Knowing Beans

Unit: Henry as Scientist
Topic: Plant growth

Thoreau Quotations

"Meanwhile my beans, the length of whose rows, added together, was seven miles already planted, were impatient to be hoed, for the earliest had grown considerably before the latest were in the ground;... I came to love my rows, my beans, though so many more than I wanted."

"I was determined to know beans."

— "The Bean-Field", *Walden* (1854)

"Though I do not believe that a plant will spring up where no seed has been, I have great faith in a seed—a, to me, equally mysterious origin for it. Convince me that you have a seed there, and I am prepared to expect wonders."

— "An Address on the Succession of Forest Trees" in *Excursions*

"The soil, it appears, is suited to the seed, for it has sent its radicle downward, and it may now send its shoot upward with confidence. Why has man rooted himself thus firmly in the earth, but that he may rise in the same proportion into the heavens above?"

—"Baker Farm", *Walden* (1854)

Background

Henry grew green beans when he was living his two years, two months and two days at Walden Pond. In his first summer at the Pond, he planted rows of beans that equaled seven miles! The next summer, he significantly scaled back his garden to a size that was more manageable. He tended to his beans—and other plants—with much care, protecting them from weeds, worms, and woodchucks. Beyond the farming he did while at the Pond, Thoreau was known to have a "green thumb" and always maintained a garden of some sort. Henry even planted a garden for his friends as a wedding gift.

Objectives

1. Learn or review the scientific method.
2. Students will investigate the conditions needed for growing green beans.
3. Students will make observations, measurements, and conclusions regarding their bean plants.

Method

Students will use the scientific methods to grow green beans and manipulate variables to determine what impacts plant growth.

Time Required

Several weeks

Materials

- Journals
- Colored pencils
- Magnifying lens
- Pencils
- Rulers
- Green bean seeds
- Plastic bags for seed germination so they can watch the seeds sprout
- Paper towel
- Stapler
- Water
- Potting soil (or different types of soil if testing the impacts of soil on growth)
- Thermometer(s)
- Beaker(s) to measure water
- ½ gallon milk cartons/jugs for transplanting the sprouted seeds into so they can watch the plants mature (beans need a 12-inch deep growing container because their roots grow about 10-inches deep)
- Newspaper (for quick clean up)
- Spoons (for putting the soil in the cup)
- Sunny, dark, warm, and cold places (depends on the different variables you are testing)
- Scale

Procedure

1. Teach or review with them the scientific method (here are the basic steps but see additional resources and vocabulary for more information)
    a. Observation – seeing, hearing, touching…
    b. Asking a question – why or how?
    c. Hypothesis – a fancy name for an educated guess about what causes something to happen.
    d. Prediction – what you think will happen if…
    e. Testing – this is where you get to experiment and be creative.
    f. Conclusion – decide how your test results relate to your predictions.
    g. Communicate – share your results so others can learn from your work.

2. Inform students that Henry kept a journal where he recorded information about his bean field and other observations. He even eventually wrote a chapter in *Walden* called "The Bean-Field". Throughout this lesson students will be writing in a "Bean Journal" about their investigation. This will be an important way to document testable questions, hypotheses, procedures, observations about changes in their plants, measurements, and conclusions.
3. Brainstorm with students what plants need to grow (light, soil, carbon dioxide, nutrients, water, the right temperature).
4. Students will start the investigation by determining a testable question, with the whole class testing one question or groups testing different questions. Some examples: Will the bean plants grow taller (or produce more beans, or have more leaves) in the window or the dark closet? Will beans grow taller (or produce more beans, or have more leaves) in the classroom or the refrigerator? Will the beans grow taller (or produce more beans, or have more leaves) by watering the plant once per week, watering three times per week, or watering every day (specify amounts using beaker measurements)? Will beans grow taller (or produce more beans, or have more leaves) in potting soil, sand, or clay?
5. Once the testable question(s) has been determined and recorded, have the students write down their hypothesis in their journal.
6. Next have the students write down the planned procedure for their experiment (or you may want to have those directions already determined), especially making sure they know and understand the variable they will be testing (i.e. watering their plant with 10 mL/week or watering their plant with 10 mL/day, keeping it in a dark place or a sunny place) and how the variable factors into their procedure.
7. Students will start by germinating their seed in a plastic bag. They will need a plastic bag, a paper towel, the stapler, water, and a seed (or more if you want to make sure one germinates). Fold and place the paper towel in the bag, and then have the students staple the paper towel and bag together about two inches from the top to create a shelf for the seed to sit on (this allows the students to watch the root grown downward and the plant sprout). Pour in the water, add the seeds (ensuring the seeds are on one side of the plastic bag where they can see the seed germinate), and seal the bag. The seeds should germinate in 7-10 days (depending on the conditions you are testing – too much or too little water, darkness, and temperature will all affect germination rates).
8. Once the seeds have germinated, have them transplant the germinated seed to a ½ gallon milk carton/jug (top cut off), but keep the testing conditions the same as they were for germination. Under optimal conditions, bean roots could reach approximately 10 inches so you want to make sure the container is deep enough.
9. Students should record daily observations about their bean seed from the time they put their seeds in the bag until they are sprouted. Once sprouted and the beans are planted, you may want to have the students observe their plants every couple of days or once a week until the experiment is completed. These observations should include date, the environmental conditions of their plant (temperature, the amount they watered the seed/plant, etc.), sketches, measurements (height, number of leaves, number of flowers, number of beans), and other observations.
10. Green beans will be ready to harvest in 50-65 days under the optimal conditions (see additional information for details on growing green beans). If beans are produced, decide as a class what you will do with them – eat them, donate them, save the seeds to grow more beans, keep harvesting so new beans will grow?

11. In their journals and upon completion, depending on grade level, some relevant questions may be:
    a. How much total water was given to their plant?
    b. What was the change in height each week? When did the plant grow fastest? Slowest?
    c. Have them weigh their beans to see how many pounds (or fraction of a pound) of beans a single plant produces. How many plants would they need to produce 10 lbs. of green beans? Or if they had 10 plants, how many lbs. of green beans would they produce?
    d. At the beginning of the experiment, have them calculate the cost to grow the green beans (soil, seeds, and water, assumes containers were re-used). Have them research the price they could sell their green beans and determine if they lost money, broke even, or made money. If they lost money, how many beans would they need to produce to make a profit?
12. Once the experiment is complete, have each student write down in their journals their conclusions from the experiment. Did their results match their predictions? If not, what are some possible reasons they didn't get the results they expected?
13. If desired, the students can write a lab report from their experiment including their question, hypothesis, prediction, procedures, conclusions, and drawings.
14. Have the students transcribe from their notebooks to the board: the final height of the plant, number of leaves, how many beans were produced, number of days to germinate, and the variable they were testing. This will help with some of the "Reflect and Explain" questions. It also allows them to see that there are lots of different data and that someone testing the same hypothesis may reach different conclusions. If there are different results and conclusions, talk to them about the need to test an idea multiple times and with the same procedures so they can compare their results.

Reflect and Explain

- Ask students what they learned during their investigation. What did they learn during the observation process? What surprised them about their results? What would they do differently the next time they did this investigation?
- Based on all the results on the board, what do they think are the ideal conditions for growing green beans? Why?
- After Henry grew beans the first year, he said "I will not plant beans and corn with so much industry another summer," because he felt that it took up too much time. Instead, Henry wanted to have more time to walk in the woods and spend time in nature. Would the students want to plant beans again? If so, how many bean plants would be manageable to care for (seven miles?!)? If not, what would they do with their time instead?

Extensions

1. Have the students create a blog with their investigation entries and digital pictures of their bean plants.
2. Using the results of their investigation, have all the students plant seeds using the optimal growing conditions and compare the new results with the initial investigation. Or grow a new plant type using what was ideal conditions for the green bean plants and investigate if these same conditions work well for the new plant.

Vocabulary

control - a group that is similar to other groups but is left alone so that it can be compared to see what happened to the other groups that are tested.

controlled variable - these are variables that you never change in your experiment.

data - the numbers and measurements you get from the test in a scientific experiment.

dependent variable - a variable that changes when the independent variable is changed.

germination - to begin to grow.

green thumb – a phrase used to describe someone who is skilled at gardening or growing plants

independent variable - a variable that you change as part of your experiment. It is important to only change one independent variable for each experiment.

photosynthesis - the process by which a green plant turns water and carbon dioxide into food when the plant is exposed to light.

variable- something that can cause something you are testing to change. There are several kinds of variables.

Common Core Standards

English Language Anchor Standards (all grades)

- CCSS.ELA-LITERACY.CCRA.W.1
  Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.
- CCSS.ELA-LITERACY.CCRA.W.7
  Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.
- CCSS.ELA-LITERACY.CCRA.W.10
  Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

- CCSS.ELA-LITERACY.CCRA.SL.1
  Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.
- CCSS.ELA-LITERACY.CCRA.SL.2
  Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.
- CCSS.ELA-LITERACY.CCRA.SL.3
  Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric.
- CCSS.ELA-LITERACY.CCRA.SL.4
  Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.
- CCSS.ELA-LITERACY.CCRA.SL.6
  Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate.
- CCSS.ELA-LITERACY.CCRA.L.3
  Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening.
- CCSS.ELA-LITERACY.CCRA.L.6
  Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when encountering an unknown term important to comprehension or expression.

Math Practice Standards (all grades)

- CCSS.MATH.PRACTICE.MP1 Make sense of problems and persevere in solving them.
- CCSS.MATH.PRACTICE.MP2 Reason abstractly and quantitatively.
- CCSS.MATH.PRACTICE.MP3 Construct viable arguments and critique the reasoning of others.
- CCSS.MATH.PRACTICE.MP5 Use appropriate tools strategically.
- CCSS.MATH.PRACTICE.MP6 Attend to precision.

Grade 3 Content Standards

- CCSS.MATH.CONTENT.3.MD.A.2
  Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l).[1] Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem.[2]
- CCSS.MATH.CONTENT.3.MD.B.4
  Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units— whole numbers, halves, or quarters.

Grade 4 Content Standards

- CCSS.MATH.CONTENT.4.MD.A.2
  Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale.

Grade 5 Content Standards

- CCSS.MATH.CONTENT.5.MD.A.1
  Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real world problems.

Additional Resources

https://askabiologist.asu.edu/explore/using-scientific-method-solve-mysteries - information on the scientific method

http://www.grow-it-organically.com/growing-green-beans.html - information on germination and optimal growing conditions for green beans