SCIENTIFIC INVESTIGATION IN THE GARDEN

Gardens are wonderful laboratories for science: soils, weather and water are all earth sciences, and plant, insect and animal life cycles are life sciences. Through observing, testing, measuring and analyzing what is happening in the garden, students can put their scientific inquiry skills to work. Younger students can do simple experiments just observing, measuring and reporting the data they collect. Older students can apply the complete scientific method (question, hypothesis, experiment, results, analysis, conclusion) to investigate questions raised in the garden. The following investigation activities are intended to inspire scientific thinking through the garden: (1) What Does a Seed Need? and (2) How Does Your Garden Grow?

Activity #1: What Does A Seed Need?

Objective: Students will learn that a seed needs only water and some growing medium to germinate and begin to grow.

Activity: Students will place bean seeds in ziplock bags under different conditions and observe them for several weeks to determine under what conditions the seed will germinate.

Grades: K-3

Materials:
- 20 lima or pinto bean seeds, not soaked
- 20 sandwich-size ziplock bags
- Magnifying glasses—one per student or pair of students
- Paper towels
- 2 cotton balls
- 2 cups potting soil
- Water
- Permanent marker
- Paper and pencils for sketching germinating seeds' growth cycle following observations
- Optional: refrigerator and 3 room thermometers, if you would like to test for effects of cold on germination, plus 10 more seeds, 5 more ziplock bags, 2 more cotton balls and one more cup potting soil

Location: Inside

Lesson: Germination is the first step in the seed growing in to a plant; it is when the baby plant first emerges from the seed. Germination only requires three elements: water, some medium in which the seed can sit and temperatures within the range for that type of plant. Most seeds do not require sunlight or soil to germinate. The students are going to place the bean seeds under different conditions to see what conditions are required for germination. The experiment instructions below produce 2 bags for each variable, one that will be placed by or taped on to a window that receives indirect sunlight and one that will be placed in a dark place (closet or closed drawer).

If you have access to refrigeration where you can leave the bags and have students check daily, you can make a third bag for each variable and keep those bags in the refrigerator. Those bags should be

labeled #1c – 5c. Use thermometers to record daily temperatures in room and in refrigerator as part of observations.

Directions:

1. Pass around the seeds so the students can feel how hard the seed and its coating are. Discuss what the baby plant might need to break open the hard seed coat and begin to grow.
2. Pass out the magnifying glasses to each student. Note the appearance of the seeds.
3. Describe the different conditions that you will use for each seed packet:
   (1) Control—dry seed in bag,
   (2) sitting on moist paper towel,
   (3) moist cotton ball in bag,
   (4) dry potting soil, and
   (5) moist potting soil.

   Half will be in indirect sun and half will be in the dark. Have students predict which seed conditions they think will result in germination of the seeds. Optional: Record students' predictions for each of the five conditions—how many students believe it will germinate v. how many students believe the seed in that packet will not germinate. Create a graph showing the students' predictions and post it near the seed bags near the window.
4. Divide the students into groups so that there are 5 groups—one for each condition. Each group will set up 2 identical seed bags.
   a. Bags #1a and 1b: Two seeds alone and dry in each ziplock bag. Label bags #1a and 1b. These are your Controls.
   b. Bags #2a and 2b: Two seeds in each bag sitting on top of folded, thoroughly damp paper towel. Towel should be slightly wrung out so seed isn't sitting in water but is kept well-moistened. Be sure seeds are visible from outside of the bag. Label bags #2a and 2b.
   c. Bags #3a and 3b: Two seeds in each bag with 1 damp cotton ball. Seeds can be near it, but not sitting on it. Label bags #3a and 3b.
   d. Bags #4a and 4b: Two seeds in each bag with 1 cup potting soil, no water. Be sure you can see the seeds from the outside of the bag. Label bags #4a and 4b.
   e. Bags #5a and 5b: Two seeds in each bag with 1 cup potting soil. Sprinkle water to moisten well the potting soil, but not so wet that it is like mud. Be sure you can see the seeds from the outside of the bag. Label bags #5a and 5b.

5. Either place on a shelf or table near a window or tape to a window all Bags #1a-5a. If you hang the bags, it is best to choose a window that does not get direct sunlight for a large part of the day. The bags should be in a location that they will not be disturbed, but are still easily accessible and visible for student operations. Hang bags at eye level.
6. Place all Bags #1b-5b in a dark location, such as inside a closet or closed drawer. An adult should be responsible for bringing them out into the light for a very brief period daily for observation, disturbing them minimally, and then immediately returning them to the dark.
7. If you are including chilling in your experiment, place Bags #1c-5c in the refrigerator. Also, place one thermometer in the refrigerator, one outside the refrigerator near where the seeds are sitting near or on a window and one in the dark space.
8. Determine a schedule for observing changes in the bags. Have students check all bags daily or every two days and document changes in a science journal or paper by writing the date and either drawing or describing (or both) the changes in the seeds in each bag.

9. Experiment should run for approximately 10 days. By then or soon after you may be getting mold in the moist bags. Create a table or chart showing which bags germinated and which did not. Compare the outcome to the students' predictions and discuss why the seeds did or did not germinate under each condition. Older students can use descriptive writing skills to write a paper describing the outcome of the experiment.

10. Optional: Take the seeds that did germinate and carefully plant them in your garden to see if they continue growing.

Activity #2: How Does Your Garden Grow?

Objective: Students will learn and practice the scientific method doing an experience testing the growing conditions plants need to survive in their garden.

Activity: Students will create different growing conditions for different plants in their garden to see the impact on plant growth.

Grades: 4-8

Materials:

- Vegetable transplants or well established seedlings ready to transplant into your garden. Choose plants that grow easily and relatively quickly in your garden—leaf lettuces or leafy greens tend to work well. Plants should be physically separated in order to change conditions for various plants. It is best to have a minimum of 3 plants growing for each condition you intend to test, plus 3 that are the control. Best system: Fill one 5- Pocket panel with control and then use a separate 5-pocket panel for each variable.
- The materials necessary to make the changes to the growing conditions, depending on the variable you choose. Examples include shade cloth, foil or some other covering if you plan to decrease in sunlight, fertilizers if you plan to test the impact of different types of fertilizer and/or effect of varying the amount of fertilizer, and any other variables that your students devise! Note: Students need to select a variable that is practical to control. For example, unless your school is in a very dry environment, it is difficult to test effectively the removal or decrease of water because we can not control the rain. You can, however, test overwatering—water your variable plants daily v. the control plants get the regular irrigation and any natural precipitation during the experiment period. You will have a similar problem with light—you can not add more light in a typical school garden. But you can remove light using a shade cloth.
- Journal—to take notes in planning for experiment and for collecting data.

Location: Outside in the garden.

Lesson: This activity should be done as part of a larger lesson introducing or reviewing the scientific method. The activity is to use the scientific method to run an experiment in your garden. These instructions are just meant to guide you through the process for how to run a science experiment in a school garden.

Pre-Experiment: Scientists use their prior knowledge about a subject to develop a question that they want to test in their experiment. Students should brainstorm about what they know about what plants need to survive. The focus should be on environmental conditions.

Question: Have students develop the question they want to test. Explain that in order to run an experiment, the students will need to have a control, which is the plant under normal conditions, and a variable, the condition that they want to change to test its effect on their plants. Scientists only test one variable at a time. Brainstorm what variables could be tested and whether they could test that variable in their school garden. Select a Question to answer (or more than one if you are having students test more than one variable), and have students record it in their journal.

Possible Variables that can be tested in a Woolly Pocket School Garden: Water (overwater), Light (remove light), Nutrients (different types and amounts of fertilizers), Growth Medium (what other medium could they use other than soil in their pocket?), Temperature (chill soil with ice or heat with plastic).

Hypothesis: Using their background knowledge about and experience with plants and their growth, students will formulate a hypothesis about a possible outcome from their test. Have students record Hypothesis in their journal.

Procedures: Students must develop the procedures for their experiment. Brainstorm together to develop the classroom plan. Be sure all understand that they must follow the procedures in order for the results of their experiment for be valid. They need to determine how they will plant their plants (this is important if their variable involves different growth mediums or fertilizers), and what conditions they will need to create in the garden to change their variable. If they are overwatering or doing a special fertilizing program, they need to create a schedule and a set of procedural steps that must be followed. Part of the developing the Procedures is deciding how long the experiment will run. They also must decide procedures for documenting observations (when, how, what data to collect, how to record it).

Experiment: Students should follow the procedures they developed to run their experiment. Note: all experiments should be conducted on established plants. Thus, once the transplants are planted, you should wait 2-4 weeks before starting your experiment changing conditions in the variable plants (this does not apply, obviously if you change of condition involves the planting medium or prior fertilization—this should be done at time of planting). You want the plant to recover from the shock of transplanting before you shock it with another stress, otherwise your results could be the result of the shock and not the change in conditions.

Results: Students should record the results of their plant observations at regular intervals and using a consistent system of observation and recording of data. The first observation and recording should be before you make the first change of conditions. The results should be recorded on different pages in two different data tables—one for the control box and one for the plants with the change in conditions. Students should brainstorm on what types of observations will be important in determining if the growth is being affected by the variable. Relevant observations should include height of the tallest plant, overall leaf color, number of leaves, etc. You may want to create a schedule of pairs of students to do the observations—you can share all data collected with the entire class.

Analysis: When the experiment time period is complete, students should complete their individual data tables with the data collected by their peers. Then either alone, in student groups or as a class, they should review and analyze the outcomes that they learn from the data. What difference was observed in the plant growth of the variable box v. the control box?

Conclusion: Based on their analysis of the data collected, students develop a conclusion about the effects of the variable on plant growth. They may prepare a complete science report that incorporates all the elements of their science experiment.