Activity 1
Growing Food in Space
(Experiential)

Level

Grades 5 and higher

Introduction

People who travel over long distances need to eat food along the way. When traveling by car it's usually easy to stop at a store or restaurant. Hikers can sometimes hunt or gather food. But passengers in a plane, train or ship don't have those options and must make sure that whatever food is needed is carried along. In deciding what food to take, travelers have many needs including nutrition, safety, convenience, taste, volume and weight. These needs are similar to those of astronauts, although some of these factors are more important for space travel than on earth. Astronauts must also consider how to package, prepare, and eat food in the special environment of microgravity.

Astronauts take enough nutritious prepared foods with them to stay healthy during their flight. But any fresh foods are usually eaten within the first few days and many astronauts have found that, on long flights, they miss the taste, texture, flavor, and aroma of unprocessed food. Greens or small vegetables grown in space using a system like Space Garden could provide a welcome addition to astronauts' diets on the International Space Station (ISS). In addition, many astronauts enjoy tending plants and watching them grow as a reminder of life back on Earth.

In this activity, students will collectively develop a list of criteria to use in selecting plant species they think would be "good" to grow in space, that is, plants that they expect to grow well in a Space Garden unit and that astronauts could eat. Students will share their own experiences about gardening, discuss how they planned their gardens and decided what to plant and what to leave out, how they cared for their gardens, and

why they think they had successes or failures. Drawing on that discussion, students will be asked to "brainstorm" about what might be special requirements for growing plants in space. They will research, through internet and/or print media, criteria used by NASA to select food for astronauts. Students will also become familiar with their Space Gardens and discuss why and how the Space Garden design is appropriate for growing plants on the ISS, as well as how it limits available plant choices. Students will also use Space Gardens to grow control plants that have been grown successfully in space. Seeds and information about the control plants are included in the Space Garden kits.

In small and whole-group discussions, students will combine information and ideas gained from previous dialogue and research to establish a common set of criteria to use in selecting (and later evaluating) one or more experimental plant species to grow in their classroom Space Gardens. During the discussion they will learn to distinguish objective criteria, such as plant mass production, from subjective considerations, such as taste, recognizing that both have value. Students will develop skills in communications, research, and critical thinking that are needed in scientific inquiry. At the end of this activity, students should understand and be able to articulate why it is important to grow plants in space, how growing plants in space is different from growing plants on earth and why they have selected particular species to test/grow in their Space Gardens.

Question

Can astronauts grow plants to eat in space?

Hypothesis

Some plants can be expected to be suitable for growing and eating in space.

Design

The group as a whole will share their own gardening experiences, noting especially planning, care, and possible reasons for successes or failures.

Students in small groups will use print and electronic media to research criteria used by NASA to determine what foods are currently selected for use on the ISS. (They may also find and want to share information on how and why some of these choices will

probably be different for the 2-year mission to Mars.)

In small groups, students will examine their Space Garden units. They will note how this system is similar to a container garden on Earth as well as specific design features of the Space Garden that make it suitable for use in the microgravity environment of the ISS. In examining their Space Gardens, students will discover additional plant selection criteria.

As a class, students will compile a list of plant selection criteria derived from their own gardening experience, research on NASA requirements, and properties of the Space Garden. Since no plant is likely to meet all possible criteria, students will need to decide which of these criteria they feel are most important in choosing food plants to be grown on the ISS. Students will learn to distinguish objective (measurable) and subjective (preferential) criteria and recognize that both are important. Through group discussion, students will decide which 4-6 selection criteria they will use to select (and later evaluate) a test plant (or plants). Using the chosen selection criteria, the students will choose which plant(s) will be the experimental plant(s) grown in Activity 2.

Timeframe

The activity will require approximately three 50-minute class periods. Suggested break points are noted in the procedure after the initial discussion and research into food selection criteria and after examination and discussion of the Space Garden unit. The final class would include research into plant properties and selection of test plants. However, the activity can easily be divided in other ways to accommodate different time requirements.

Learning Objectives

By participating in this activity students will:

- Improve communications skills by sharing their gardening experiences and by articulating how they planned and cultivated their gardens.
- Improve abstract thinking by reflecting on and articulating possible reasons for success or failure in their gardens.

- Practice research skills by using print and electronic media to discover and list criteria used by NASA to choose foods for astronauts.
- Gain decision-making skills and improve communication by ranking selection criteria in order of importance and discussing reasons for the ranking.
- Gain decision-making tools by learning to distinguish between objective and subjective criteria for making choices.
- Practice research skills by using print and electronic media to determine how well possible test plants might be expected to meet the established criteria (e.g., size, nutrition, palatability).

Materials

- Classroom Space Garden kits, each containing 5 Space Garden units - at least 3 Space Garden units for each type of test plant (2-4 students per unit) plus 2 kits for control plants
- Flip chart and markers to facilitate group discussions
- Rulers (metric)
- Computers with internet access and/or access to library materials about living in space
- Gardening books, seed catalogs (paper and/or electronic) and/or seed packets for information about possible test plants
- Seeds and information for control plants
- De-ionized or distilled water
- Liquid and dry measures (metric - measuring devices for children's medication or the small measuring cups that accompany liquid medication can be used)

Procedure

Activity 1, Part 1

1. Introduce the group to the concept of growing plants in space, including a brief discussion of the need (nutritional and psychological benefit) and some major differences between gardening in space and gardening on Earth (microgravity, limited space, no bugs). Students may discover and want to share more information about

these topics during their research.

2. *Experience.* Ask the group to suggest several plants they might want to grow for food if they were traveling in space. How/why did they make these selections? After the students have researched and discussed criteria for choosing test plants, they will look at these suggestions again and discuss which they still feel are appropriate, which are not suitable, and what others they might want to add to the list.
3. *Experience and share.* Ask the students to share their personal experiences with growing plants at home, thinking especially about how they decided what to grow, how they cared for the growing plants, and what worked and what didn't. The flip chart can be used (by yourself or a volunteer participant) to list major points for these categories.
4. *Process*. Using ideas the students have generated as a basis for further discussion, ask them to reflect on how choosing plants to grow at home is different from choosing plants to grow in space. For example: *Planning*: "I want to win the biggest pumpkin contest at the 4-H Fair." vs. "I want to eat something sweet that can grow in a very small space." or *Cultivating*: "I'm going away to camp for two weeks, so the sun and the rain will take care of my garden." vs. "My plant is growing in a small container, so I will need to care for it almost every day." or *What worked/what didn't*: "Chipmunks ate all my beans!" vs. ???. Well…what plants will grow and how to grow them during spaceflight is the question we're trying to answer!!
5. *Experience.* Students meet in small groups to "brainstorm" possible criteria for choosing foods for astronauts.[1] Print or electronic media can be used to gather information confirming their suggestions and/or expanding their lists of criteria. Give students time to read and think about the print or electronic information available.
6. *Share and process.* Students meet as a whole group to consolidate and talk about the results of their small-group discussions and research. Did the small groups all generate the same set of criteria? In what ways are the lists the same? In what ways

[1] Nutrition is a critically important consideration for extended missions in space. Space Garden activities would coordinate well with a more extensive discussion and/or lesson about nutrition, basic food groups, understanding food labels and choosing a balanced diet. (More information on this topic is available from http://www.nutritionexplorations.org/ and the USDA website http://www.nal.usda.gov/fnic/pubs/bibs/edu/preschool.html.

do they differ? Why? Similarly, ask students to compare their combined list to NASA's stated criteria for choosing astronauts food (see Appendix 1).

Possible break point

7. *Experience*. Distribute Space Garden units to each small group to examine. (Small groups of 2-4 students work well, providing the benefits of interaction with others and the opportunity for hands-on experience.) Ask each group to measure and record the dimensions, inside and out, of the collapsed and expanded Space Garden. How much additional room for growth is provided by expanding the bellows?
8. *Share and process.* Is the Space Garden similar to anything with which the students are familiar (e.g., a terrarium or container garden)? How is the Space Garden different from most Earth-bound plant growth systems?[2]
9. *Experience, share and process.* What are some of the Space Garden's special features? (For example, expanding bellows with variable opening to the ambient environment, "underground" watering mechanism with a narrow injection port (the flight version also has a one-way valve to prevent leakage), soil containment mechanism (foam pad) and special growth medium.) Why are these features important for growing plants in microgravity? (For example, solid and liquid particle containment (loose particles may disrupt equipment or be inhaled by astronauts); light weight (every pound at liftoff to the ISS costs approximately $10,000); compact size but expandable to optimize available light and accommodate growing plants.)
10. *Generalize.* After examining the Space Garden units, do the students want to add (or modify) selection criteria? Why?

[2] The Space Garden is different from the Astronaut Plant Bags used in space. The design and functionality are the same, but some of the materials are different. NASA standards for flammability and environmental interactivity require the use of much more costly components.

11. *Share, process, and generalize.* Some of the selection criteria suggested by the students will undoubtedly be related to conditions under which the plants will be grown (objective) and some will reflect personal preferences (subjective). Both objective and subjective criteria are important in choosing plants that can and will be eaten in space. Ask students to classify their combined list of criteria as either objective or subjective.
12. *Share, process, and generalize.* Recognizing that some in each category may be considered more significant than others, ask students to rank each criterion on how important they feel it would be in determining what food plants might be suitable for gardening in space.
13. *Generalize and apply.* At the end of the group discussion, students should agree on four to six criteria that they feel are most important in choosing plants for food in space. These chosen criteria will be the basis for selecting a plant or plants to be tested in the Space Gardens. Does the final list contain both objective and subjective criteria? [3] Why were these criteria chosen over other possible criteria? Are some criteria more important than others? Are the chosen criteria objective or subjective?
14. *Generalize and apply.* Ask students to consider the information they have gathered from experience, research, and examining the Space Garden units in order to choose appropriate plant species to test in Activity 2 and for evaluating the test plant's suitability for space gardening. Remind the group of the list of possible test plants they generated at the beginning of the activity. Knowing what they do now, are there plants they would remove from the list? Are there others they would add? Why?

Possible break point

15. *Experience*. To make a final choice of test plants, students will need additional information about the properties (e.g., size at maturity, days to maturity, what part(s) can be eaten, taste, etc.) of plants they might want to choose. Sources for this type of

[3] The criteria for choosing food plants to be grown in space are not all the same as choosing foods to be carried into and eaten in space. An extra activity might introduce the concept of set theory, including drawing a Venn diagram to graphically illustrate where these criteria overlap and where they are different.

information include seed catalogs (print or on-line), gardening books, and seed packets. Give students time to find, read, and think about the print or electronic information available.

16. *Share, process, and generalize.* Ask students to compare selection criteria chosen earlier with what they have now discovered about plants they are interested in growing. Do the characteristics of those plants fit the selection criteria? Which plants still fit and which ones don't? Were different plants suggested by the research that might be included?
17. *Apply*. Testing the hypothesis. Are there plants that can be expected to meet the criteria for successful growth in the Space Garden (in space) and consumption (by astronauts)? Now that the students have decided on criteria for choosing a test plant and are familiar with characteristics of possible test plants and features of the Space Garden, discuss with them why or why not certain plants might be more suitable than others. Is there at least one type of plant expected to meet all of these criteria? If so, the hypothesis is true: plants can be expected to grow and be eaten in space. If not, the hypothesis is not true, at least for the current choice of criteria and available plants. If no suggested species meets all of the selection criteria, the lists may need to be revised or compromises made.
18. *Apply*. Choosing test plants. The number of other species tested can be varied, depending on the number of students and Space Garden units available. (Be sure to reserve at least one Space Garden unit for growing the control plant.)[4] Each small group can grow the same species or each group can choose a different test plant.[5] (There are advantages to both in later discussion and analysis of the results.) The test plants should be chosen by small groups (or the group as a whole if only one plant will be selected) by discussing and applying the selection standards and taking into consideration what is known about how the possible plants can be expected to grow. Species selected should be expected to meet all or most of the selection criteria established by the group as whole. Students should share their selection with the

[4] It is very important to include an experimental control as a standard for comparison and verification. Why controls are needed and the dangers of omitting them would be a fruitful topic for further discussion.
[5] It is recommended that each test plant chosen should be grown in at least two Space Garden units.

group and explain how the selection was made. Purchase or order seeds if needed.

End Activity

In addition to increased knowledge about how food is provided during space-flight, participants in Activity 1 will have gained valuable experience in the process of decision-making, gathering information from their own experience and from research, considering various criteria for making choices, and recognizing that criteria can be subjective, objective, or more significant than others in certain situations. They will discover that processing information from experience and research leads to greater clarity and a better understanding of problems they are trying to solve. Small and large group discussions and articulation of the reasons for final choices will enhance communications skills.

Extra

What foods are currently available for astronauts?
Study the food pyramid and design a sample menu for a week for an astronaut on the ISS
What plants have been grown in space? Why?
Design a “perfect” food plant to grow in space. What would it look like? What part would be eaten? How would it taste? What would it need to grow? What else can you think of?

Appendix 1

NASA considerations in selecting food for spaceflight: [6]

FOODS
Safe
Nutritious
Light weight
Compact
Appealing (i.e., good taste, smell, appearance and texture)
Easy to eat in microgravity
Easy to digest
Diet has variety
Causes no gastroenterological problems
Causes no hygiene problems (e.g., rotting waste parts)
Able to withstand temperature, acceleration and vibration of space flight
Does not require large amount of water for rehydration

PACKAGING
Light weight
Compact
Provides protection and stability for food for extended periods
Allows easy food preparation with little crew input
Allows easy disposal of waste food and package
Able to withstand temperature, acceleration and vibration of spaceflight

Additional possible considerations for food plants:

Seeds light weight
Plants compact
Plants fast growing
Easy to grow in microgravity
Does not require large amounts of water or added nutrients
Nutritious
Safe
Appealing (i.e., good taste, smell, appearance and texture)
Adds variety to the diet
High ratio of edible parts to waste

[6] http://liftoff.msfc.nasa.gov/academy/astronauts/food-constraint.html