



## Activity 2 How Does My Garden Grow? (Experiential)

### **Level**

Grades 5 and higher

### **Introduction**

Almost every plant on earth uses energy from light to combine water, carbon dioxide from the air, and nutrients from the soil to produce roots, shoots, leaves, flowers and seeds. No animal on earth or in space can accomplish this feat. Instead, all animals from earthworms to humans must depend, directly or indirectly, on energy stored by plants to live and grow.

In this activity, groups of 3-4 students each (there should be at least 4-5 groups) will (a) prepare Space Garden units and plant seeds for test and control plants, (b) care for and observe plant growth in their Space Garden, and (c) collect data and evaluate the test plant's suitability for cultivation in space.

How Does My Garden Grow? provides students with the opportunity to learn about basic plant growth and development and plant culture techniques while growing their plants in the Space Garden units. They will also learn units of measure and gain experience measuring, weighing, and estimating.

### **Question**

What are some plants that astronauts can grow for food in space?

### **Hypothesis**

Plant "X" will grow in a Space Garden and will meet objective and subjective criteria for being successfully grown in space.

### **Design**

Students will grow plants, measure plants, and evaluate them against established criteria and against control plants. They will communicate their data using tables, graphs, photos, and narrative presentation.

### **Timeframe**

A maximum period of 30-60 days will be required, depending upon the length of the growing periods for the specific plants chosen by the students. The time for each class period will vary according to the observations or measurements being made. At least a few minutes will be required every 2-3 days throughout the course of the activity for observation, measurement, and maintenance of the Space Garden.

### **Learning Objectives**

By participating in this activity students will:

- Learn about plant cultivation by preparing and caring for their Space Gardens
- Learn about plant growth by observing the emergence and growth of seedlings
- Learn that different types of plants have different growth requirements and different growth patterns
- Gain experience in measuring, weighing, and determining/estimating area and volume
- Learn to evaluate results by comparison with established criteria
- Use tables, graphs or other media to present data
- Gain communication skills by presenting in oral and/or written form the results and conclusions regarding the suitability of the chosen plant for space gardening

### **Materials**

Space Garden kits - 1 kit per 4 students, plus 2 kits for control plants

Small dishes (e.g., custard cups)

Marking tape & pen

Metric ruler

Scale accurate to 1 mg

Seeds for test plants

Seeds for control plants

Light source

### **Procedure**

1. *Experience, share, and process.* Distribute Space Garden units and ask students to examine the contents. Ask students to review and discuss some of the special features of the Space Garden units, such as the expanding bellows, “underground” watering mechanism, narrow injection port and syringe for injecting fluids, soil containment mechanism, and special growth medium. Why are these features important for growing plants in microgravity?
2. *Experience, share, and process.* Open the Arcillite<sup>1</sup>/fertilizer mix<sup>2</sup> and distribute small amounts (about 15 cc) in dishes to each small group (2-4 students). Ask students to suggest ways in which this growth medium is different from outdoor garden dirt (e.g., no micro flora/fauna, coarse granular texture) and commercial potting soil (e.g., coarse granular texture, very little dust, no obvious organic matter). How do these characteristics help to make Arcillite suitable for use as a rooting medium in microgravity? What are possible disadvantages?
3. *Experience.* Ask students to “play” with the Arcillite, tipping their dishes from side to side or bouncing them up and down a bit. Did the Arcillite move and slide around? Ask them to use the syringe included with the Space Garden kits to add approximately 15 ml of distilled water and mix it thoroughly with the Arcillite. Now

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<sup>1</sup> Arcillite is heat-treated clay. On earth it has several applications in industry and even in cosmetics. It is often used as a non-clouding, non-nutritive rooting medium for ponds and aquariums. It is also sometimes used as an additive to improve the aeration, water-holding, and nutrient-holding capacities of potting media. In space Arcillite has been successfully used as a substrate for growing wheat and *Brassica rapa*, a plant related to cabbage. Hartz brand kitty litter or Oil Absorb can be used as a substitute for Arcillite.

<sup>2</sup> The clay-based Arcillite contains no nutrients, therefore a slow-release fertilizer has been added.

ask them to tip the dishes again. Does the Arcillite still move around freely? Does free water spill out of the dish? (Thoroughly moist but with no free water is the appropriate degree of wetness for planting the Space Garden.) This exercise demonstrates the cohesive<sup>3</sup> (particles stick to each other) and adhesive (particles stick to the container) qualities of the moistened Arcillite. Why are cohesion and adhesion important for growing plants in space?

4. *Experience.* Ask the students to hold the moistened Arcillite over another container and turn the dish upside down. Of course, it falls out! Why would this matter in microgravity? Moving the unit suddenly or bumping into it might cause unrestrained particles to escape. This is why each Space Garden has additional means of holding the rooting medium in place—the foam pad and the base of the bellowed chamber. Why is this sort of precaution not usually necessary on earth?
5. *Experience.* Preparing to plant the Space Garden. Ask students to pour enough Arcillite into the bottoms of their Space Gardens to reach the top lip. [The person or group responsible for growing the control plant should use the same procedures as for the test plant(s).]
6. *Optional: Share, process, generalize, and apply.* Estimating the amount of water needed. Some students may want the additional challenge of estimating how much water they will need to add and then seeing how accurately they predicted the amount. Ask students to discuss possible ways to determine how much water to add. Are there ways to make the estimate by processing and applying information they already have? [For example, pour Arcillite from the base into a beaker to measure its volume. If 15 cc of Arcillite requires 15 ml water (as we saw in step 3), how much water should be required to wet the amount in the Space Garden? Be sure to pour dry Arcillite back into the Space Garden base.] At the end of step 7, ask students to

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<sup>3</sup> Water molecules, which are polar and strongly attracted to each other, are highly cohesive. They are constantly forming and breaking hydrogen bonds weak enough to allow water to flow, but strong enough to prevent individual molecules from rapidly dispersing. This is a very useful quality in microgravity, especially if some water should happen to “escape.” The surface tension of water, the result of hydrogen bonding, will hold droplets together.

compare the estimated amount of water needed with the actual amount used. Was their estimate accurate? Why or why not?

7. *Experience, share, and process.* Ask the students to use the syringe (to simulate the procedure in space) to slowly add water (keeping track of how much) through the port until the Arcillite appears evenly wet and water shows at the top. Let the Space Garden sit for a few minutes. (Why let it sit?) If there is still water visible, withdraw just enough through the port so that the free water disappears. What is the total amount of water added? Did each group add the same amount of water? If not, what might account for the differences? What was the largest amount? What was the smallest? What was the average?
8. *Experience.* Ask the groups to plant their chosen seeds according to package directions. If the foam barrier with small holes is used, place the seeds so that sprouts will come through the holes when the seeds germinate. Be sure to plant the control units (seeds and planting instructions provided) at the same time as the test plants. This is Day 1. Were there any problems with following the package directions?
9. *Experience, share and process.* Adequate light is very important. Fluorescent tube lights in an ordinary fixture work well. All units should be placed under the same light source. The tops of all Space Garden units (with the bellows completely closed) should be approximately 1 cm from the light source. Why is light important? What might happen if there is too little (or too much) light? What might happen if some units are closer to the light than others? Why is it important in an experiment to treat all units as nearly the same as possible?
10. *Share and process.* Before leaving Day 1, ask students to examine the group data collection sheets. Does the data sheet have room for all the information the students want to track? If not, what is missing? (Feel free to modify or add to the data sheets.) Why is it important to keep track of this kind of information? Ask the students to fill in as much of the information as they can at this time.

### **Break point**

11. *Experience.* Three to six days after planting (DAP) the seedlings will have emerged, depending upon plant type. Ask students to record the date of emergence on the group data sheet. Did all of the plants emerge on the same day? If not, why might there be differences (e.g., plant type, variability in seed, variability in conditions, etc.)? Do all of the plants look alike? How do they look different (e.g., size, color, direction of growth, number of cotyledons, shape of leaves, etc.)? Students may want to sketch or photograph their plants at this and later stages of development to illustrate their reports on results.
12. *Experience.* Students should observe their Space Gardens at least 2-3 times each week and add water as needed, not necessarily every day. To water the plants, use the syringe to add enough water to saturate the Arcillite (measure this amount), then withdraw and discard 60 ml of water. This method ensures that all units will be hydrated correctly and uniformly. The process of flushing and removing water also helps to aerate the rooting medium.
13. *Experience.* Ask students to record the date and amount (in ml) of water used each time (amount injected into the Space Garden port - 60 ml = amount added) on their group data sheets. Could the amount of water required for the plants to grow be a consideration in suitability for space gardening?
14. *Experience.* Students will observe their plants growing and should expand the Space Garden bellows as necessary to provide more room. The tops of each unit should be kept approximately 1 cm from the light source. (Light baffles can be constructed using aluminum foil to help distribute light evenly around the plants.)
15. *Experience.* At least once a week, ask the students to remove the top (bellows) of their Space Garden units and observe their plants closely. What are some of the similarities and differences among the different plant types? Do the plant types look more or less similar to each other as they mature than they did at the seedling stage? In what ways? This is a good time to make/take additional sketches and photos. Depending on what criteria were used in plant selection, students will want to

measure and record various plant dimensions, such as overall height and leaf length and width. Some may want to estimate the total area of plant material (Hint: the area of an oval is length X width X 0.8).<sup>4</sup>

16. *Experience and share.* At the maturity date (as noted on seed packet), harvest the plants. (The time of harvest can be adjusted at the discretion of the students, but be sure that a reasonable amount of time is given for the plants to develop.) Do these plants look like what they would be expected to look if they were grown in their gardens at home? How are they the same? How are they different?
17. *Experience.* If size and/or weight were among the selection criteria, ask students to measure and record the area and weight of the leaves. If the leaves are not the edible portion, (e.g. radishes or tomatoes) measure and weigh the edible portion. What is the ratio (area and/or weight) of the total plant to the edible portion?
18. *Process and share.* Ask each group of students to evaluate its plant choice against the selection criteria. Did their chosen plant meet the selection criteria? How did their test plant compare to the control plant? Why or why not is their test plant suitable for space gardening? Ask each small group to prepare a brief presentation. Graphs and tables can be used to present statistical information. Sketches and/or photos documenting plant growth would enhance interest and presentation.
19. *Share and process.* Ask each small group to present its report. Did all groups get the same results? What were the similarities and differences? Is one type of plant clearly better than the others? Would the students choose the same set of selection criteria again? Would they choose the same test plants? If the group would make different choices, why not run the experiment again? This is a good time to introduce the notion that most advancements in science are made by doing experiments that help scientists to clarify and refine their understanding. The results from one experiment can lead to more experiments and more information.

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<sup>4</sup> This is a good time to introduce the difference between calculating area (accurate, but difficult for uneven shapes) and estimating (easier because it's based on idealized shapes, but less precise).

**Extra**

- Students may want to prepare a presentation for another group to share what they have learned about growing plants in space, why it is important, what plants might or might not work, and how it can be done.
- Ask students to design their own Space Garden. What materials would they use? How big would it be? What special features would it have? What soil would it use? How would it get water and light? What else??
- How would the students now design an optimal plant. Would it be the same as the one they imagined at the end of Activity 1? How would it be the same? How would it be different?

## How Does My Garden Grow? - Group Data Collection Sheet

Group # \_\_\_\_\_

Type of Plant: \_\_\_\_\_

Names

Date planted: \_\_\_\_\_

\_\_\_\_\_

Number of seeds planted: \_\_\_\_\_

Date first plant emerged: \_\_\_\_\_

\_\_\_\_\_

Initial water added: \_\_\_\_\_ ml

Distance of Space Garden top from light: \_\_\_\_\_ cm

\_\_\_\_\_

Type of rooting medium: \_\_\_\_\_

Nutrients added? \_\_\_\_\_

\_\_\_\_\_

Expected days to maturity: \_\_\_\_\_

Actual days to harvest: \_\_\_\_\_

What criteria were used to select this type of plant? Did the plant type meet these criteria?

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## Some things to think about...

How many DAP before the first seedling was visible? How many days before the last one appeared?

How many of the original seedlings germinated? What is the germination rate?

Did all of the germinated plants survive? What is the survival rate?

When and how much were the bellows expanded? Then how far was the top from the light source.<sup>5</sup>

Were any plants deliberately removed? Why?

Did the plant mature in the expected time?

How much does the plant weigh? (Carefully rinse rooting medium away and remove excess moisture.)

Weight of entire plant: \_\_\_\_\_ mg    Weight of edible portion: \_\_\_\_\_ mg

What is the ratio of the edible portion to the whole plant?

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<sup>5</sup> Light intensity is related to irradiance by the inverse square law.  $E$  (intensity) =  $I$  (irradiance)/ $d^2$