Stamen: The stamen is the male reproductive organ found in flowering plants and including the pollen-producing anther and the filament.

Stewardship: The management and conservation of earth's natural resources.

Stratification: A moist chilling requirement needed to coax seeds out of dormancy into germination.

Variables: The changing quantities within the context of an experiment. For example if you are trying to find out how temperature affects how fast something will compost, your variables would be the different temperatures.

Viable: Able to live and grow. Viable seeds are seeds that are alive.

Wicking: For Fast Plants, wicking refers to the action of water traveling from a reservoir up through a piece of wick (felt or cotton fabric) into the soil to deliver moisture to plant roots. Wicking occurs as the result of capillary action.

Resources & References

**NOTE: Brand and trade names were used in this publication for the convenience of the reader. The Cooperative Extension Service does not endorse products mentioned nor imply criticism of similar products not named.

Resources

Fast Plants: Specially bred mustard plants that complete their life cycle within 28 days. They are great for growing in a classroom under fluorescent lights and utilizing for experiments. They can be purchased through Carolina Biological Supply Company: http://www.carolina.com.

North Carolina 4-H Plant and Soils Web site: Contains supplementary Soil Solutions curriculum materials at http://www.ces.ncsu.edu/4hplantandsoils/

- Seed germination video
- Pollination photos
- Word document work sheets to download for experiments
- Other ideas to keep you growing

"Dirt Made my Lunch" by the Banana Slug String Band: Song available on the Banana Slug's CD entitled, Singing in our Garden. Also available as a single download from Apple's itunes http://www.apple.com/itunes/.

Folkmanis Bee Puppet: Produces a nice puppet that fits snugly on the hand. For ordering information contact Folkmanis, Inc. at http://www.folkmanis.com/.

Salad Green Seeds: Johnny's Selected Seeds has a diverse supply of salad greens. Their catalog is free at: http://www.johnnyseeds.com/.

Osmocote Slow Release Fertilizer: Osmocote and other similar branded fertilizers are pelleted and release their nutrients into the soil slowly. They can be found in stores that carry gardening supplies.

Nutrient Test Kits: Nutrient test kits can be found through Carolina Biological Supply Company's online store at http://www.carolina.com.

pH Paper: pH paper can be purchased through any science supply store including Carolina Biological Supply Company's online store at http://www.carolina.com.

Online Reference Publications:

Soil Sampling guide: http://www.soil.ncsu.edu/publications/Soilfacts/AG-439-30/AG-439-30.pdf

Composting bulletin: http://www.ces.ncsu.edu/depts/hort/hil/pdf/ag-467.pdf

Vermicomposting: http://www.bae.ncsu.edu/topic/vermicomposting/pubs/worms.html

Natural Resource Conservation Service Soil Web Survey: http://websoilsurvey.nrcs.usda.gov/app/

Soil Ball: http://soils.usda.gov/education/resources/k_12/lessons/experiments/soil_air/

Soil Crayons: http://soils.usda.gov/education/resources/k_12/lessons/texture/

Cornell Composting in Schools: http://www.css.cornell.edu/compost/schools.html

North Carolina Department of Agriculture: http://www.ncagr.com/stats/codata/index.htm

For More Information, Contact:
Your local county Cooperative Extension center: http://ces.ncsu.edu/

References

Naylor, S., Keogh, B. and A. Goldsworthy. 2004. *Active Assessment: Thinking, Learning and Assessment in Science.* David Fulton Publishers, Ltd. UK.

Chin, C., Brown, D.E. and B.C. Bruce. 2002. Student-generated questions: A meaningful aspect of learning in science. *International Journal of Science Education* 24(8):521-549.

Krumme, G. Accessed July 2, 2007: http://faculty.washington.edu/krumme/guides/bloom.html

Bartholomew, M. 2005. *Square Foot Gardening: A New Way to Garden in Less Space with Less Work*. Rodale Inc., PA

USDA Soil Texture Triangle: http://soils.usda.gov/technical/manual/images/fig3-16_large.jpg

NRCS Soil Texture by Feel Key: http://soils.usda.gov/education/resources/k_12/lessons/texture/

Raven, P. H., Evert, R.F., and S.E. Eichhorn. 2005. Biology of Plants. W.H. Freeman Publishing Company, NY.

Credits

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E07-50247
4H-1-142

Name: _____

Soil Solutions Cumulative Assessment

1. Why is soil important?
    a. It filters pollutants out of water
    b. It helps recycle waste
    c. It provides a space for plants to grow
    d. All of the above

2. Soil is made up of air, water, mineral soil particles, and decomposed organic material.
    a. True
    b. False

3. Which soil particle size is the smallest?
    a. Sand
    b. Silt
    c. Clay
    d. Humus

4. What does hand texturing tell you about the soil?
    a. The color of the soil
    b. How much clay, silt, and sand is in the soil
    c. The amount of water in the soil

5. Which kind of soil does water drain through quickly and is usually dry?
    a. Sand
    b. Silt
    c. Clay
    d. Humus

6. Which soil does water drain through the slowest?
    a. Sand
    b. Silt
    c. Clay
    d. Humus

7. What mostly fills the pore spaces in soil?
    a. Air and water
    b. Worms
    c. Insects
    d. Bacteria

8. Some plants are more adapted to grow in certain soils than others.
    a. True
    b. False

9. What kind of soil would you want in your garden? Why?

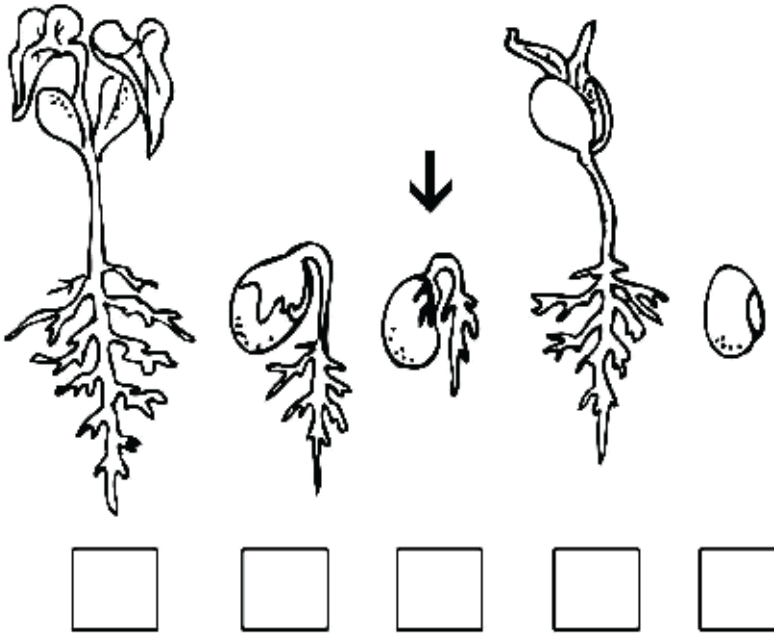
10. If you put soil and water in a jar and shake it up, what would happen?

11. Write down 5 different plants we grow for food in North Carolina.

12. Describe what happened to your plants that grew in different soils?

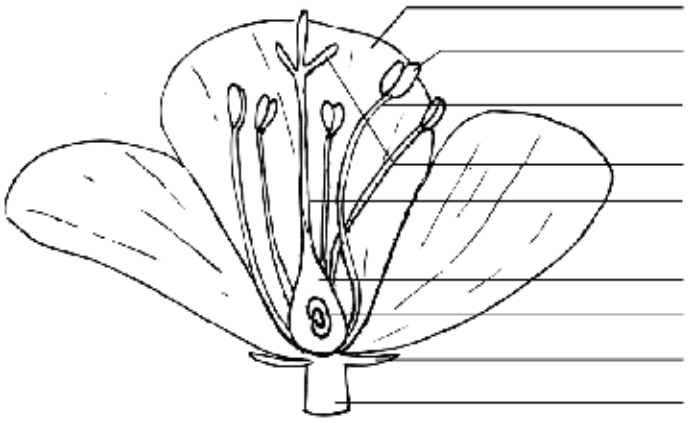
13. What is the most important in the process of germination?
    a. Water
    b. Air
    c. Light
    d. Soil

14. Below are some pictures of a seed growing. The pictures are not in order. Number the pictures in the order that shows the correct growth of the seed.



15. Look at picture with the arrow above it. Describe what is happening at that stage of the life cycle.

16. Look at the flower in front of you. Draw a picture of the flower and label any parts you can identify.



17. You would like to grow a corn plant in your garden. Describe what you would have to know in order for it to grow well.

18. Circle the materials you would put in your compost pile

Dead leaves	Hair	Newspaper
Eggshells	Fish scraps	Coffee grounds
Dryer lint	Weeds	Cheese
Ashes	Banana peels	Diseased plants

19. Composted materials can be put back into the garden to give plants the nutrients they need to grow.
    a. True
    b. False

20. Microorganisms are responsible for the rise in temperature in a compost pile as ingredients begin to decompose.
    a. True
    b. False

21. List 3 ways you could tell if a plant was growing well.

Vocabulary Matching
DIRECTIONS: Choose the word from the Word Box that matches each definition. Write the letter on the line.

22. ____ The process of a seed starting to sprout and grow.

23. ____ The process of pollen moving from the stamen to the pistil.

24. ____ A common pollinator of flowers.

25. ____ This plant part develops after the flower has been pollinated.

26. ____ Many flowers offer this sweet reward to pollinators.

27. ____ This flower part produces pollen.

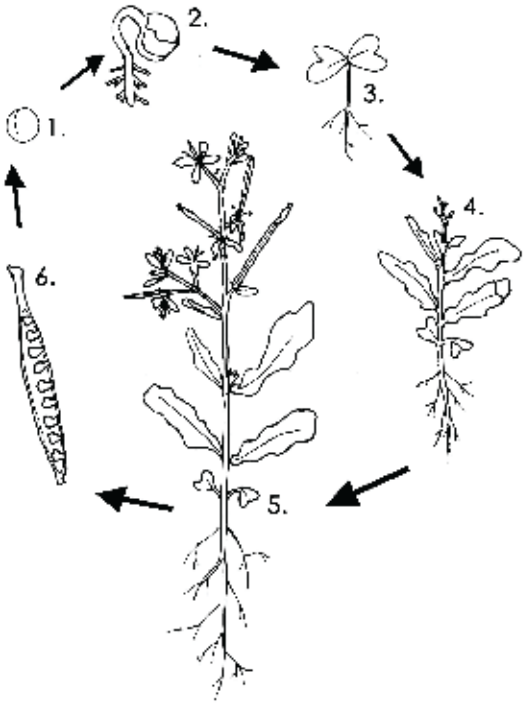
Word Box

a. Bee
b. Germination
c. Nectar
d. Seed
e. Pollination
f. Anther

28. Which of the following do plants **NOT** need in order to grow:
    a. Water
    b. Soil
    c. Light
    d. Nutrients

29. A plant that is grown in low light will produce fewer seeds.
    a. True
    b. False

30. Below is a diagram of the fast plant life cycle. Each number corresponds to a stage of growth. Write a short description of what is happening at each stage.



1._____
_____

2._____
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3._____
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4._____
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5._____
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6._____
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ANSWER KEY

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8. Some plants are more adapted to grow in certain soils than others.
   (a.) True
   b. False

9. What kind of soil would you want in your garden? Why?

   Based on the soil solutions investigations, students should come to the conclusion that each soil texture has benefits and disadvantages. For example, clay can cause water to drain too slowly, but it holds many nutrients; on the other hand, sand can be too dry. A combination of clay, sand, silt, and humus would be best.

10. If you put soil and water in a jar and shake it up, what would happen?

The students should recall the soil shimmy. When water and soil is shaken together and allowed to settle, the largest soil particle, sand, will fall to the bottom, followed by silt, clay, and sometimes a layer of humus on top.

11. Write down 5 different plants we grow for food in North Carolina.

The answers may depend on the actual plants that the students grew. They could include any of the following: soybean, corn, wheat, rye, oats, peanuts, tomatoes, potatoes, sweet potatoes, watermelons, squash, beans, apples, blueberries, peaches, melons, grapes, raspberries, etc.

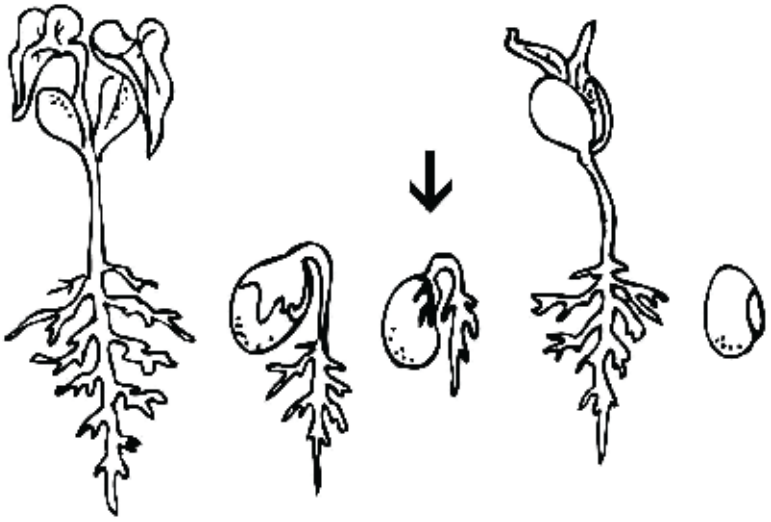
12. Describe what happened to your plants that grew in different soils?

The experiment results should vary depending on the soils used, but one might expect to see plants grown in sand to grow poorly and exhibit signs of stress like brown leaves and stunted growth. Plants grown in a soil that is well-drained and kept moist should grow well with dark green leaves and healthy development.

13. What is the most important in the process of germination?

(a.) Water
b. Air
c. Light
d. Soil

14. Below are some pictures of a seed growing. The pictures are not in order. Number the pictures in the order that shows the correct growth of the seed.

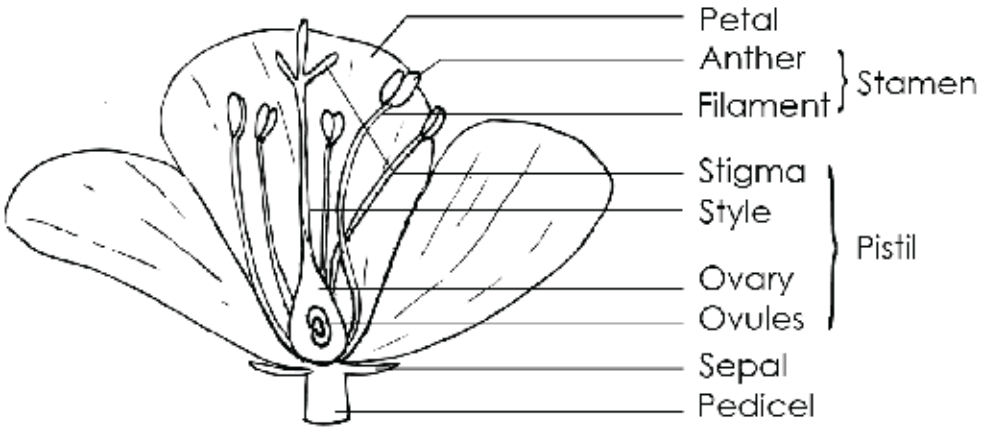


5 *3* *2* *4* *1*

15. Look at picture with the arrow above it. Describe what is happening at that stage of the life cycle.

The seed is just beginning the process of germination. The radicle or root is starting to emerge. It must have been given the proper environmental conditions, including warm temperatures and water to imbibe.

16. Look at the flower in front of you. Draw a picture of the flower and label any parts you can identify.



17. You would like to grow a corn plant in your garden. Describe what you would have to know in order for it to grow well.

Based on prior experiences in growing plants, students might suggest they need to know what type of soil is available, how many nutrients are in the soil, what the pH is, how much light is present, what the temperature is, how much water is available to the plants and given those conditions, what corn needs in order to grow well.

18. Circle the materials you would put in your compost pile

(Dead leaves)	(Hair)	(Newspaper)
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   b. False

20. Microorganisms are responsible for the rise in temperature in a compost pile as ingredients begin to decompose.
   (a.) True
   b. False

21. List 3 ways you could tell if a plant was growing well.

There are a number of different ways to measure plant growth. Some of the ways could include: number of leaves, plant height, leaf color, disease incidence, pest problems, number of flowers, number of seeds germinated.

Vocabulary Matching

DIRECTIONS: Choose the word from the Word Box that matches each definition. Write the letter on the line.

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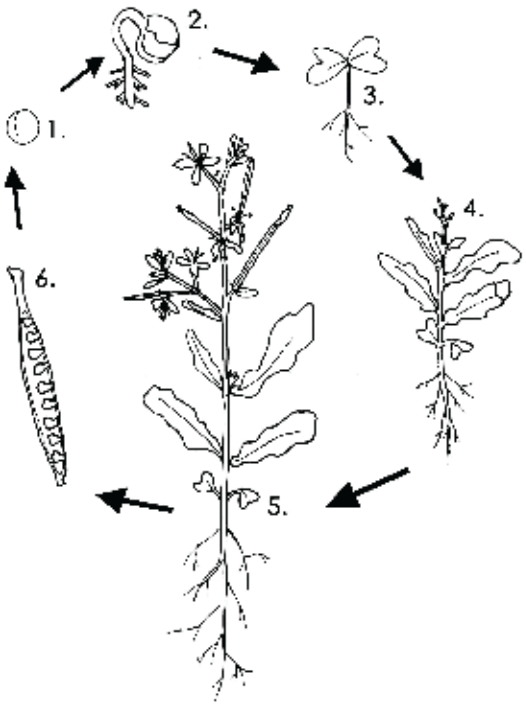

1. *Seed: the seed needs warm temperatures, oxygen, and water to start the process of germination.*
2. *Germinating Seed: the seed has begun to take in water (imbibe) and sprout a root.*
3. *Seedling: the cotyledons (seed leaves) have unfolded and the plant can begin to make food (photosynthesize) with light. It needs water, light, and carbon dioxide to grow.*
4. *Larger seedling, vegetative growth: the plant begins to grow taller and bigger by taking in more light and making more food. The roots are taking in water and nutrients to help it grow.*
5. *The plant is beginning to flower. Only Bees will need to pollinate the flowers in order for seeds to develop.*
6. *Fruit: the flowers were pollinated and fertilized allowing for fruit development. The seeds are found inside the fruit and will be the start of more plants.*