How Does Your Garden Grow?

HOW DOES YOUR GARDEN GROW?

Adapted from Schaumburg Illinois School District 54 Science Curriculum

Teacher's Guide

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M.A.S.H.
Math **A**nd **S**cience **H**ands-On

A Science Literacy Project

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HOW DOES YOUR GARDEN GROW?

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ACTIVITIES:

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Supplies List

Item	Quantity
10 Gallon Container	1
**Ammonia (dropper bottle)	3
**Assorted Food Coloring	1 pack
Cheesecloth	5 yds.
Condiment cup, 2 oz.	100
*Corn Seeds	2 pkt
**Epsom salts (small box)	1 box
**Filter Paper	1 box
Funnels	10
Hand Lenses	15
**Iodine	1 btl
*Lettuce Seeds	3 pkts
**Lima Beans, Large	2 bag
**Liquid Plant Food	1 blt
Medicine Cups	50
*Pea Seeds	2
Petri Dishes	10
**pH Paper	1 roll
Pipettes	15
Plastic Cups (10 oz.)	55
Plastic Spoons	10
*Potting Soil	2 bag
*Radish Seeds	1 pkt
*Red Beans	2 lbs
**Rooting Powder	1
**Rubbermaid #16	150
**Salt	1 box
**Sugar	1 box
Teacher Guide	1
*Tomato Seeds	1
**Toothpicks	1 box
*Vermiculite	1 bag
Vial w/ pop-on lid	40
*Ziploc Sandwich Bags	2 box
*Wax Paper	1 roll

*Consumable **These items are consumable after a number of uses.

HOW DOES YOUR GARDEN GROW?

M.A.S.H. at a Glance

Introduction

This section is written to provide you with a quick overview of the major curriculum elements around which the M.A.S.H. Kits are designed. The acronym M.A.S.H. represents Math And Science Hands-on. M.A.S.H. Kits were developed through a cooperative effort among local school districts, Educational Service Center Region 16, and Southern Illinois University at Edwardsville and originated from a regional Title II Science Cooperative. Funding by the Illinois State Board of Education through a Science Literacy Grant provided development, piloting, and revision of these kits, designed to meet the needs of teachers wanting to teach activity-based science in southwestern Illinois. Specifically, these needs were identified as: availability and cost of materials, lack of time needed to teach science inquiry, and teachers' limited background in science. The thrust of development focused on these needs. The key elements of the M.A.S.H. Kit program are: scope and sequence of fundamental science concepts, alignment with state goals, emphasis on science process skills, cooperative learning, integration of language arts, opportunity to apply mathematics skills in real problem solving situations, teacher ownership, and alternatives in assessment. Special recognition should be given to the exemplary science kit program from Schaumburg Illinois School District 54, for their initial assistance and ideas.

Scope & Sequence

Each kit is developed around a fundamental theme in science that can be matched to concepts covered in most textbooks. Students explore these central themes as they complete approximately ten developmentally appropriate, process-based activities. The primary sequence introduces a theme from life, physical, or earth science. The intermediate kits further develop these same themes. Middle school kits continue to reinforce these same basic themes while utilizing a higher level of technology.

State Goals

The M.A.S.H. Kits were developed by Illinois educators primarily to assist classroom teachers in meeting the educational needs of their students. As a result, each investigation's instructional objectives focus upon the Illinois State Goals for Learning. These goals include the basic concepts and fundamental skills in science, mathematics, social studies, language arts, fine arts, health, and physical education. Each investigation has been carefully selected to prepare students to meet or exceed Illinois goals. At the beginning of each of the activities the specific goals and objectives addressed by that activity has been identified and referenced.

Science Process Skills

The activities in the kits address the science process skills necessary for students to utilize when learning science: observe, measure, classify, infer, predict, communicate, formulate hypothesis, experiment, and interpret data.

Cooperative Learning

The instructional approach utilized in this curriculum is one of having students work in cooperative groups. It is recommended that the size of your cooperative groups not exceed four students. Many educational benefits occur when students work together in groups to investigate and solve problems. Cooperative learning more closely resembles the way individuals work together to solve problems in the real world. Another important reason for the use of cooperative groups is to make the acquisition, costs, and management of materials reasonable for the classroom teacher.

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Language Arts

Students read about, talk about, and write about the exciting science activities they are doing. This additional use of language along with the science investigation, reinforces the students' understanding of the scientific principles being explored. Not only do many of the kits include their own science-related books, but an additional list of resources is located in the introduction of each kit guide.

Mathematics

Many of the science investigations result in an opportunity for the students to apply mathematics skills in a variety of ways. Students are encouraged to quantify their observations with metric measurements; record and report those same observations with charts, tables, and graphs. Often times students will need to apply mathematical operations to solve problems or answer questions.

Alternatives in Assessment

The Unit Test provided in this guide can be used to determine students' understanding of the major concepts dealt with in the kit. Unit Tests use a variety of different questions such as multiple choice, fill in the blank, short answer, etc. The Unit Test may be given in a pre-post type format to determine: 1) the increase of students' understanding as a result of this unit and 2) clarify students' prior skills and knowledge to determine the direction instruction should take. Kits also include a performance based assessment that gives teachers the opportunity to observe what students actually can do with the science concepts and skills they have learned.

Teacher Ownership

The success of this program has been strongly dependent upon teacher ownership, especially at the very beginning of the projects' early stages of developing, piloting, and editing of the core activities. Continued teacher ownership has resulted in the creation of extension activities which provide additional instructional opportunities in all curricular areas. These extensions continue to be developed by classroom teachers using the M.A.S.H. kits. Materials for these activities may or may not be included in the kit. If you have a great extension idea for a kit activity, please send it to us at Southern Illinois University Edwardsville, Box 2226, Edwardsville, IL. 62026.

HOW DOES YOUR GARDEN GROW?

Major Purpose

Magic beans? Beanstalks? Jack and a Giant? In fairy tales, anything is possible. From a small bean, a giant stalk can burst forth reaching heights in which only Giants and magic kingdoms exist. Plant growth and care, however, should not be seen as an adventure in a fairy tale or the result of magic. It can be a very real part of every child's life. From decorative window boxes to small home gardens to agricultural enterprises, plants play an essential and varying role in our society and therefore are an idea source for further study.

In *How Does Your Garden Grow* students can be farmers, biologists, and scientific investigators all in one. *How Does Your Garden Grow* enables students to explore the important chemical and physical processes which occur in the creation, growth, and existence of a plant. From photosynthesis to soil quality, students are introduced to the principles and processes which make plant life possible. In *How Does Your Garden Grow,* students are able to participate in and affect one of the greatest scientific and biological processes of all time: life.

Objectives

After completing *How Does Your Garden Grow*, a student will be able to:

Generally:

- create bar graphs based on information found through observations
- understand the importance of a control group in scientific experimentation
- chart observations according to different characteristics and outcomes
- calculate percentages

Specifically:

- explain the growth cycle of a plant with regards to such processes as photosynthesis, phototropism and geotropism
- test for soil chemistry and describe its effect on plant growth
- understand the process by which plants absorb food and water
- describe the affects of artificial fertilizers on plant growth

HOW DOES YOUR GARDEN GROW?

These safety rules may be discussed and posted during science activities or the teacher may have the class generate a list of safety procedures to follow.

SAFETY POSTER:

1. Always wear proper eye and clothing protection.
2. Work only with materials that have been approved and provided by your teacher. Never take chemicals or equipment from the supply shelf yourself.
3. Never perform an experiment your teacher has not reviewed and given you permission to perform. Listen carefully to the teacher's instructions and ask for help if you are unsure of what to do.
4. Do not use any equipment that is not working properly or is unsafe for any reason. Report faulty or damaged equipment to your teacher.
5. Tie back long hair. Confine all loose clothing.
6. Always be careful when handling chemicals. Immediately wash chemicals off your skin with water. Carefully clean up any spills.
7. Never put any equipment in or near your mouth or eyes. Never eat or drink while in the science area.
8. Do not taste anything during an experiment unless the teacher tells you that it is safe.
9. Clean up work area and return all materials to their proper place.
10. Always be careful when handling sharp items such as scissors, mirrors, compasses, pins, tacks, and paperclips.
11. Speak quietly in groups so that directions can be heard.
12. Immediately inform your teacher of any accidents.
13. Some plants are poisonous. If you do not know if a plant is edible, do NOT eat it.
14. Some seeds are poisonous and some produce poisonous toxins. If you do not know if a seed is edible, do NOT eat it.
15. Some plants are dangerous to the touch. Cactus plants can stick to your skin. Poison ivy, poison oak, and poison sumac can all cause severe skin irritation.
16. Many common household plants are poisonous. Poinsettia and philodendron are examples.

HOW DOES YOUR GARDEN GROW?

Cooperative Learning: Classroom Management Techniques

1. In order for your students to complete the activities successfully, it is essential that they know, and follow, the ten rules for group work:
    - Move into groups quietly, without bothering others
    - Use quiet voices
    - Stay with your group
    - Everyone does a job
    - Everyone shares the work
    - No one is bossy
    - Everyone shares materials
    - Everyone shares ideas
    - Take turns talking
    - Care about others' feelings

2. Initially avoid competition between groups. This can be accomplished by carefully selecting groups in a variety of manners — randomly (i.e. by birthdays), by students' abilities, or by allowing the students to choose groups for themselves. It is important to note that if the final technique is used to form groups, the students must be made aware that if their group does not perform adequately or productively, alternative selection methods will be employed (i.e. teacher selection).

3. Clearly define the task to be done.

4. Be sure there is a "product" connected with the group activity.

5. In setting time limits, allow too little time rather than too much time for the group to finish.

6. Each person in the team should play an active role. Regular rotation of roles should occur to give each student the opportunity to play a different role. Roles students can have are:

Principal Investigator:	This person keeps the group members on task, makes sure the activity is understood by all and is completed. Any questions will be immediately clarified with the teacher.
Materials Manager:	This person obtains all supplies the group needs. If the group is large enough, a second Materials Manager can be assigned to be responsible for returning materials to the supply area and having the group clean up its work area.
Recorder/ Evaluator:	This person writes down responses that team members have formulated. This person notes how well group members perform their responsibilities, contributing to the overall performance and outcome of the group.
Reporter:	This person writes down the group's conclusions and reports to the class. The reporter may also need to record the group's data on a class graph or chart. If the group is large enough, two Reporters can be assigned — one to record conclusions and chart data, the other to present their findings to the class.

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7. Follow the Five C's of group work to have a safe, and FUN, science activity:

Caution:	Laboratory group work requires caution in every part. Safety instructions should be followed and a safety checklist should be implemented before each activity.
Cooperate:	To ensure successful group work, each member must cooperate with the other members of the group.
Contribute:	Each member must make an effort to contribute something to the group.
Control:	Group work requires control over our body movements, voices, and actions. To avoid chaos in the classroom, control must be practiced by each member of the group.
Clean-Up:	Each group member must do his or her part to clean up after the activity. Students must make sure the work area is clean and all materials are put away.

8. The culmination of a group activity should be a time of sharing and evaluating how well group members worked together as well as examining the groups' end results or products.

HOW DOES YOUR GARDEN GROW?

Resource List

Brown, Renata. Gardening Lab for Kids: 52 Fun Experiments to Learn, Grow, Harvest, Make, Play and Enjoy your Garden. Massachusetts: Quarry Books, 2014.

Lerner, Carol. Plant Families. New York: Morrow Junior Books, 1989.

Markmann, Erika. Grow It! Indoor/Outdoor Gardening Guide For Kids. New York: Random House, 1991.

Messner, Kate & Neal, C. S. (Illustrator). Up in the Garden and Down in the Dirt: (Nature Book for Kids, Gardening, and Vegetable Planting, Outdoor Nature Book). California: Chronicle Books, 2017.

HOW DOES YOUR GARDEN GROW?

NAME _____

How Does Your Garden Grow? Test

1. A monocot splits into _____ part(s).

2. A dicot splits into _____ part(s).

3. Identify the embryo and cotyledon in the picture below.

4. The purpose of the cotyledon is to:

5. How could you test for the presence of starch?

HOW DOES YOUR GARDEN GROW?

6. List 2 factors that affect the germination of a seed.

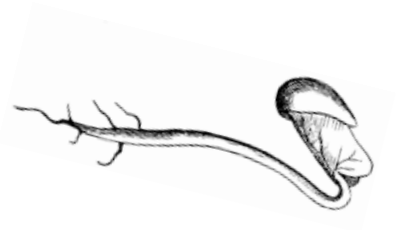
   a)

   b)

7. A strip of pH paper from a soil test is green. How would the plants in the area look?

8. In the picture below, draw a sun to show from which direction the sun is coming.

9. Look at the picture below. Which direction is downward? (Ignore the direction of the paper.)



10. In photosynthesis, plants give off which? (carbon-dioxide, oxygen).

11. Animals give off which? (carbon-dioxide, oxygen)

HOW DOES YOUR GARDEN GROW?

12. Explain why celery turns red if placed in red water.

13. In photosynthesis plants make _____.

14. List 2 ways to grow plants besides seeds.

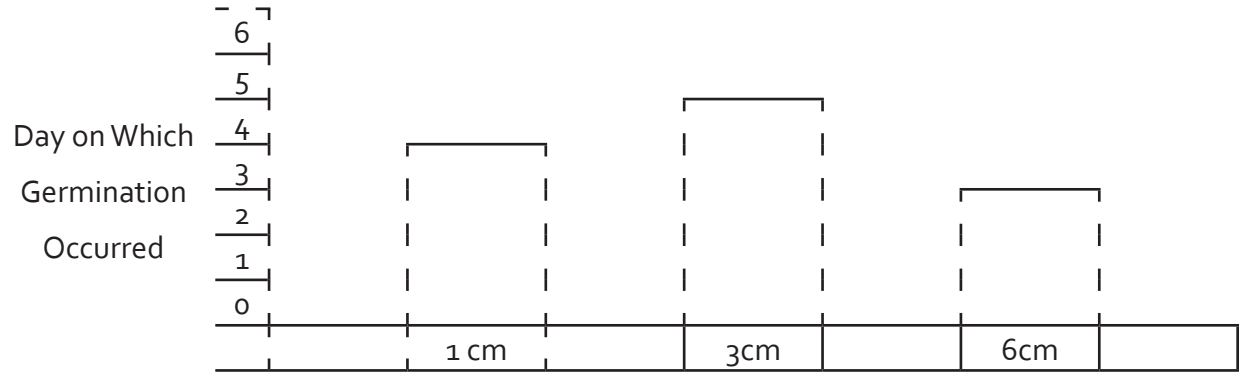
    A.

    B.

15. What is the key difference between hydroponically grown plants and normally grown plants?

HOW DOES YOUR GARDEN GROW?

Answer the question using the graph below.



16. Is there a relationship between seed size and rate of germination? Explain why or why not.

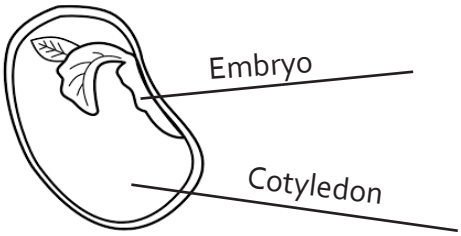
17. Fill in the blanks on the chart and design a graph to record the information in the chart.

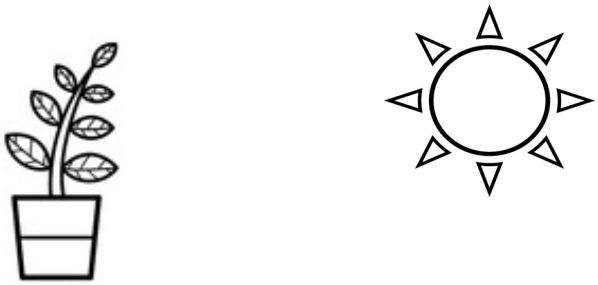
Plant	Stem Height Before	Stem Height After	Stem Growth
Plant with Fertilizer	10 cm	24 cm	_____ cm
Plant without Fertilizer	8 cm	16 cm	_____ cm

18. Using the information in your graph, did fertilizer affect the growth of the plant? Explain why or why not.

HOW DOES YOUR GARDEN GROW?

How Does Your Garden Grow? Test Answer Key

1. one
2. two
3. 

4. provide food for the embryo
5. using iodine - it turns purple in the presence of start
6. temperature, depth seed is in soil, amount of water, amount of oxygen
7. the plants should be healthy since the pH of the soil is around 7
8. 
9. Down <---  ----> Up
10. carbon-dioxide
11. oxygen
12. xylem tubes in the stem of celery conduct the red water up the stem, turning it red
13. food
14. tubers (potatoes), cuttings, runners, rhizomes, bulbs
15. hydroponics does not use soil
16. no, because otherwise the 6 cm seed would have sprouted later than the 3 cm seed

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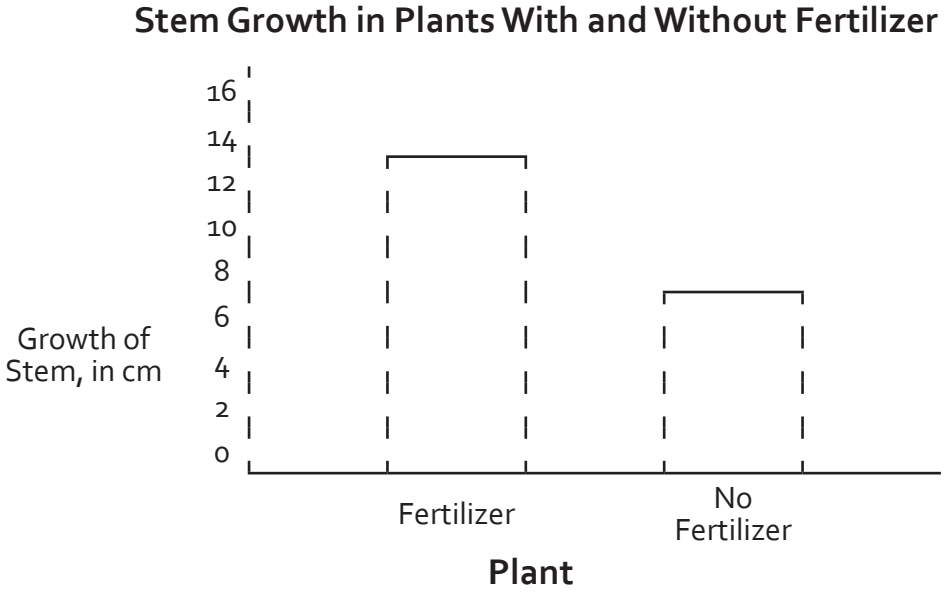
17.

Plant	Stem Height Before	Stem Height After	Stem Growth
Plant with Fertilizer	10 cm	24 cm	14 cm
Plant without Fertilizer	8 cm	16 cm	8 cm

18. yes, because the stem growth of the plant with fertilizer was greater in the one without fertilizer



HOW DOES YOUR GARDEN GROW?

ACTIVITY #1: The Seed

TIME: 40 minutes initially - 1 week for observations

OBJECTIVES: Students will identify the parts of a seed and will understand the relationship between the structure of a seed and its function. Students will use iodine to test for the presence of starch in seeds. Students will compare the growth of a monocot and a dicot seed.

TEACHER BACKGROUND INFORMATION: Some scientists classify plants by the way they reproduce. Some plants reproduce with seeds, others do not. Scientists put all the seed plants in two groups depending on whether they produce seeds in flowers or cones. Scientists put all the plants that do not have seeds in other groups. Examples are algae, mosses and liverworts, horsetails and club mosses, and ferns.

The seeds of flowering plants contain one or more "seed leaves" called cotyledons. These are a source of food for the embryonic plant. The embryo can be easily seen in bean seeds and resembles a tiny plant. Plants which have seeds with one cotyledon are called monocots. Plants which have seeds with two cotyledons are called dicots. A peanut splits into two sections, so a peanut plant is a dicot. A kernel of corn has one cotyledon and does not split into two parts. A corn plant is a monocot.

Looking at seeds is one way you can classify monocots and dicots. Another way is by counting flower petals. Monocots have petals in groups of three. A tulip has six petals. Six is two groups of three so a tulip is a monocot. Dicots have petals in groups of four or five. A hibiscus has five petals so it is a dicot.

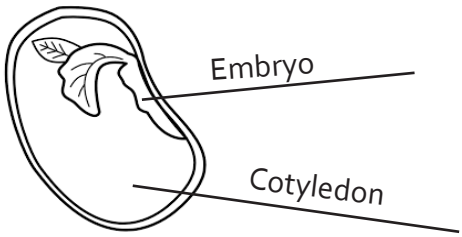
Iodine is an indicator for starch. Starch is a carbohydrate used as an energy source for living things. In the presence of starch, the yellow-orange iodine turns a deep purple color. Iodine is deadly if taken internally. Remind students not to taste the iodine. Diluting the iodine 1:9 substantially reduces the chance of poisoning.

MATERIALS (per group of 2):

- 3 red bean and 3 corn seeds
- 2 red bean seeds that have been soaking for 24 hours
- 1 hand lens
- 1 pipette
- 1 condiment cup

TEACHER PROVIDED MATERIALS:

- Iodine solution - 9 parts water/1 part iodine
- Paper towels
- Student Activity Sheet 1



PROCEDURE:

Part I - Seed Parts

1. Students will take a soaked bean and place it on a paper towel.
2. Have them separate the bean along the curved, outer part and use the hand lens to identify the cotyledon and the embryo.
3. Discuss monocots and dicots, explaining why a bean is a dicot and corn is a monocot. You may want to let the students see that a corn seed cannot be split into two parts.
4. Students should complete Part I on Student Activity Sheet 1.

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Part II - Seeds are a Source of Energy

1. Using the seed from Part I, have students scratch the surface of the cotyledons with their fingernail and add a drop of iodine. Students should bring their pipette to the container of iodine, squeeze the bulb, insert the tip, and release the bulb to suck up a few drops of iodine. They should then carefully carry the pipette back to their seats. They should not squeeze the bulb at the top until they are ready to release the iodine. Remind them not to taste the iodine, and that it will stain their skin and clothing.
2. Students should answer the questions on Part II of the worksheet.

Part III - Comparing the Seed Growth of a Monocot and Dicot

1. Have students line the sides of the condiment cup with a damp paper towel. Then have them fill the center of the condiment cup with damp paper towels so that the cup is filled. This will help the seeds stay firmly pressed between the cup and the paper towel lining the cup.
2. Students should place 3 bean seeds and 3 corn seeds between the side of the cup and the paper towel.
3. The cups should be set in a warm place out of sunlight. A temperature slightly above 22 degrees Celsius will allow for germination in 3 to 4 days.
4. Students should keep the towel moist but not soaking. Observe the seeds daily and make sure the water level is below the seeds. If the seeds soak in water they will rot and should be removed.
5. Students should complete the bar graph under Part III on Student Activity Sheet 1. Two bars for each plant part are necessary - one for corns and one for beans. They should record on which day the roots, stems, and leaves appear for the monocot and the dicot. They should complete the questions on the worksheet.

FORMATIVE EVALUATION: Students will be evaluated on the completion of Student Activity Sheet 1.

HOW DOES YOUR GARDEN GROW?

Name _____

Activity #1: The Seed

MATERIALS per group of 2: 2 soaked bean seeds, 1 pipette, 1 hand lens, paper towels, iodine solution, 1 condiment cup, 3 bean seeds, and 3 corn seeds.

PROCEDURE:

Part I - Seed Parts

1. Take a soaked bean, dry it, and place it on a paper towel.
2. Carefully separate the bean with your fingernail along the curved, outer part of the bean. If you pull too hard you will damage the inside.
3. The two sections are the cotyledons. They provide food for the embryo or baby plant. Once the embryo grows and is able to make its own food using sunlight, the cotyledons are no longer necessary and fall off.
4. Use the hand lens to identify the embryo. Make a drawing under Part I of what you see and label the embryo and cotyledon.

Part II - Energy Source for Seeds

1. Using the seed from Part I, scratch the surface of the cotyledon with your fingernail.
2. Use your pipette as your teacher has instructed you and place a drop of iodine on the area that has been scratched. Iodine will stain your skin and clothing and is poisonous if tasted!
3. Answer the questions under Part II.

Part III - Comparing the Seed Growth of a Monocot and Dicot

1. Line the side of a condiment cup with a damp paper towel.
2. Fill the center with damp paper towels so that the cup is filled.
3. Carefully place 3 bean seeds and 3 corn seeds between the cup and the lining of the paper towel.
4. Place the cups where your teacher has instructed you.
5. Observe your seeds daily and make sure the paper towels remain damp. Do not let your seeds soak in water because they will rot and will have to be removed.
6. Record on which day the leaves, stems, and roots appeared for both the corn and the bean. Then answer the questions.

HOW DOES YOUR GARDEN GROW?

Part I: In the space below, draw a diagram of the seed you observed and identify the following parts: embryo, cotyledon.

Part II:

1. What happened when iodine was place on the cotyledons?

2. What does this indicate is present?

3. How is this material helpful to the embryo?

4. Name some seeds we use as food.

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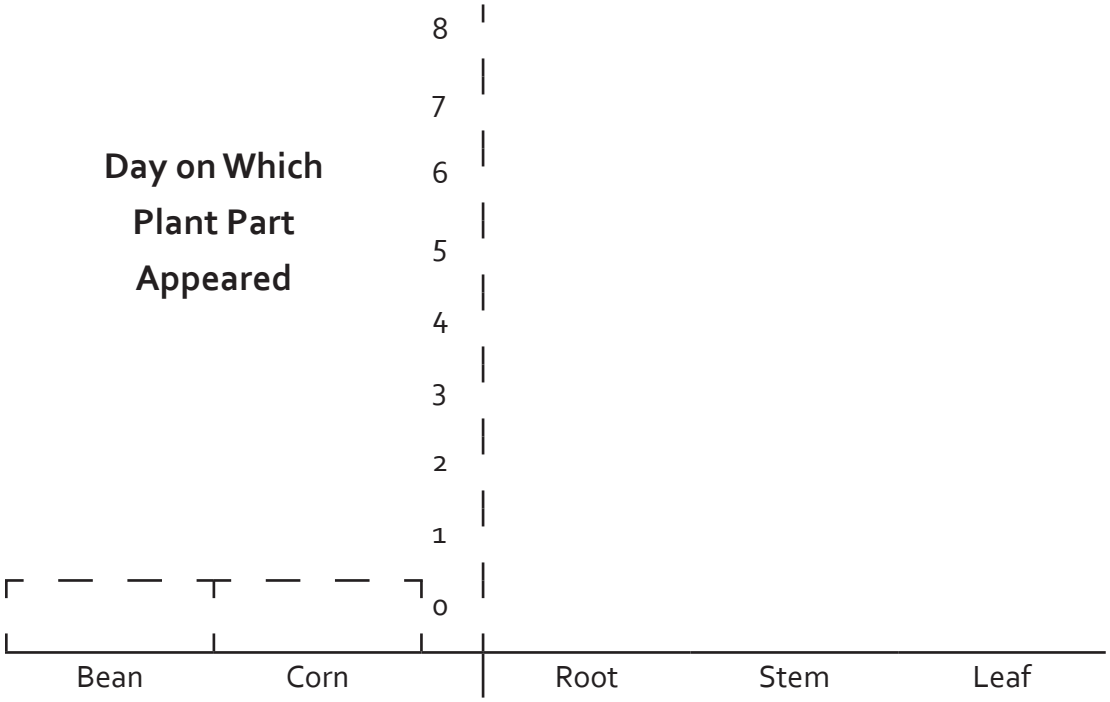
Part III:

1. Make a bar graph that shows the day on which the plant parts appeared. Two bars - one for beans and one for corn - are needed for each plant part. Color the squares below to indicate which bar represents bean and which bar represents corn.



2. Explain the difference between a monocot and dicot plant.

3. Corn is a (monocot, dicot). A bean is a (monocot, dicot).

4. What happens to the cotyledons after the plant grows several leaves?

5. Which sprouts first: the root or the stem?

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ACTIVITY #2: Will Light Prevent Seeds From Germinating?

TIME: 40 Minutes the first day, observation time is 3-5 days

OBJECTIVE: Students will determine if light will prevent bean seeds from germinating (starting to grow).

MATERIALS (per group of 2):
- 6 red bean seeds
- 2 baggies
- 6 lettuce seeds
- Masking tape

TEACHER/STUDENT PROVIDED MATERIALS:
- School paper towels
- Scissors
- Student Activity Sheet 2

PROCEDURE:

1. Start this activity on a Thursday or Friday. The seeds can be checked in 3-5 days.
2. Ask the class whether or not they think a bean seed would germinate (start to grow) in the light. Call on a few students to give and explain their answers. (Do not tell the students if their answers are right or wrong.)
3. Tell the class that they will conduct an experiment that will help answer the question.
4. Each team should place a damp paper towel in 2 baggies and place 3 bean seeds and 3 lettuce seeds inside each one. The baggies should be sealed.
5. Place one baggie in a dark place so no light is allowed to enter.
6. The other baggie should be kept in indirect sunlight. Ask the students what is the only difference between their two baggies? (Amount of light the seeds receive.)
7. Ask the students how the two test groups are alike. (Type of seeds, number of seeds, type of baggie, temperature, etc.)
8. Emphasize that a good experiment will always compare at least two test groups and will keep all factors for both groups the same except for what is being tested.
9. Many of the students will not understand why the seeds that received no light were tested. Explain that you need to make sure that is light and not some other factor that might prevent the seeds from germinating. If you only tested the seeds in light and they did not germinate, you might conclude that the light prevented the seeds from germinating when in fact the seeds might have been dead in the beginning. By testing the seeds from the same package in the dark as well as in the light, you would be able to tell if the seeds were dead in the beginning. The group without light is the control group.
10. Observe the results in about 5 days and have students complete the chart and make a bar graph on Student Activity Sheet 2. Two bars for each condition (dark, light) must be drawn - one representing lettuce and one representing beans for a total of 4 bars.
11. Conclusion -- Ask the students if light will prevent bean seeds from germinating. Ask them to give evidence to support their conclusions. (Light will not prevent bean seeds from germinating because about the same number of my bean seeds germinated in each container. Or, light prevented my lettuce seeds from germinating because none germinated.)

12. Discussion: Ask the students why some seeds did not germinate even though others in the same container did germinate. (Dead seeds)
13. Follow up experiment: some students might like to test the effect of light on seed germination using seeds they bring from home.

FORMATIVE EVALUATION: Students will be evaluated on the completion of Student Activity Sheet 2.

HOW DOES YOUR GARDEN GROW?

Name _____

Activity #2: Will Light Prevent Germination?

MATERIALS per group of 2: 6 red beans, 2 baggies, 6 lettuce seeds, masking tape, school paper towels, scissors

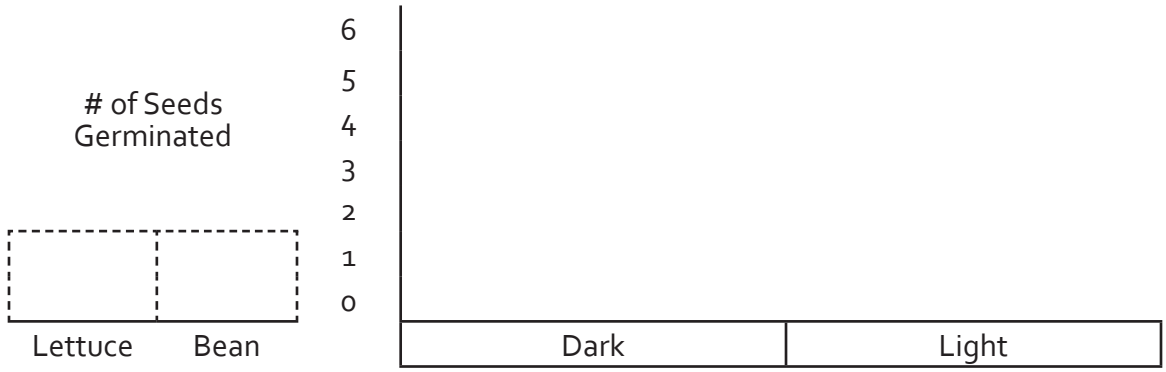
PROCEDURE:

1. Place a damp paper towel in the two baggies and place 3 bean seeds and 3 lettuce seeds inside each one. The baggies should be sealed and one placed in a dark place so no light is allowed to enter.
2. Observe the results in about 5 days. Complete the chart and make a bar graph on Student Activity Sheet 2. Two bars for each condition (dark, light) must be drawn - one representing lettuce and one representing beans for a total of 4 bars.

NUMBER OF BEANS GERMINATED		
	BEAN	LETTUCE
DARK		
LIGHT		

HOW DOES YOUR GARDEN GROW?

The Effect of Light on Bean and Lettuce Seeds



Condition

1. What was the key difference between the two baggies of lettuce and bean seeds?

2. How are the 2 sets of seeds alike?

3. Will light prevent bean seeds from germinating? Give evidence to support your answer.

4. Calculate the percentage of seeds that germinated.

germinated seeds / # total seeds X 100 = % germinated

Beans

DARK _____

LIGHT _____

Lettuce

DARK _____

LIGHT _____

HOW DOES YOUR GARDEN GROW?

ACTIVITY #3: Germination: Depth, Warmth, Size

TIME: 50 Minutes initially - one week to observe

OBJECTIVE: Students will determine how temperature, soil depth, and seed size affect the rate of germination.

TEACHER BACKGROUND INFORMATION: Several factors affect seed germinations, most notably temperature, amount of oxygen, and amount of water.

Temperature: When you read the planting directions on seed packets, you will find information on when to plant such as "Sow as soon as the ground can be worked.", "Plant after all danger of frost is past.", "Plant after all danger of frost is past and the soil has become thoroughly warm."

The seeds that can be sown in cold or cool soil and grow best in cool weather are called the cool weather crops. Those that need warm soil for germination and many days of summer heat are called warm-weather crops.

Tests have determined the range of temperatures at which each kind of seed will germinate. See the chart at the end of the teacher procedure.

Depth: The amount of oxygen in the soil depends upon the structure of the soil and the amount of water in the soil. When water moves through the soil it drives air out by filling the air spaces between soil particles. As water drains through, air carrying oxygen moves from the soil surface into the soil. The deeper the depth, the less oxygen that is present

MATERIALS (per group of 2):

- 5 pea seeds
- 1 condiment cup
- One 10 oz. clear plastic cup
- 2 baggies
- Soil
- 9 red bean seeds
- 2 tomato seeds
- 2 radish seeds
- 2 lima bean seeds
- 3 corn seeds

TEACHER/STUDENT PROVIDED MATERIALS:

- 1 metric ruler
- Paper towels
- Student Activity Sheet 3

PROCEDURE:

Part I - Temperature and Germination

1. Have students put a damp paper towel in each baggie. They should place 3 pea seeds in one bag and 3 corn seeds in the other bag.
2. The baggies should be sealed tightly and labeled as either corn or pea.
3. Baggies will be placed in either a refrigerator, at room temperature or near a heat source. Assign students to a particular location so that there are the same number of baggies of peas and corn at each location. Students will observe everyone's baggies when recording their results. The seeds should be observed for 5 days.
4. Students should complete Part I of Student Activity Sheet 3.

HOW DOES YOUR GARDEN GROW?

Part II - Soil Depth

1. Students should fill the 10 oz. plastic cup with about 2 em of soil. They will need to use their rulers to measure this.
2. They should press the soil and place 3 red bean seeds on the soil so that they are visible through the side of the cup.
3. They will then add another 2 cm of soil to the cup, press the soil, and add 3 more bean seeds. They should repeat the process so that they have 3 layers of beans. The top layer should also be covered with 2 cm of soil.
4. The soil should be moist but not soaking. Have students place the cup in a dark, warm location.
5. Students should check after a few days to see which layer sprouted best. Remind them to keep the soil moist.
6. Students should complete Part II of Student Activity Sheet 3.

Part lll - Seed Size and Germination

1. Have students label a plastic condiment cup on the outside with the following: radish, tomato, pea, lima bean.
2. They should line the cup with a damp paper towel as before, and fill the center with more damp paper towels. Two of each seed type should be placed between the wall of the cup and the paper towel. Be sure the students place the correct seed by the correct label. The same rule about the water applies in this case - damp but not soaking.
3. The cups should be set in a warm, dark place and observed daily for 8 days (or until all the seeds sprout). Students should record their results on their sheet.
4. Have students figure the percentage of seed germination.

   $\frac{\text{\# germinated seeds}}{\text{\# total seeds}} \times 100 = \%\ \text{germinated}$

FORMATIVE EVALUATION: Students will be evaluated on the completion of Student Activity Sheet 3.

HOW DOES YOUR GARDEN GROW?

GERMINATION TEMPERATURE FOR PLANTS

CROP	MINIMUM TEMP. F.	OPTIMUM TEMP. F.	MAXIMUM TEMP. F.
Bean	60	80	85
Beet, cabbage, carrot, cauliflower, radish, turnip	40	85	95
Corn	50	95	105
Cucumbers, eggplant, melons, okra, pepper, pumpkin, squash	60	90	100
Lettuce, onion, parsley, peas, spinach	35	75	85
Soybeans	40	50-86	95
Tomato	50	85	95
Wheat	35	60	104

HOW DOES YOUR GARDEN GROW?

Name _____

Activity #3: Germination: Depth, Warmth, Size

MATERIALS per group of 2: 5 pea seeds, 9 red bean seeds, 1 condiment cup, 2 tomato seeds, 2 radish seeds, 2 lima bean seeds, 3 corn seeds, one 10 oz. clear plastic cup, 2 baggies, soil, 1 metric ruler, paper towels

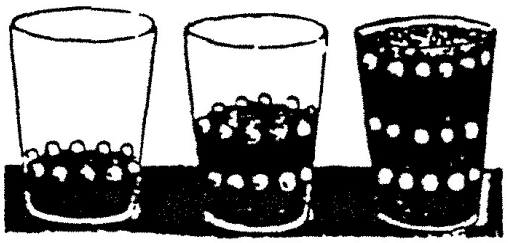
PROCEDURE:

Part I - Temperature and Germination

1. Take two damp paper towels per group.
2. Place 1 towel in one baggie and the other towel in another baggie. Place 3 pea seeds on one towel and 3 corn seeds on the other towel.
3. Press out the air and seal the baggie.
4. Label the baggie as either corn or pea.
5. Place your baggies where your teacher has you do so.
6. Baggies will be placed in either a refrigerator, room temperature, or near a heat source.
7. You will observe all the bags daily for 5 days and record your data on Part I of Student activity Sheet 3.

Part II - Soil Depth

1. Fill a 10 oz. plastic cup with about 2 em of soil. You will have to use your metric ruler to measure the depth.
2. Press the soil down and place 3 bean seeds on the soil so that they are visible through the side of the cup.
3. Add another 2 cm of soil to the same cup and add 3 more bean seeds.
4. Repeat Step 3. Then add 2 cm of soil so that the top layer is covered.



5. Moisten the soil with water, but don't add too much. Pour off any extra water. Remember, too much water will cause the beans to rot.
6. Place the cup in a dark, warm location.
7. After a few days, check to see which layer sprouted best. Be sure to keep the soil damp during the experiment, but not too wet.
8. Fill in the graph and answer the questions on the student worksheet.

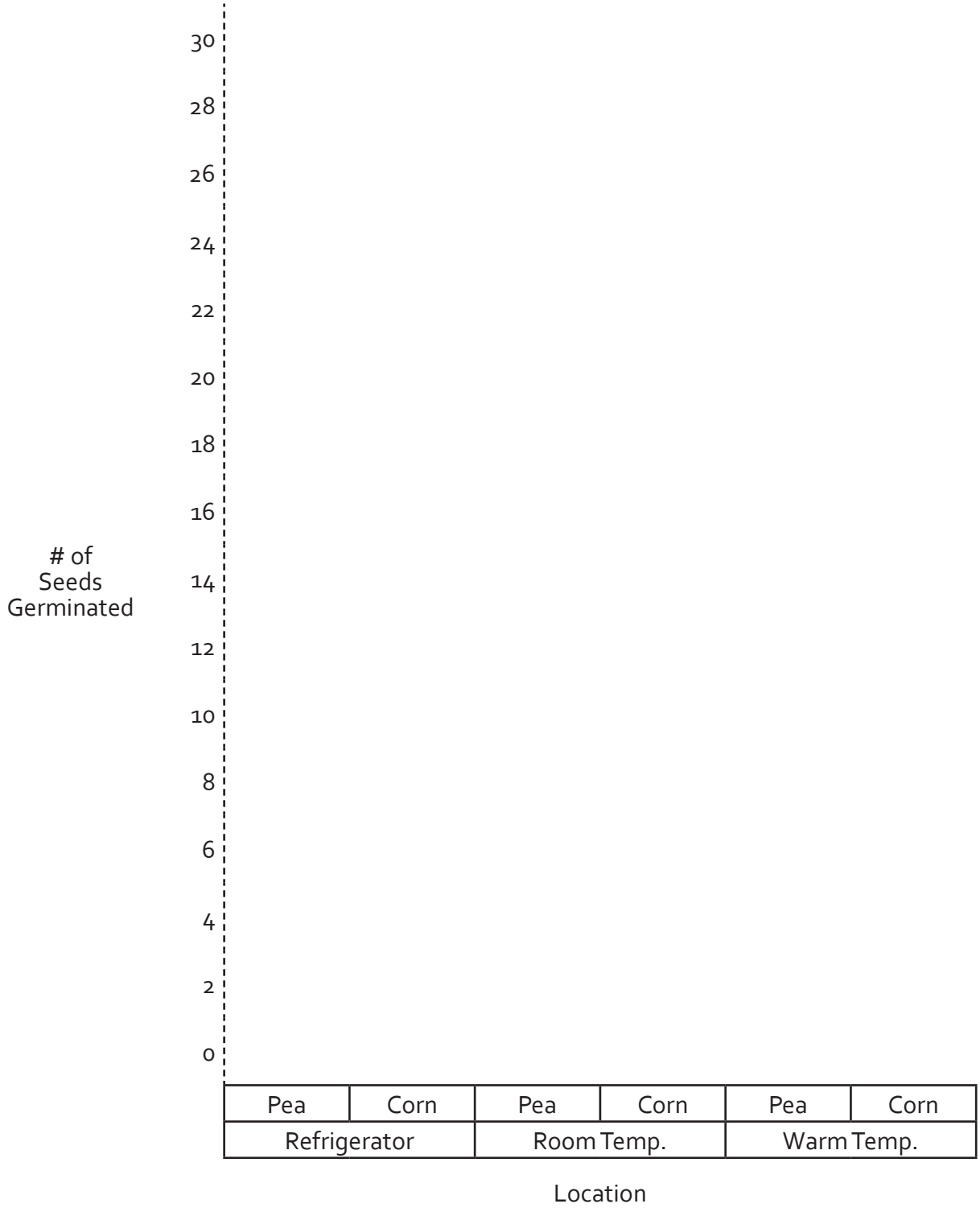
Part III - Seed Size and Germination

1. Label a plastic cup on the outside with the following: radish, tomato, pea, lima bean.
2. Line the cup with a damp paper towel and fill the center with more damp paper towels.
3. Place the seeds in the appropriate place in the cup to correspond with their labels. Make sure the seeds are between the wall of the cup and the paper towel.
4. Dampen the soil.
5. Place the cups in a dark warm place.
6. Observe daily for 8 days or until all the seeds sprout. Record the results on Part III of Student Activity Sheet 3.

HOW DOES YOUR GARDEN GROW?

Part I - Temperature and Germination

The Effect of Temperature on the Germination of Pea and Corn Seeds



HOW DOES YOUR GARDEN GROW?

Questions:

1. In which location did the peas germinate best?

2. In which location did the corn germinate best?

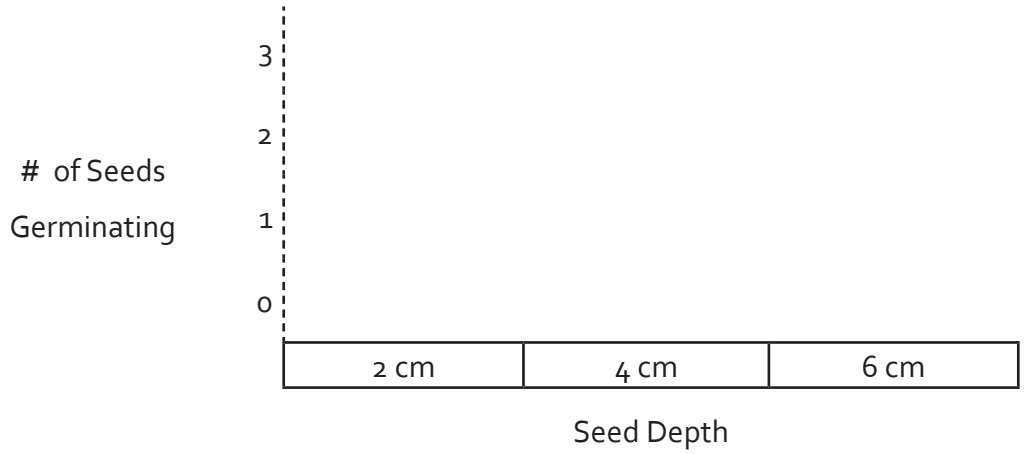
3. Which seed represents a cold-weather crop?

4. Which seed represents a warm-weather crop?

HOW DOES YOUR GARDEN GROW?

Part II - Soil Depth and Germination

The Effect of Seed Depth on the Germination of Pea and Corn Seeds



Questions:

1. In which location did the beans germinate best?

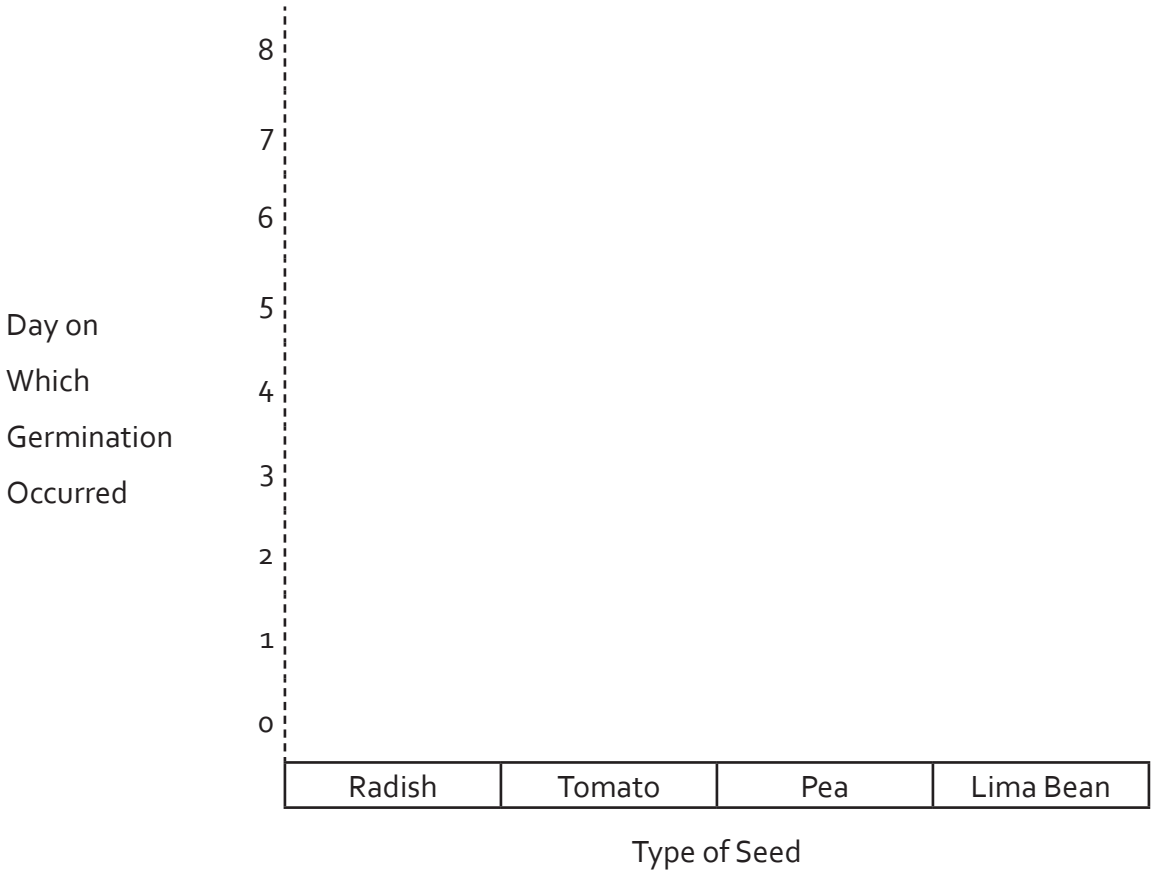
2. What factor prevented good germination at the deeper depths?

3. If there was a successful germination at a deeper depth (6 cm), what could have caused the germination?

HOW DOES YOUR GARDEN GROW?

Part III - Seed Size and Germination

The Effect of Seed Size on the Rate of Germination in Radish, Tomato, Pea, and Lima Bean Seed



ACTIVITY #4: Soil Chemistry

TIME: 2, 40-50 Minute Sessions

OBJECTIVE: Students will understand how a pH scale works. Students will recognize that soils have different chemistries by testing soil samples for their pH.

TEACHER BACKGROUND INFORMATION: All soils fall into one of three categories: acidic, neutral, or alkaline. Soils that give acid reactions are called "sour" soils. Soils that give alkaline reactions are called "sweet" soils.

Students are familiar with many substances classified in these three categories. For example, orange juice, vinegar, and lemon juice give acid reactions. Baking soda, milk of magnesia, and ammonia give alkaline reactions.

In the same way the temperature scale was set up so that we may read temperatures, a scale has been set up to read the degree of acidity and alkalinity. The scale was created with 0.0 being a very acidic reading and 14.0 being a very alkaline reading. The midpoint, 7.0, represents the neutral point.

A special name was given to this acid and base (alkaline) scale. It is called a "pH" scale. It is always written with a small "p" and a capital "H".

A "pH" scale is used to express the acid alkaline nature of water, blood, paper, food products, laundry solution, metal plating baths, and many other liquids, gases, and solids, including soil.

Soil pH affects the availability of the nutrients plants need for efficient growth. Soils in the 6.0 and to 8.0 pH range are generally satisfactory except for acid-loving plants. The pH value of a soil sample indicates the "chemical climate" of the soil.

The soil samples to be tested can be brought in by either you or the students. In either case, the area to be sampled should be cleared of debris (leaves, twigs, and so on). About 4 good-size scoops of soil should be sufficient. The sample should not be touched with bare hands! Use a trowel or shovel to place the soil into a labeled bag indicating the location from which it was taken. It is not necessary for all groups to use the same soil samples.

Distilled water has a neutral pH.

MATERIALS (10 Groups of 3 students):

- 3 ziploc bags
- 4 plastic vials with lids
- 1 funnel
- 3 pieces of filter paper
- 4 small strips pH indicator paper
- 4 medicine cups
- Masking tape to label vials

TEACHER/STUDENT PROVIDED MATERIALS:

- 3 soil samples from different locations
- Plastic spoons for each soil sample
- Paper towels
- Student Activity Sheet 4
- 1 gallon of distilled water

HOW DOES YOUR GARDEN GROW?

PROCEDURE:

Part I

1. Obtain soil samples as explained in the teacher information above.
2. Label a container for each soil sample and place a plastic spoon in each. The spoons should not be transferred from one sample to another. Students should label 3 of their plastic vials with masking tape to correspond to the soil samples they are testing. (You may wish to have done this in advance.) Two spoonfuls of each sample should be sufficient for testing.
3. Have students add enough distilled water to completely cover the soil, cap the vial, and shake well for 15 seconds.
4. After the soil has settled (about 1 minute), students should filter the liquid into a medicine cup. To do this, the filter paper is folded in half to make a half circle, and then again to make a curved triangle. Open the paper so that one side has 3 thicknesses and one side has 1 thickness. It will resemble a cone cup.
5. The filter paper should be placed in a funnel and wet with distilled water. (It is suggested that you demonstrate the folding and preparation of filter paper.) The funnel should be placed in a medicine cup. Pour enough liquid from the vial to half fill the funnel. Allow 20 mL of liquid to filter into the medicine cup. There are markings in mL on the medicine cups.
6. The filter paper should be discarded, and new pieces used for the remaining soil samples. The funnel should be rinsed between uses with a small amount of distilled water.

Part II

1. Students will now test the pH of their samples. But first, 20 mL of distilled water should be added to one of the medicine cups. It will serve as a control - a test group to which nothing has been done.
2. Each sample will be tested by dipping the pH paper in the medicine cups. By comparing the color of the paper to the chart that comes with the roll of pH tape, students can determine if the sample is acidic, alkaline, or neutral.
3. Have students complete Student Activity Sheet 4.
4. A natural extension would be to try growing seeds in any of the soil samples tested.

FORMATIVE EVALUATION: Students will be evaluated on the completion of Student Activity Sheet 4.

HOW DOES YOUR GARDEN GROW?

NAME _____

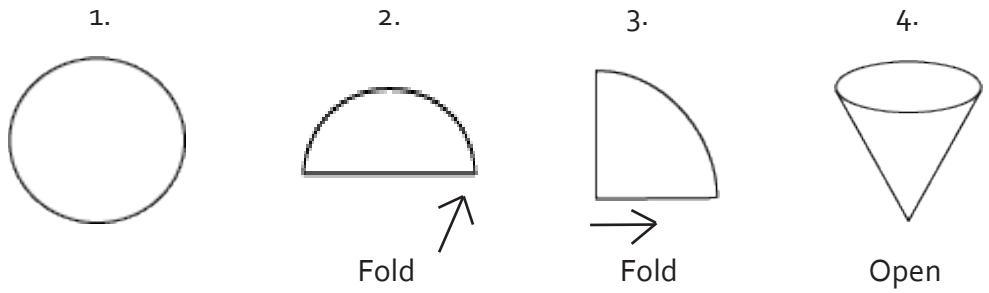
ACTIVITY #4: SOIL CHEMISTRY

MATERIALS per group of 3: 3 ziploc bags, paper towels, 4 plastic vials with lids, 1 funnel, 3 pieces of filter paper, 4 small strips pH indicator paper, 4 medicine cups, 3 soil samples, stilled water, masking tape

PROCEDURE:

Part I

1. Use masking tape to label your vials and medicine cups so they match each soil sample. The fourth vial and medicine cup should be labeled "Distilled Water". Add 2 spoonfuls of each soil sample to the matching vial. Be careful not to touch the soil samples or mix up the spoons that belong in each container of soil.
2. Add enough distilled water to cover the soil completely. Cap the vial and shake well (15 seconds).
3. Allow the soil to settle for 1 minute.
4. Fold a circle of filter paper in half to make a half circle, then fold it in half again to make a rounded triangle. .
5. Open the filter paper like a cone cup, so that one side is made of 3 thicknesses of filter paper and the other side is made of 1 thickness.



6. Place the filter paper in the funnel and wet the paper with distilled water. Only a little bit of water is necessary.
7. Put the funnel in the medicine cup that matches the soil sample.
8. Pour enough liquid from the vial to half fill the funnel.
9. Allow 20 mL of liquid to filter into the medicine cup.
10. Discard the filter paper. Rinse the funnel with a little bit of distilled water.
11. Repeat steps 2-11 for the other 2 soil samples.

HOW DOES YOUR GARDEN GROW?

Part II

1. Add 20 mL of distilled water to the medicine cup labeled "Distilled Water".
2. You are now ready to test your soil samples and the distilled water to determine the pH.
3. Dip the end of the pH paper into the first sample. Record the color of the paper on the sheet and then compare the strip to the color chart your teacher has.
4. Test the remaining samples using a new strip of pH paper each time. Complete the worksheet.

<u>Soil Reaction</u>

Distilled Water Sample

Color _____ pH _____

Soil Sample 1

Location _____

Color _____ pH _____

Soil Sample 2

Location _____

Color _____ pH _____

Soil Sample 3

Location _____

Color _____ pH _____

HOW DOES YOUR GARDEN GROW?

Questions

1. Why do you think the distilled water was used rather than tap water? (Test some tap water with a strip of pH paper to find out.)

2. What role does the distilled water test sample play in this activity?

3. Which soil samples have a pH value that falls into the:

   A. Acid pH range? _____

   B. Neutral pH range? _____

   C. Alkaline pH range? _____

4. If you had soil samples that had similar pH values, can you think of a reason why this happened?

5. Can you explain differences in pH values of your soil samples?

HOW DOES YOUR GARDEN GROW?

ACTIVITY #5: Smart Beans - Phototropism and Geotropism

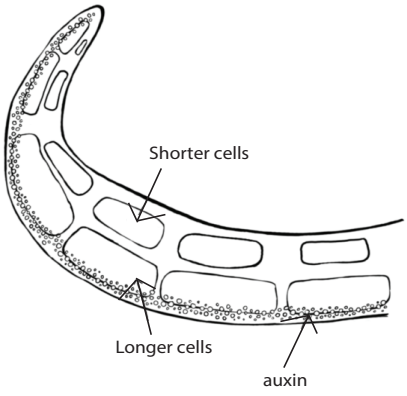
TIME: 40 Minutes to prepare; 1 week to observe

OBJECTIVE: The student will be able to demonstrate the concepts of geotropism and phototropism.

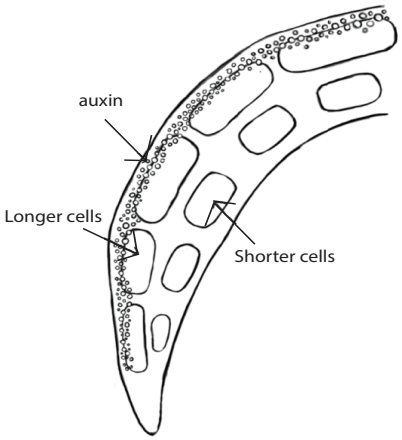
TEACHER BACKGROUND INFORMATION: Plant stems always grow toward light. This is called phototropism. When one part of a plant is exposed to light, it causes the plant growth hormone, auxin, to move to the part of the plant receiving a lesser amount of light. The auxin stimulates plant growth here, causing the cells to elongate so the stem leans toward the light

Plants respond to gravity in the phenomenon known called geotropism. In a plant that has been laid on its side (or in an emerging seedling), auxin accumulates on the bottom side of a plant's root. Instead of causing elongation though, it inhibits cell growth on the lower side so that the upper side grows faster. The uneven growth causes the root to grow downward. (Think of a bendable straw being pulled downward. The inner curve is shorter than the outer curve.)

In a plant that has been laid on its side (or in an emerging seedling), auxin will again accumulate on the lower side. In the stem, though, it causes elongation on the lower side so that the stem will grow upward. (Again, think of a bendable straw being pulled upward. The outer curve is longer than the inner curve.



Example of geotropism in stem



Example of geotropism in root

This activity requires one young bean plant for each group. These should be planted by the students 4-5 days in advance. Enough medicine cups, soil, and bean seeds have been provided.

MATERIALS (per group of 3):
- 1 small bean plant
- 1 petri dish
- 1 piece of filter paper
- Masking tape
- 3 bean seeds

TEACHER PROVIDED MATERIAL:
- Shallow plastic pan with water in which to place petri dishes
- Student Activity Sheet 5

HOW DOES YOUR GARDEN GROW?

PROCEDURE:

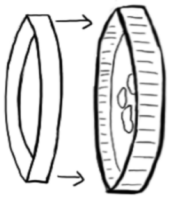
Part I - Phototropism

Have students place their young bean plant so that it faces a sunny window. After several days, half of the students should turn their plant around. They should record what happens on Part I of Student Activity

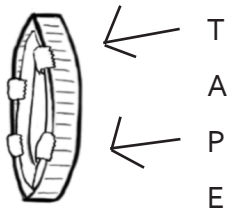
Part II - Geotropism

1. Have students cut a piece of filter paper to fit the lid of a petri dish (the lid is the larger of the two pieces). This should be placed in the lid and moistened with water.
2. Three bean seeds should be placed on the paper, and the bottom of the petridish placed inside the lid so that it holds the beans against the paper.

Lid



Base Lid



3. The top and bottom of the dish should be taped tightly together with masking tape. The dishes should be placed upright in a shallow pan with water. Have students check periodically to be sure the paper is still moist
4. When the roots and sprouts are 2 cm long, students should rotate the dish and observe what happens over the next few days. This information should be recorded on Part ll of Student Activity Sheet 5.

Phototropism Extension: Have students bring in a shoebox with a lid. Make dividers for the box. Students should cut holes in the dividers to form a path from a corner on one end to the corner on the opposite end. One hole should be cut in the outside of the box at the end of the "maze". Because only the end hole will allow light in, the plant will make its way through the holes in search of light

The young bean plant should be placed as far away from the exit hole as possible. The box should be tightly covered with a lid so no light is allowed to enter. The box should be placed so that the exit hole faces a sunny window.

Have students open the box every few days to water the plant and chart its progress.

FORMATIVE EVALUATION: Students will be evaluated on the completion of Student Activity Sheet 5.

HOW DOES YOUR GARDEN GROW?

NAME _____

PHOTOTROPISM AND GEOTROPISM

MATERIALS per group of 3: 1 small bean plant, 1 petri dish, 1 piece of filter paper, masking tape, 3 bean seeds

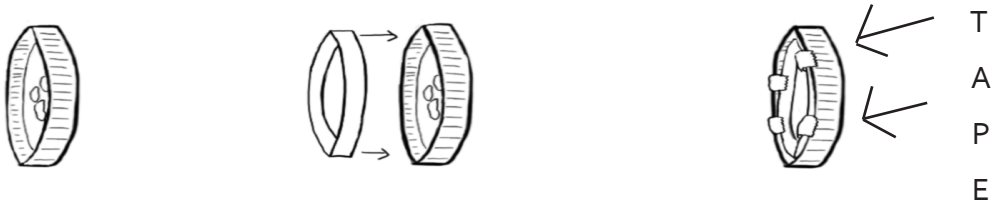
PROCEDURE:

Part I - Phototropism

1. Place your bean plant so that it faces a sunny window.
2. After a few days, record which direction the stem has turned.
3. If your teacher instructs you to do so, turn your plant again. Record which direction the stem has turned. All information should be recorded on Part I of Student Activity Sheet 5.

Part II - Geotropism

1. Cut a piece of filter paper to fit the lid of a petri dish (the lid is the larger of the two pieces). The paper should be placed in the lid and moistened with water.
2. Place 3 bean seeds on the paper and put the bottom of the petri dish inside the lid so that it presses against the beans and holds them in place.



Lid Base Lid

3. The top and bottom of the dish should be taped tightly together with masking tape. A short piece at the top and at the sides near the bottom should be enough.
4. Write your initials on the masking tape and place the dish upright in a shallow pan with water. Check periodically to be sure the paper is still moist.
5. When the roots and sprouts are 2 cm long, rotate the dish and observe what happens over the next few days.

HOW DOES YOUR GARDEN GROW?

Part I - Phototropism

1. Draw a picture that shows how your plant responded when placed in the sunny window. Draw the window.

   Some plants were turned. Draw a picture that shows how the plants looked immediately after being turned. Draw the window.

   Draw a picture of these same plants a few days later. Draw the window.

2. Plants grow (toward, away from) light.

Part II - Geotropism

1. Describe the directions the roots and stems grew before you rotated the petri dish.

2. Which direction were the roots and stems immediately after you rotated the dish?

3. Which directions were the roots and stems a few days later?

ACTIVITY #6: Photosynthesis: Let's Get Together With Light

TIME: One 30 minute period, one 10 minute period a week later

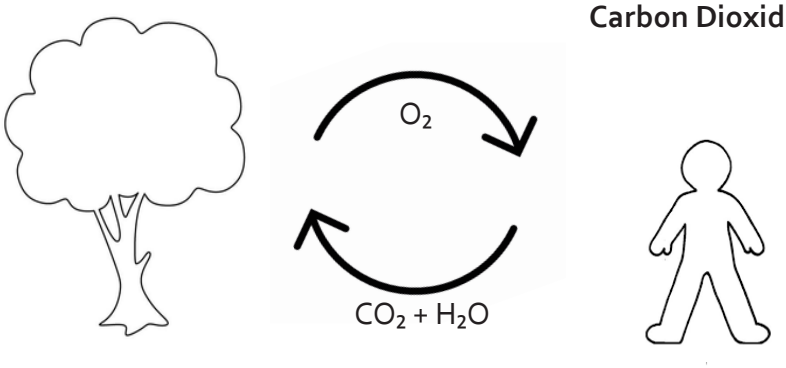
OBJECTIVE: The students will be able to describe the process of photosynthesis and tell how it affects their lives. The students will observe what happens to plants when sunlight is withheld.

TEACHER BACKGROUND INFORMATION: Photosynthesis is a food-making process that occurs in green plants. It is the chief function of leaves. Food energy originally comes from light and is stored in food made by green plants.

The light used in photosynthesis is absorbed by a green pigment called chlorophyll. In plant cells, chlorophyll is contained in bodies called chloroplasts. In chloroplasts, light causes carbon dioxide to combine with hydrogen atoms of water to form sugar. Oxygen is given off in the process. From sugar, and with nitrogen, sulfur, and phosphorus, green plants make starch, fat, protein, and vitamins.

Green plants convert carbon dioxide (CO_2) and water (H_2O) into food ($C_6H_{12}O_6$) and oxygen (O_2). Human beings and animals get energy by eating food and using oxygen in the air to "burn" food. In the process, carbon dioxide and water are returned to the atmosphere. Thus, the carbon dioxide and oxygen balance on earth is maintained.

Carbon Dioxide - Oxygen Cycle



This experiment will be set up by the teacher and observed by the whole class.

MATERIALS:
Iodine

TEACHER PROVIDED MATERIALS:
Black construction paper
Stapler
Paper towels
Optional: board

PROCEDURE:

1. Go outside and point to a plant and ask the students why the leaves are green. Examine several other plants including trees if available. Tell students that it is chlorophyll which makes the plants green. Lead a discussion about the process of photosynthesis (background information). Discuss the effects of the photosynthetic process on the students' lives. Have students describe a world in which the plants are being removed rapidly. Compare this with the rapid cutting down of the rain forests. Discuss the overall global effect. (Disruption of food chain, imbalance in the ratio of carbon dioxide and oxygen.)

2. Experiment - find a tree with low branches and wrap black paper around a leaf so that it is partially covered. Secure the paper with staples. Do this to two other leaves. This will block out the sunlight but allow the leaf to remain alive. Return to the leaves after seven days and examine them. The leaves will be yellowish because there was no sunlight for the chlorophyll to absorb and turn the leaf green.

   As an additional demonstration, lay a board down on some nicely growing grass. Return to the spot after seven days and examine it. The growth will have stopped and the grass will be yellowish.

3. Test for the presence of starch. Remove the covered leaves from the tree and take them back to your classroom. Place your leaf on a paper towel or in a petri dish and add several drop of iodine to the covered and uncovered parts of the leaf. The iodine leaf will tum purplish-black to indicate the presence of starch.

FORMATIVE EVALUATION: In essay form the students will write a paragraph on how plants affect their lives.

HOW DOES YOUR GARDEN GROW?

ACTIVITY #7: Water Transport in Plants

TIME: 30 Minutes to set up, 1 day to observe. Should be started first thing in the morning.

OBJECTIVE: The students will be able to observe the transport of water and other solutions through the xylem tubes of plants.

TEACHER BACKGROUND INFORMATION: All cells must be fed, given water and receive oxygen for energy. The classic experiment for demonstrating transport is using colored water and a stalk of celery. We will expand on that experiment and see if celery will not only transport water, but also substances we can taste, such as sugar and salt. Xylem tubes are tiny tubes which transport water throughout a plant. Phloem tubes transport food throughout a plant.

The celery should be freshly cut before class.

MATERIALS (per group of 3):

4 ten oz. plastic cups
Food coloring
60 mL of sugar
Hand lens
Masking tape
Medicine cup
Tap water
60 mL of salt
Plastic spoon

TEACHER/STUDENT PROVIDED MATERIALS:

4 stalks of celery with leaves - try to make them of similar size and age
Student Activity Sheet 7
Knife or razor blade
Metric ruler

PROCEDURE:

1. Have students examine a piece of celery to observe the outer covering with an interior containing scattered, hollow tubes. These are xylem cells.
2. They should label 4 cups- #1, #2, #3, #4- with masking tape and use the medicine cups to measure 150 mL of water in each
3. To the correct cup the following should be added:

   Cup #1- 10 drops of food coloring.

   Cup #2 - nothing.

   Cup #3 - 60 mL of salt.

   Cup #4 - 60 mL of sugar.
4. Have students stir each cup 50 times with a spoon. Remind them to be sure to rinse the spoon before changing cups.
5. Students should place a freshly cut stalk of celery in each cup and record their observations of the height the food coloring moved after 3 hours, 6 hours, and overnight.
6. After 24 hours, students should cut a piece of celery above the solution line from stalks #2, #3 and #4. Their partners should taste it (without knowing where it came from) and see if they can identify it as sugar, salt, or plain. Remind them never to taste anything without the permission of the teacher. They should record their results in graph form on Student Activity Sheet 7.

FORMATIVE EVALUATION: Students will be evaluated on the completion of Student Activity Sheet 7.

HOW DOES YOUR GARDEN GROW?

Name _____

Activity #7: Water Transport in Plants

MATERIALS per group of 3: 4 ten oz. plastic cups, food coloring, tap water, 60 mL of sugar, 60 mL of salt, hand lens, plastic spoon, 4 stalks of celery with leaves, metric ruler, masking tape, 1 medicine cup

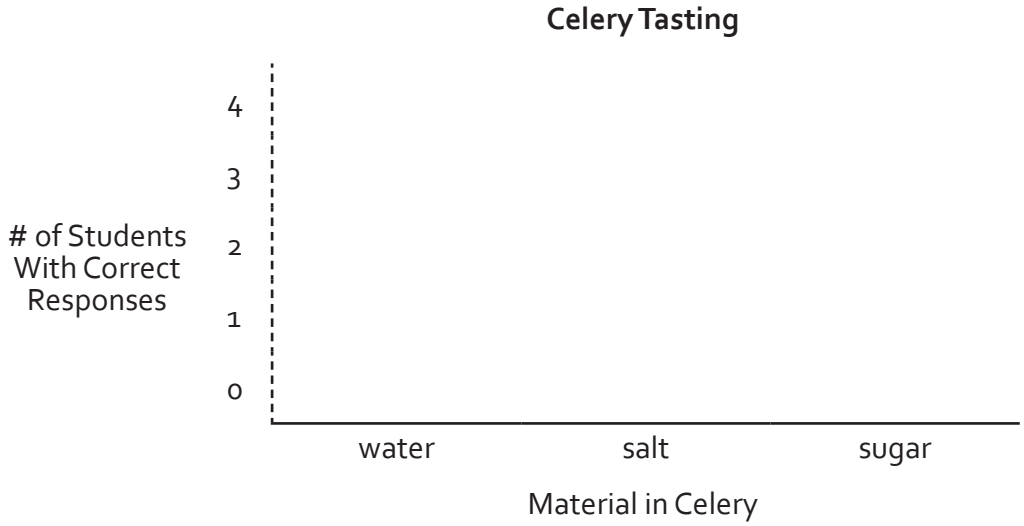
PROCEDURE:

1. Examine a piece of celery.
2. Use a hand lens to observe the outer covering with an interior of scattered, hollow tubes. These are the xylem cells.
3. Label 4 cups- #1, #2, #3, #4- with masking tape.
4. Use the medicine cup to measure 150 mL of water into each of the 4 cups.
5. In cup #1, add 10 drops of food coloring.
6. In cup #2, add nothing.
7. In cup #3, add 60 mL of salt (use the medicine-cup to measure the salt but dry it out first!)
8. In cup #4, add 60 mL of sugar.
9. Stir each cup 50 times with a plastic spoon. Be sure to rinse the spoon before changing cups.
10. Place one stalk of celery in each cup.
11. Use a metric ruler to record the height of the food coloring after 3 hours, 6 hours, and overnight. Record your observations on Student Activity Sheet 7.
12. After 24 hours, remove stalks #2, #3, and #4. Cut a piece from the celery above the solution line in the cup and taste it. Caution! Never taste anything without the permission of your teacher!
13. Without allowing your lab partners to see which sample they are tasting, have each one taste a sample to see if they can tell what they are tasting. Record your results in graph form on Student Activity Sheet 7.

HOW DOES YOUR GARDEN GROW?

NAME _____

TIME	HEIGHT OF COLORING
1 Hour	
3 Hour	
6 Hour	
24 Hour	



HOW DOES YOUR GARDEN GROW?

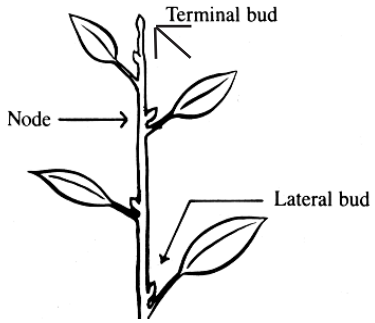
ACTIVITY #8: Effects of Nutrients and Hormones on Plants

TIME: 30 Minutes to prepare, 1-2 weeks to observe

OBJECTIVE: Students will observe how plant hormones and commercial fertilizers affect plant growth. Students will graph the growth of experimental and control groups of plants.

TEACHER BACKGROUND INFORMATION: Auxin is a hormone produced by plants. Auxin has the power to determine if a leaf should fall or hold or if a fruit should drop or hold. Auxin causes leaves to move to face the sun and calls the signals on cell enlargement in stem, bud, roots and leaves. Auxin determines the direction of growth and governs the development of buds and flowers. The production of auxin is in the growing region of plants - the tips of stems and the youngest leaves of all branches.

In this experiment, students will explore the effect of auxin on plant growth at the root and stem. It is necessary to remove the terminal bud on 2 of the plants. This is the bud at the very tip of the stem. This activity requires 4 young bean plants per group.



MATERIALS per group of three:

- 4 young bean plants
- 2 plastic vials
- Rooting powder (commercial auxin)
- Fertilome plant food
- Medicine cup

TEACHER/STUDENT PROVIDED MATERIALS:

- Scissors
- Metric rulers
- Student Activity Sheet 8
- Distilled water

PROCEDURE:

Part I - Hormones and Stem Growth

1. Have students remove the terminal bud from 2 of the bean plants. (This is the bud at the very top of the stem). Apply a small amount of rooting powder to the cut stump on one of the bean plants. Avoid sticking plant into the powder because the powder will clump to ether and be worthless. Take some powder out of the container. The other plant will serve as the control plant - the plant to which nothing has been done.
2. All other variables should be kept the same for both plants. This means keeping them in the same light, watering them with the same amount of water, and so on.
3. Students should record their results on Student Activity Sheet 8.

HOW DOES YOUR GARDEN GROW?

Part II - Hormones and Root Growth

1. Have students take 4 leaf cuttings (2 from each plant) from the remaining bean plants and dip two of the stems into rooting powder. Again, the rooting powder should be taken out and placed on a paper towel, etc. and the students should dip the cutting into it. Do not put the cutting directly into the container of rooting powder.
2. The 2 treated leaves should be placed in a plastic vial with 10 mL of distilled water in the bottom. Again, use medicine cups to measure. The 2 untreated leaves should be placed in vials with distilled water only. These are the control cuttings - leaves to which nothing has been done.
3. After 5 days, students should count the number of roots formed in each vial and record this on Student Activity Sheet 8.

Part III - Fertilizer (Nutrients) and Plant Growth

1. Mix a tablespoon of fertilome to a quart of water. Students will water one of their plants with this mixture and the other one will be given plain water. This last bean plant will serve as a control because it is left alone. All other variables should be kept the same. This means both plants should receive the same amount of water, light, and so on. Both plants should be watered whenever the soil is dry, using the appropriate type of water.
2. Have students measure the height of both plants before starting and record this on Student Activity Sheet 8. The height of the plant should be measured at the end of the experiment and the amount of growth recorded. Students should also count the number of leaves on both plants before starting. The number of leaves should be counted at the end of the experiment and recorded on the worksheet.

FORMATIVE EVALUATION: Students will be evaluated on the completion of Student Activity Sheet 8.

HOW DOES YOUR GARDEN GROW?

NAME _____

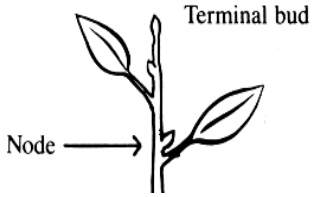
ACTIVITY #8: EFFECTS OF NUTRIENTS AND HORMONES ON PLANTS

MATERIALS per group of 3: 4 young bean plants, 2 plastic vials, rooting powder (commercial auxin), Fertilome plant food, scissors, metric rulers, distilled water, medicine cup

PROCEDURE:

Part I: Hormones and Stem Growth

1. Remove the terminal bud from 2 of the bean plants. (This is the bud at the very top of the stem).



2. Apply rooting powder to the cut stump on one of the bean plants. The other plant will have no rooting applied to it.
3. All other variables should be kept the same for both plants. This means keeping them in the same light, watering them with the same amount of water, and so on.
4. Record your results on Student Activity Sheet 8.

Part II: Hormones and Root Growth

1. Cut 4 leaves as close to the stem as possible from the 2 remaining bean plants.
2. Dip two of the stems of the leaves in rooting powder.
3. The 2 treated leaves should be placed in a plastic vial with 10 mL of distilled water in the bottom. Use the medicine cup to measure the water.
4. The 2 untreated leaves should be placed in vials with 10 mL distilled water only.
5. After 5 days, count the number of roots formed in each vial and record this on Student Activity Sheet 8.

Part III: Fertilizer (Nutrients) and Plant Growth

1. Add enough of the fertilizer-water mixture to dampen the soil of 1 of the 2 remaining bean plants. The other bean plant will be given plain water. All other variables should be kept the same. This means both plants should receive the same amount of water, light, and so on. When the plants need watering, use either the plain or fertilizer water.
2. Measure the height of both plants from soil level to the plant tip and record this on Student Activity Sheet 8.
3. Count the number of leaves on both plants and record this information also.
4. Measure the height of the plants at the end of the experiment Record this on the sheet. Count the number of leaves at the end of the experiment and record this also.
5. Subtract the numbers to see the amount of growth for each plant, and the number of leaves for each plant. These numbers are used to complete the graph on the worksheet.

HOW DOES YOUR GARDEN GROW?

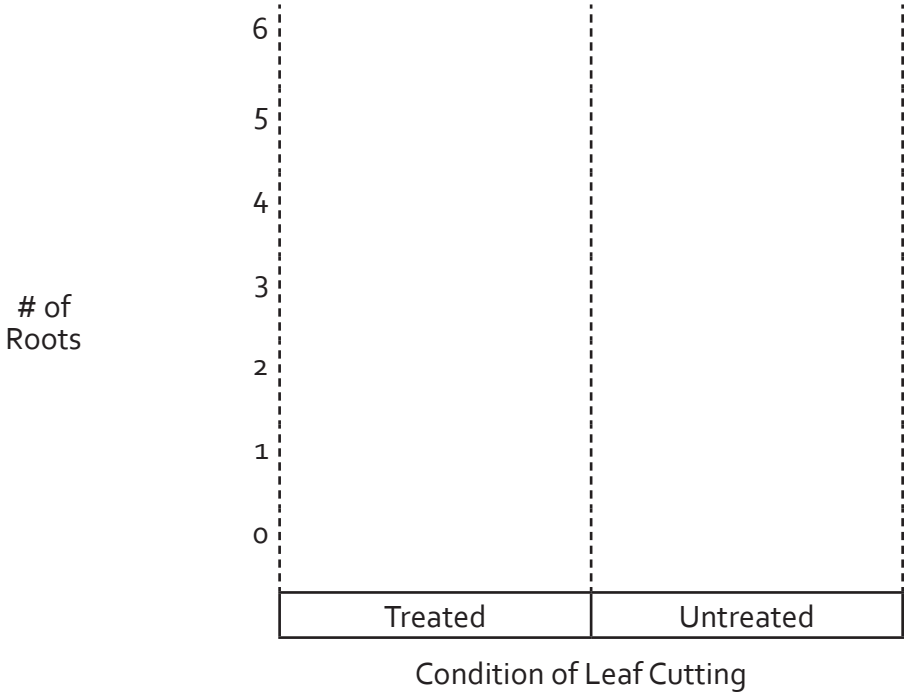
Part I - Hormones and Stem Growth

1. Why was no rooting powder applied to one of the plants?

2. What changes did you notice in the plant with the rotin powder applied to the tip as compared to the one without rooting powder?

Part II - Hormones and Root Growth

Root Growth in Auxin Treated and Untreated Plants

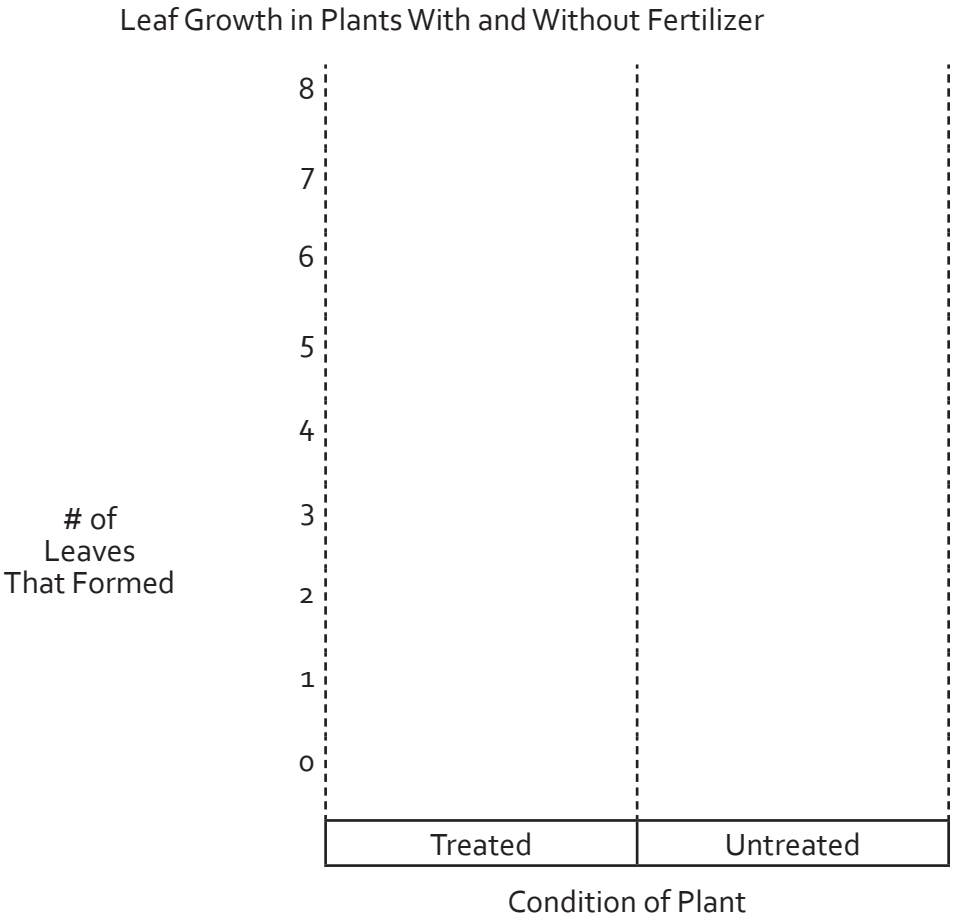


Question: Why was no rooting powder applied to two of the leaves?

HOW DOES YOUR GARDEN GROW?

Part III - Fertilizer (Nutrients) and Plant Growth

Graph the number of leaves that formed for each plant.



Number of Leaves on Treat Plant Before _____

Number of Leaves on Treated Plant After _____

_____ (After) -- _____ (Before) = _____ # of Leaves That Formed

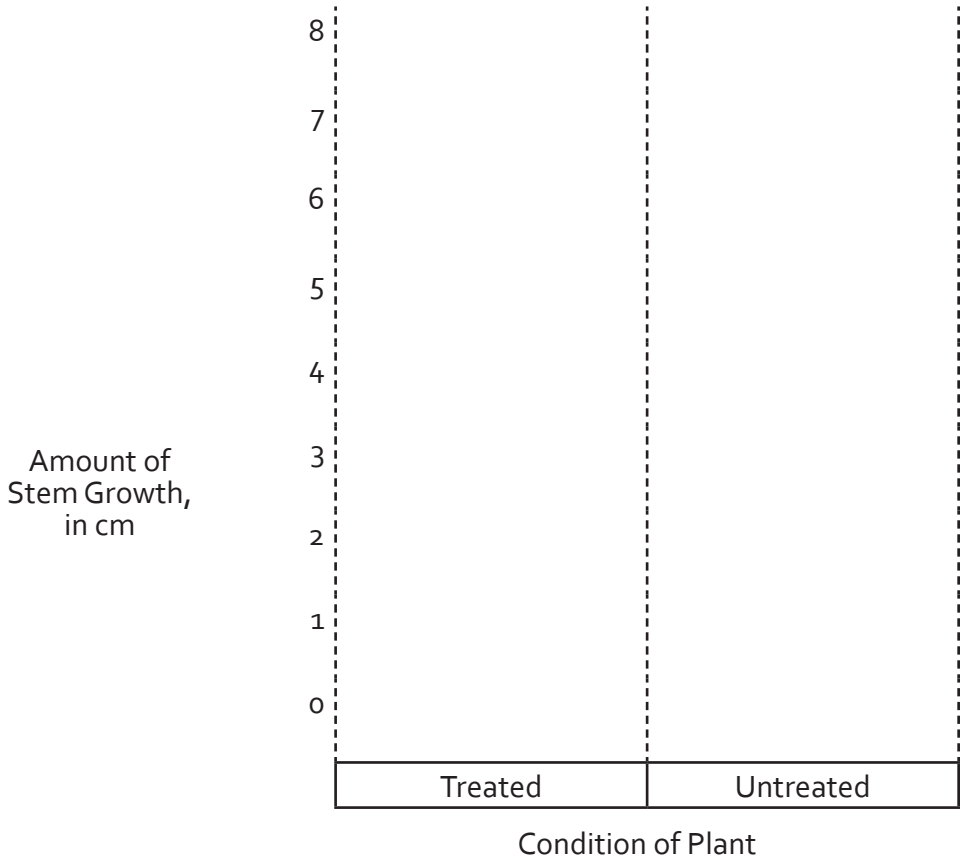
Number of Leaves on Untreated Plant Before _____

Number of Leaves on Untreated Plant After _____

_____ (After) -- _____ (Before) = _____ # of Leaves That Formed

HOW DOES YOUR GARDEN GROW?

Stem Growth in Plants With and Without Fertilizer



Height of Treated Plant Before _____ cm

Height of Treated Plant After _____ cm

_____ (After) -- _____ (Before) = _____ Amount of Stem Growth

Height of Untreated Plant Before _____ cm

Height of Untreated Plant After _____ cm

_____ (After) -- _____ (Before) = _____ Amount of Stem Growth

Question: Why were two plants given no fertilizer?

ACTIVITY #9: Plant Propagation

TIME: 40 Minutes to prepare, several weeks to observe

OBJECTIVE: Students will learn various methods for plant propagation.

TEACHER BACKGROUND INFORMATION: Propagation is the process by which a plant is increased in numbers. This may be done by seeds, cuttings, tubers, runners, and rhizomes.

Cuttings: Geraniums, coleus, begonia, English ivy, chrysanthemum, and wandering jew are plants whose cuttings root easily. Cuttings must be taken from the growing tip of the plant and should be 3" - 4" long. The lower leaves of the cutting are removed to about 1 1/2". Cuttings can then be inserted into a rooting media such as sand, vermiculite, or a sand and peat mixture. The media should be watered and the container enclosed in a plastic "tent" to keep the cuttings from drying out before they have a chance to root. A plastic baggie placed over the cutting and held with a rubberband works well.

Tubers: A tuber is a thickened underground stem used for food storage by the plant. A white potato with eyes will form stems when placed in water. Stick three toothpicks in the side of the potato about an inch from the top. Place the potato in a tall jar so the toothpicks rest on the rim. The jar should be filled with water so that the bottom of the potato is always in water. If the jar is placed in the light (not direct sunlight), the eyes will grow and turn green.

Runners: These are shoots that grow horizontally above the soil surface. New plants develop at the joints where the runner is in contact with the soil. Strawberry, ajuza, and spider plants have runners that can illustrate this. Cut off the forming plant at the end of the runner and place the root end into a growth medium such as a resealable bag of damp vermiculite or sand. Every so often, you need to check to make sure the medium is damp and the bag has not collapsed on the plant. Opening the bag and blowing will provide additional air. To guarantee greater success, leave the runner attached to the forming plant for a week or two after you have placed it in the growth medium. This is more difficult because you will need to watch the growth medium more carefully so it does not dry out. Once the plant has begun to grow on its own, you can plant it in a regular flower pot and maintain it like any other house plant.

Rhizomes: These are horizontal stems which grow below or at the soil surface. Several plants can be obtained from one rhizome by dividing it into sections, each with at least one bud. This should be placed in a baggie with damp vermiculite or sand and sealed. Every so often, you need to check to make sure the medium is damp and the bag has not collapsed on the plant Opening the bag and blowing will provide additional air. Examples of plants with rhizomes are iris, canna, and lily-of the-valley.

MATERIALS:

- 6 cups vermiculite
- 1 box rubberbands
- 10 condiment cups
- 10 baggies
- 1 box toothpicks

TEACHER PROVIDED MATERIALS: the plant parts mentioned in the teacher information, additional sand, and vermiculite

PROCEDURE:

1. Have the student groups pick one of the methods above they are interested in and for which they can supply the plant parts. A letter to parents explaining the activity follows on the next page.
2. Follow the directions in the teacher information for propagation.

HOW DOES YOUR GARDEN GROW?

Dear Parent:

We are beginning an activity on propagation of plants by various methods. If you have any of the plants or plant parts listed below that you would allow your child to bring to class, it would be greatly appreciated. As always, thank you for your support!

Sincerely,

Plants and Plant Parts

Cuttings: Geraniums, coleus, begonia, English ivy, chrysanthemum, and wandering jew

Tubers: White potato with eyes

Runners: Strawberry, ajuza, or spider plants

Rhizomes: Iris, canna, and lily-of-the-valley

HOW DOES YOUR GARDEN GROW?

ACTIVITY #10: Hydroponics

TIME: 50 Minutes

OBJECTIVE: Students will observe hydroponically grown plants to determine whether hydroponics work as well as soil.

TEACHER BACKGROUND INFORMATION: Hydroponics is an alternative method of growing plants without soil using a nutrient solution. Some plants are naturally hydroponic such as dune grasses, which grow on the beach, and seaweed. The advantages of hydroponics over soil are many. Hydroponics uses less land, has a higher nutritional value and greater freshness, is less expensive and environmentally sound. There is little water waste since plants are organically grown. Root system is reduced so less space is needed. Indoor growing reduces the need for pest control. Crops can be grown year round. Hydroponics can be used in desert regions or for outer space programs.

Growing plants hydroponically requires some special care. The pH must be checked to be sure the water is between 5.5 and 6.5. Ammonia should be added to raise the pH and vinegar should be added to lower the pH.

Hydroponic plants also require a nutrient solution. The following recipe can be used to make a nutrient solution.

1 tablespoon 5-10-5 plant fertilizer
1 teaspoon Epsom salts
1 teaspoon washing ammonia

Mix with a gallon of distilled (pH correct) water (teacher provided).

Hydroponic plants may be grown in a variety of mediums which can help support the plant's root system. As long as the medium does not add any nutrients to the plant, it is considered to be hydroponic. Some mediums are: sand, gravel, LECA - light expanded clay aggregate, small stones, colored gravel (aquarium), cinders, volcanic lava, charcoal, sawdust, vermiculite and perlite.

In growing hydroponic plants, it is necessary to change the nutrient solution frequently. The solution must not be in direct sunlight to prevent algae growth. The attached chart shows a list of symptoms that can cause trouble for your plants.

Additional information on hydroponics can be found in the following book:

Bonnett, Robert L. 49 Science Projects - Botany, Book 3277, Tab Books.

HOW DOES YOUR GARDEN GROW?

MATERIALS (per group of 3):

3 healthy plants in soil
Enough vermiculite (about 1 cup) to fill 2 condiment cups
1/2 yard doubled piece of cheesecloth
Plastic spoon
Prepared nutrient solution
Medicine cup

TEACHER/STUDENT PROVIDED MATERIALS:

2 buckets or containers
Several shovelfuls of soil from a wooded area
Measuring cup

PROCEDURE:

Preparing Soil Leachate

1. Have students place 15-20 spoonfuls of soil on a folded piece of cheesecloth. Two people should hold the cheesecloth over a bucket or container while the other student pours tap water (about 2 quarts or 2000 mL) into the soil.
2. After several minutes, when the water has drained through, pour the water into another container. Place the cheesecloth with soil back over the bucket and pour the same water back through again. Repeat this 5 times.
3. Students will have made a liquid called soil leachate. This liquid will be used to feed one of the test plants. The liquid needs to be saved so that it can be added to the plant periodically throughout the experiment. Check the pH of the leachate.

Planting Hydroponically:

1. Students should carefully remove 2 plants from soil and rinse off the roots with tap water.
2. The plants should be held suspended in the condiment cups while vermiculite is poured to within 1 cm of the top.
3. The third plant should be left in soil. It is the control plant, used as a comparison.

HOW DOES YOUR GARDEN GROW?

Setting Up The Experiment:

1. Students should label the cups of the hydroponic plants with the words "Soil Leachate" and "Nutrient Solution".
2. They should add 90 mL of the soil leachate to the appropriate cup, 90 mL of the nutrient solution to the appropriate cup, and enough water to dampen the soil of the third plant. Use the medicine cup to measure.
3. Students should check the plants and water the plants with the appropriate solution every 3 or 4 days. Remember to check the pH of your gallon of nutrient solution daily and add ammonia or vinegar as is appropriate.
4. Remind students that other variables such as temperature and amount and type of light should be the same.
5. Allow at the minimum 1 week for observation, longer if possible.
6. Students will be required to design their own charts for recording data, along with graphs to record any numerical measurements. Develop as a class a list of things to observe. Suggested items are: number of leaves produced, plant color, stem growth, and general appearance of the plants. Remind students of the labels all graphs should have. These are:

   - a title ("Effect of Fertilizer on Plant Growth")

   - what is being measured ("Plant Height in cm") on the y axis

   - the units with which you are measuring (0, 1,...) on they axis

   - what you are testing ("Amount of Fertilizer") on the x axis

   - the name of each test group or the amount of item being tested (2 mL, 4 mL, ...) on the x axis

Refer to any of the graphs used previously in these activities for additional examples. A sample set of charts and graphs is shown below. As the teacher, you have the final decision as to what can be expected from your students. Some samples have been shortened to save space.

	APPEARANCE OF PLANT
SOIL	
LEACHATE	
NUTRIENT	

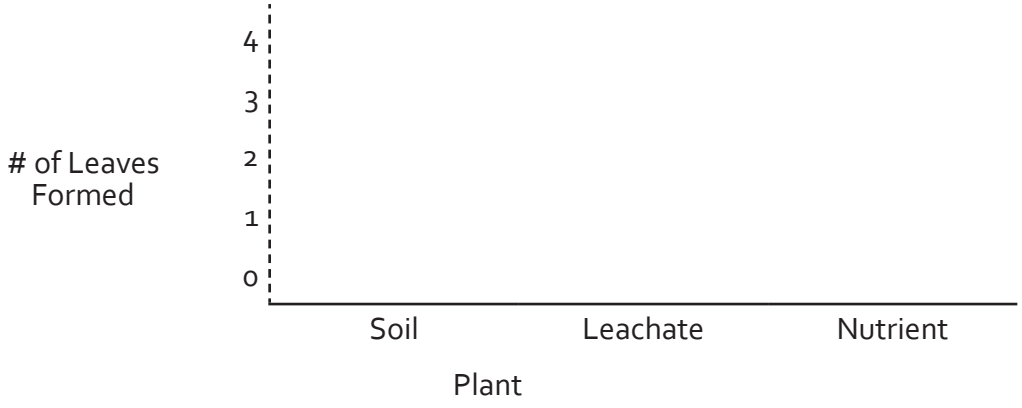
HOW DOES YOUR GARDEN GROW?

PLANT COLOR

	SOIL	LEACHATE	NUTRIENT
DAY 3			
DAY 4			
DAY 5			

	# LEAVES BEFORE	# LEAVES AFTER	# LEAVES FORMED
SOIL			
LEACHATE			
NUTRIENT			

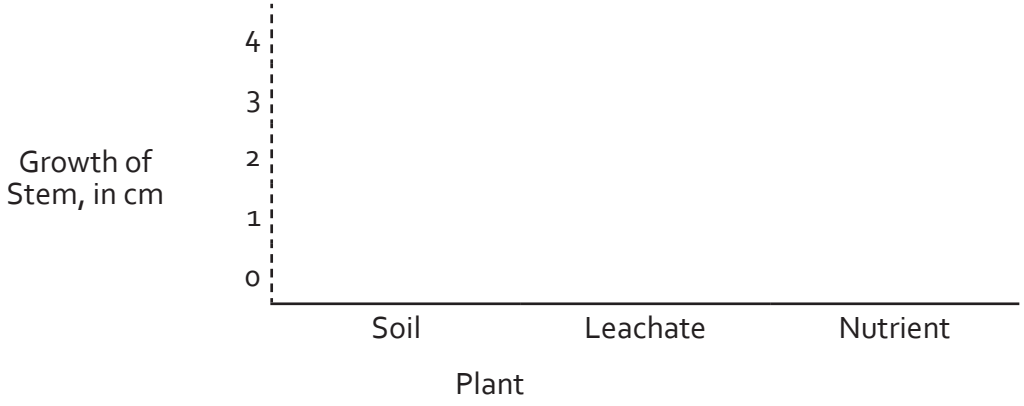
Leaf Formation in Soil and Hydroponically Grown Plants



HOW DOES YOUR GARDEN GROW?

	STEM HEIGHT BEFORE	STEM HEIGHT AFTER	STEM GROWTH
SOIL			
LEACHATE			
NUTRIENT			

Stem Growth in Soil and Hydroponically Grown Plants



FORMATIVE EVALUATION: Students will be evaluated on their methods of collecting and organizing data.

HOW DOES YOUR GARDEN GROW?

NAME _____

ACTIVITY #10: HYDROPONICS

MATERIALS per group of three: 3 healthy plants in soil, enough vermiculite to fill 2 condiment cups, strip of pH paper, 1/2 yard doubled piece of cheesecloth, plastic spoon, medicine cup, prepared nutrient solution, 2 buckets or containers, 15-20 spoonfuls of soil

PROCEDURE:

Preparing Soil Leachate

1. Place 15-20 spoonfuls of soil on a piece of cheesecloth that has been folded in half.
2. Have 2 of your partners hold the cheesecloth above your bucket. Pour 2 L of tap water onto the soil.
3. After several minutes, when most of the water has drained through, pour the water into another container.
4. Place the cheesecloth with the soil back over the bucket and pour the same water through the soil again.
5. Do this procedure a total of 5 times.
6. The liquid that you have made is called soil leachate. This liquid will be used to feed one of your test plants.
7. Check the pH of your leachate using a strip of pH paper.

Procedure for Planting Hydroponically:

1. Carefully remove 2 plants from the soil.
2. Carefully rinse off roots to remove the soil.
3. Hold the plant suspended in a condiment cup while one of your partners adds vermiculite to within 1 cm of the top of the cup. Repeat for the other plant.
4. The third plant will be left as is, growing in soil.

Setting up the Experiment:

1. Label one of the hydroponic plants in the cup with the words " Soil Leachate".
2. Label the other cup with the words "Nutrient Solution".
3. Add 90 mL of the soil leachate to the appropriate cup.
4. Add 90 mL of the prepared nutrient solution to the appropriate cup.
5. Add enough water to dampen the soil of the third plant
6. Check and water the plants with the appropriate solutions every 3 or 4 days.
7. All other conditions such as temperature, amount and type of light should be the same.
8. Record the observations you have decided upon as a class. You will need to do this for at least a week, 2 if possible.
9. You will have to set up charts to record your observations. You will also have to make graphs that show any measurements you made. These are things you counted, measured with a ruler, etc. Your teacher will go through this with you.

HOW DOES YOUR GARDEN GROW?

ACTIVITIES REQUIRING ADVANCE PREPARATION

Activity 1 - soak beans 24 hours before use

Activity 5 - germinated bean seeds - prepare 4-5 days ahead

Activity 8 - 40 young bean plants with 4-5 leaves. This must be done 7-10 days in advance.

Activity 10 - 30 young bean plants with 4-5 leaves. This must be done 7-10 days in advance.

You will need to give yourself time to do the activities in this unit. The growing process cannot be rushed and you will need to plan ahead to do several activities in this kit.

ACTIVITIES REQUIRING TEACHER/STUDENT SUPPLIED MATERIALS NOT FOUND IN THE CLASSROOM

Activity 4 - 1 gallon of distilled water, soil samples from different locations

Activity 5 - shallow plastic pan

Activity 7 - 4 fresh celery stalks for each group

Activity 8 - 1 gallon distilled water

Activity 9- several types of plants listed in ("Teacher Background Information", Activity 9) to use for propagation

Activity 10 - several shovelfuls of soil from a wooded area

1 gallon of distilled water

2 buckets or containers per group

*NOTE: Due to the limited space available in the Rubbermaid tubs, the teacher will need to supply two 4 quart (by volume) bags of potting soil. An alternative is to create your own mixture using potting soil and soil you gather.

SCIENCE PERFORMANCE ASSESSMENT INSTRUMENT

HOW DOES YOUR GARDEN GROW?

M.A.S.H. KIT #12

(Grade 4-5)

This Assessment is a Combination of Assessments Developed by:

Sandra Krummrich, John Brueggeman, Barb Elledge,
Valerie Holmes, Joan Klockenkeper, Rober Marchioro

Edited by:
Carol Hotz

HOW DOES YOUR GARDEN GROW?

***ILLINOIS GOALS*:**

Goal III - The principles of scientific research and their application in simple research projects.

Goal IV - The processes, techniques, methods, equipment, and available technology of science.

LEARNER OUTCOMES:

Each student will be able to observe, measure, and record data over a period of time and draw conclusions based on his/her/their observations.

STUDENT'S PERFORMANCE:

1. A daily journal will be kept by each student. It will contain the observations, data collected, and drawings.
2. At the close of this experiment, each student will use data to make a line graph that shows the growth of each of the three plants in his/her/their group.
3. Each student will write a narrative paragraph at the end of his/her/their observations, outlining the problem investigated and giving his/her/their conclusions for the different growth rates of the three plants in his/her/their group.

SCORING INSTRUCTIONS:

Data table & journal	title	1 point
	observations	4 points
	clarity of information	4 points
Line graph	title	1 point
	horizontal label	1 point
	vertical label	1 point
	key	2 points
	overall organization	2 points
Paragraph	problem stated clearly	2 points
	variable identified	1 point
	results stated clearly	2 points
	overall organization	2 points
	conclusions	2 points
	total =	25 points

Exceeds: 23-25 pts. Meets: 18-22 pts. Does Not Meet: Less than 18 pts.

HOW DOES YOUR GARDEN GROW?

STUDENT MATERIALS:

clear plastic cups
seeds
30 mL medicine cup
journals

Teacher provided:
water
paper towels metric rulers
colored pencils, pens, or crayons

STUDENT'S PERFORMANCE:

1. This experiment will cover a period of 10- 12 days.
2. The teacher will watch for accuracy. Students need to measure water carefully.
3. The teacher will check the student's journal entries to see that the student is making and recording observations.

HOW DOES YOUR GARDEN GROW?

STUDENT ACTIVITY SHEET

AVERAGE GROWTH OF A BEAN INVESTIGATION

MATERIALS: 3 plastic cups per group, 6 beans, 30 mL medicine cups, paper towels, metric rulers, water, colored pens, pencils, or crayons, student journals

SET UP YOUR MATERIALS ACCORDING TO THE DIAGRAM BELOW:

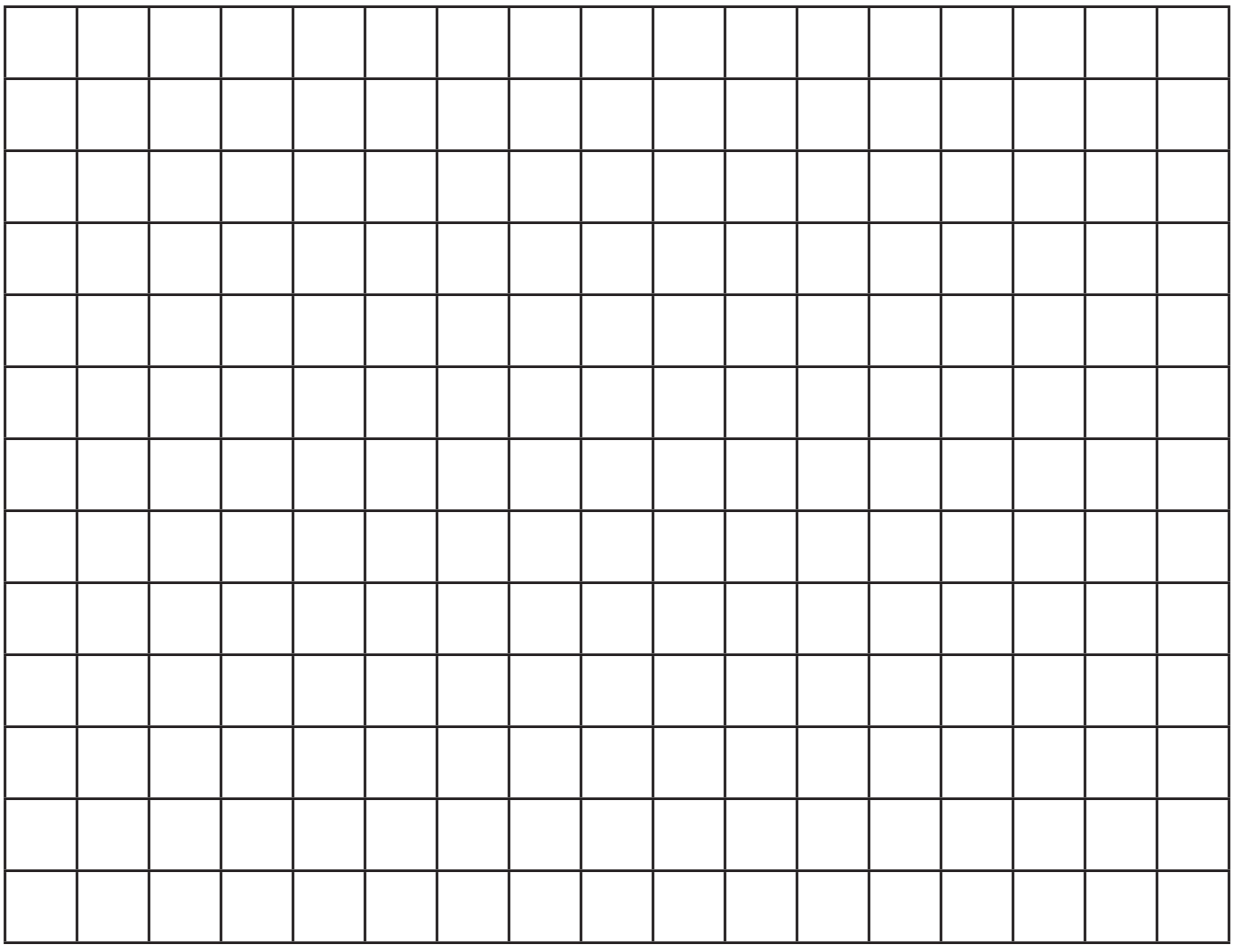
STUDENT DIRECTIONS:

1. Get into cooperative groups of three.
2. Have your materials requisition person pick up three plastic cups, six beans, three 30 mL medicine cups, and six paper towels from the material table.
3. Fold three paper towels, wet them, and place one in each of the plastic cups.
4. Place two beans in each cup so that they rest between the paper towel and the inside of the cup.
5. Wad up the other three paper towels and place one in each cup to hold the wet paper towel and the beans in place against the side of the cup.
6. Label the three cups in your group - 1, 2, and 3.
7. Cup 1 will be placed in full sunlight.
8. Cup 2 will be placed in partial sunlight.
9. Cup 3 will be placed in darkness.
10. Each cup will receive 15 mL of water every day. Make certain that the paper towel is kept moist. Do not over water your beans.
11. Observe and measure the daily changes in each bean seed embryo. To do this, measure the overall length of the bean from root tip to plant top, record your observations, and enter this information in your journal of what is happening in each cup.
12. Graph the daily length of the bean and its embryo on Sheet B.
13. Use different colors for each bean as you develop your line graphs.
14. As a concluding activity, write a narrative paragraph summarizing your observations in the investigation.

HOW DOES YOUR GARDEN GROW?

Sheet B

GRAPH



AFTER YOU COMPLETE YOUR GRAPH BEGIN WORKING ON SHEET C.

HOW DOES YOUR GARDEN GROW?

Sheet C

Writing Assignment
Narrative: Experiment

Think about the experiment you have just completed. Prepare a lab report describing your investigation to the members of your class. Be sure your report contains a description of your investigation and summarizes results of your investigation.

Write your paper using the following guidelines:

- State the problem you investigated.
- Describe all variables in the experiment.
- Identify the dependent variable.
- Indicate the result of your environment.
- Tell what happened during your experiment that led to this result.
- Explain how you made your prediction.

Check points to remember:

- Take some time to plan your paper on scratch paper.
- Organize your ideas carefully. Remember what you know about paragraphs.
- Use language and information appropriate for the students in your class.
- Check that you have correct sentences, punctuation, and spelling.

PLEASE PLACE ALL MATERIALS
(INCLUDING YOUR WORK) BACK IN THE PACKET.
THANK YOU.

HOW DOES YOUR GARDEN GROW?

Sheet D *Score ( )*

(Be sure to follow your writing guidelines and write in complete paragraphs)