HANDS-ON ACTIVITY

How Fast Can a Carrot Rot?

Quick Look

Grade Level: 6 (6-8)
Time Required: 2 hours 30 minutes
One class period (~60 minutes) to design and begin the experiment; 15 minutes for observations and measurments, which can be done 2 or 3 times a week, for 2-3 weeks
Expendable Cost/Group: US $2.00
Group Size: 4
Activity Dependency:
Dirty Decomposers
Subject Areas: Biology
NGSS Performance Expectations:

MS-LS1-5

Everyone knows carrots are good for you, but they are also good for experiments about decomposition by soil microbes.

Summary

Students conduct experiments to determine what environmental factors favor decomposition by soil microbes. They use chunks of carrots for the materials to be decomposed, and their experiments are carried out in plastic bags filled with dirt. Every few days students remove the carrots from the dirt and weigh them. Depending on the experimental conditions, after a few weeks most of the carrots have decomposed completely.
This engineering curriculum aligns to Next Generation Science Standards (NGSS).

Engineering Connection

Engineers must understand what causes vegetables to decompose in order to develop methods for transporting and preserving them from the fields to grocery stores. Additionally, engineers design waste treatment systems that use microbes to break down waste.

Learning Objectives

After this activity, students should be able to:

- Describe a controlled experiment that tests for the effects of a physical feature of the environment, such as temperature or moisture level, on the rate of decomposition by soil microbes.
- Describe some of the physical conditions that are favorable or unfavorable to microbial decomposers.

Educational Standards

- NGSS: Next Generation Science Standards - Science
- Common Core State Standards - Math
- International Technology and Engineering Educators Association - Technology
- State Standards

Materials List

- several triple-beam balances (or electronic balances), accurate to at least 0.1 g
- 2 one-pint plastic bags with zipper closures per student
- several permanent markers for labeling the plastic bags
- 8-20 pounds, more or less depending on class size and student plans for experiments, of good quality potting soil (the most expensive you can afford)
- several garden trowels, large spoons and/or plastic cups for digging and scooping soil
- 10-12 large carrots, cut into pieces about 3-4 cm long and 2-3 cm in diameter
- inexpensive watercolor paintbrushes, one or two per group, for brushing dirt from the carrots prior to weighing

Depending on what questions the student groups decide to test, you may also need:

- other types of soil (for example, soils with high clay or sand contents, topsoil from a nearby woods, garden or inconspicuous lawn area, etc.)
- refrigerator space

- incubator space (Create a makeshift incubator from a large cardboard box, such as one that computer components are shipped in, lined with aluminum foil. As the heat source, use a very small desk lamp or a 25-watt light bulb screwed into a base obtained for a few dollars at a hardware store. For safety reasons, only use the incubator during school hours, unplugging it overnight or running it on a timer. Monitor the temperature and try to maintain it at about 40 °C or 100 °F; if it gets too hot, open the box flaps slightly; if it is too cool, use a higher voltage light bulb.)
- several thermometers
- several small beakers, graduated cylinders and bowls for mixing soil or adding measured amounts of water or other substances
- safe, acidic liquid such as lemon juice or vinegar

Pre-Req Knowledge

Students should know how to use a balance to find the mass of a small object to at least the nearest 0.1 gram.

Introduction/Motivation

Use the activities described in the Introduction/Motivation section of the Dirty Decomposers associated lesson to stimulate interest in this activity. Having planned their own experiments, students should be sufficiently motivated to conduct them in order to find out if their predictions are true.

Procedure

Once students have designed their experiments and you have approved their designs, they are ready to conduct their experiments. Make sure they weigh their carrots before beginning the experiments, and label their plastic bags with pertinent information such as the owner's name and whether it is an experimental or control carrot. Then allow about 10-15 minutes every 3 or 4 days for students to remove the carrots and weigh them again. Remind them to return their carrots promptly to the plastic bags to prevent mixing up control and experimental carrots.

Since the experiments take several weeks to complete, ask groups to report on their observations periodically. Some of them may be surprising! For example, if students test the effects of cold temperatures on decomposition, they will probably find that refrigeration causes their carrots to increase in mass at first. If so, ask them why they think this happens. Most likely, it is because the carrots absorb moisture from the damp soil. After the first few days, however, the mass of the

carrots will probably remain unchanged because the cold temperatures prevent the microbes from doing their job of decomposition. We keep fruits and vegetables in the refrigerator for the same reason.

If students saturated their soil with water at the beginning of the experiment, they will probably discover a very foul odor when they open their plastic bags a week or so later. In this case, the waterlogged conditions favor the anaerobic bacteria living within the soil, which then go to work decomposing the carrot. A byproduct of their respiration is hydrogen-sulfide gas, which has a swampy aroma. (Air-freshener spray may help keep student complaints down.) Expect students to notice, however, that these anaerobic decomposers work just as quickly, if not more quickly, than their aerobic counterparts.

Be sure to ask the class what the sources of error are in their experiments. The most obvious is the fact that some dirt remains adhered to their carrots each time they weigh them, and depending on the conditions they test, this amount of dirt may vary throughout the experiment. Point out that they can get some idea of the amount of error from the difference between the initial and first experimental masses of their control carrots. Since the decomposers will not have had much effect in such a short period of time, any initial weight gain in the carrots is mainly due to dirt adhering to the carrot.

Later in the experiment, depending on the conditions tested, some carrots may break into several small pieces, and students must be sure to find all the pieces and weigh them together. In general, expect students to be able to recognize the major error sources as being measurement errors, errors due to adhering dirt, and later, errors due to overlooking small bits of carrots within the soil.

Have students continue weighing their carrots every three or four days until most of the experimental carrots are completely decomposed, or only very small bits remain. For students who test the effects of warm temperatures or wet conditions, this may only take two weeks or less, but for others, plan on letting the experiment continue for at least three weeks.

Assessment

Experiment Steps: Ask students to complete a written assignment in which they design and list the steps for a controlled experiment that would address the question, "Will fertilizer added to the soil increase the rate of decomposition of a carrot by soil microbes?"

Biome Ranking: If students are already knowledgeable about different biomes, provide them with a list of biomes and ask them to put them in order from those in which they think decomposition by soil microbes will occur most quickly to those in which they think it will occur most slowly. Then ask them to write a paragraph justifying their rankings.

Investigating Questions

- Why is it necessary to have some carrots that serve as controls?
- Has the mass of your experimental carrot changed since the beginning of the experiment? In what way? Why do you think that happened?
- Has the mass of your control carrot changed since the beginning of the experiment? In what way? Why do you think that happened? (Expect the control carrots to weigh slightly more the first time they are weighed after the experiment has begun, due to soil adhering to the carrot that was not present at the initial weighing. After that, the mass of the control carrot should not change by more than a fraction of a gram. Slight differences at each weighing are due to differences between the amounts of soil adhering each time, and differences between balances if the same balance is not used each time.)
- What are the sources of error in the experiments? (The most obvious is the fact that some dirt remains adhered to the carrots each time they are removed from the soil, and depending on the conditions being tested, this amount of dirt may vary throughout the experiment. Point out that they can get some idea of the amount of error from the difference between the initial and first subsequent masses of their control carrots. Since the decomposers will not have had much effect in such a short period of time, any initial weight gain in the carrots is mainly due to dirt adhering to the carrot.)
- Why do people keep vegetables, fruits, leftovers and other foods in the refrigerator? See the Lesson Background & Concepts for Teachers section in the associated lesson. Like all chemical reactions, those involved in cellular functions of the soil microbes, including those involved in decomposition, occur more slowly at lower temperatures. Eventually, even foods kept under refrigeration will spoil. Freezing, however, seems to stop decomposer microbes entirely.)

Safety Issues

- While the bacteria and fungi that occur naturally during the experiment are generally harmless, students should nevertheless wash their hands thoroughly with soap and warm water after handling the soil and carrots.
- After each weighing session, have students clean all work surfaces thoroughly with spray cleaner or soapy water.

Activity Extensions

Based on the observations and results of their experiments, students may generate new, testable, questions about decomposition by soil microbes. In particular, they may want to test other food ma terials (see Procedures section) non-organic materials such as cardboard or Styrofoam. These can e asily be tested using the same general experimental setup as was used for their carrots.

Activity Scaling

- For older students, 7th and 8th graders, have them prepare scattergraphs that show how the mass of the carrots changed over the time of the experiment. Since the mass changes as a result of the decomposition that occurrs over time, mass is the dependent variable and thus belongs on the y-axis. Time is the independent variable (time passes no matter what; it is independent of everything except the motion of the Earth) and thus belongs on the x-axis.

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