

- fits into acceptable size packages for portion control
- acceptable taste
- travels well and fit into storage compartments well
- does not produce crumbs
- stores well for long periods of time without spoiling
- simple to prepare for eating

Lesson Development

To prepare for this activity, the following background information is recommended:

- Read NASA’s 21st Century Explorer Web Text Explanation titled “Why do astronauts eat tortillas instead of bread?” at <http://ksnn.larc.nasa.gov>.
- Read the following text taken from the Observation Section of the Food for Spaceflight Student Section.

Observation

As astronauts travel into space, they need energy and proper nutrition to help keep them healthy. Astronauts have to take their food with them when they go into space. There are no refrigerators in space, so space food must be specially prepared and preserved to avoid spoilage, especially on longer missions. Food preparation, or making food ready to eat, varies with the type of food. Some foods can be eaten in their natural form, such as nuts or dried fruit. Other foods require removing the water, or dehydrate, in order to preserve and store the food. The dehydrated food is prepared by adding water back to it, or rehydrated in order to return the food to the way it was when first cooked. Macaroni and cheese, and spaghetti are dehydrated foods that astronauts must prepare this way.

One of the favorite foods of the astronauts is the tortilla. Tortillas are popular in space for several reasons. First, they are nutritious. Tortillas contain large amounts of carbohydrates that the body needs to function. Second, tortillas are easily stored since they lay flat and they don’t take up too much room. Third, tortillas are one of the perfect space foods because they do not produce small, broken pieces, or crumbs.

Crumbly or loose foods can float and make the inside of the International Space Station or space shuttle unclean and become an annoyance or even a hazard to crews and equipment. Tortillas are easier to handle in reduced gravity and they also stay fresh longer than sliced bread. Making a wrap type sandwich with a tortilla requires less handling than when using two slices of bread.

Unlike tortillas found in restaurants, NASA’s are mold resistant. The specially formulated tortillas are produced with less water than normal and are packaged in plastic bags filled with nitrogen. The tortillas taken on the ISS have a shelf life of about eighteen months.

In this activity you will select, compare, test and package foods for spaceflight suitability.

- If needed, additional research can be done on the following science topics:
 - food packaging
 - bacteria found on food
 - dehydration and rehydration
 - thermostabilization
 - food guide pyramid
 - history of space food
 - freeze drying

Instructional Procedure

1. Throughout this lesson, emphasize the steps involved in the scientific method. These steps are identified in **bold italic** print throughout the Instructional Procedure Section and in **bold** print throughout the Food For Spaceflight Student Section.
2. Preview the Scientific Investigation Rubric with the students, highlighting each Performance Indicator.
3. Show NASA's 21st Century Explorer newsbreak "Why do astronauts eat tortillas instead of bread?" to engage students and increase student knowledge about this topic.
4. Remind students about nutritional guidelines and food packaging for spaceflight.
5. Review the problem with the students.
Problem: What foods are best suited for spaceflight and what makes foods suitable for spaceflight?
6. Have the students read the **Observation** Section in the Food for Spaceflight Student Section and discuss in their groups.
7. Encourage your students to discuss and make **observations** about this topic by completing the first two columns in the KWL (KNOW/WANT TO KNOW/LEARNED) chart on the Food for Spaceflight Student Section. Use the KWL chart to help students organize prior knowledge, identify interests, and make real-world connections. As students suggest information for the "KNOW" column, ask them to share how they have come to know this information.
8. Ask your students if they have predictions relating to this activity and the "problem question". Help them refine their predictions into a **hypothesis**. In their Student Section, they should restate the "problem question" as a statement based upon their observations and predictions. Encourage students to share their hypothesis with their group.
9. Students will **test** their hypothesis following this procedure.
(The following steps are taken from the Student Section. Educator specific comments are in italics.)

Go over the rules of the science lab regarding smelling (wafting) and tasting. Tell your students that just as in the food lab at Johnson Space Center, you may not taste in the science lab. Taste testing at JSC is done in a separate area from the lab and you should do the same.

1. Brainstorm with your teacher and class about the kinds of foods the astronauts take into space. Discuss why foods must be freeze-dried, thermostabilized, or dehydrated.
2. Place the portioned foods that your group brought from home in one location for discussion. Observe these foods with your group. Discuss with your group why you brought the foods you did.
3. As a group, set up a list of properties that would make your food suitable for spaceflight. You will look for these properties during testing. Record these properties on the Food for Spaceflight Data Sheet.

After formulation of properties, call on groups to share them, and modify them if needed with suggestions from class discussion. Refer to the posted criteria about food suitability for spaceflight.

4. What types of tests would qualify the foods for spaceflight? As a group, create tests for the foods you brought from home. These tests will discover if the food shows properties that would make them suitable for spaceflight.

Give the groups time to discuss these ideas. Tests might include:

- *handling the food to test for crumbs*
- *wafting the food to test for desirable smells*
- *simulated bite test to produce crumbs*

- *reviewing the food label to test for proper nutrition and portion size*
5. Record your tests on the Food for Spaceflight data sheet in the student section.
 6. Put on your safety glasses. Remember smelling rules in the science lab and do not taste.

Stress the importance of keeping eye protection on during this portion of the lesson. Go over the rules of the science lab regarding smelling (wafting) and tasting.
 7. **Test** each food using the suitability tests you formulated.

Have students test food items and decide which would be acceptable for spaceflight. For testing, stay within the capabilities of your classroom. Narrow the choices as time allows.
 8. **Collect and record data** on the Food for Spaceflight Data Sheet.
 9. Based on your test and the posted criteria, decide if each food is suitable for spaceflight and check “yes” or “no” on the Food for Spaceflight Data Sheet.

After testing, compare the results of your test to the posted criteria on what makes food suitable for spaceflight.
 10. Gather all food items that are suitable for spaceflight together. Set all other food items aside.
 11. Discuss the packaging materials you have to use and determine which packaging material would be best for each food.
 12. Package the foods with the food packaging material. Label each food item with mailing labels or tape and a marker.
 13. **Record** the materials used for packaging each food on the Food for Spaceflight Data Sheet.

Study Data

After conducting all tests, packaging and labeling, study the data by answering the questions on the Food for Spaceflight Student Section.

Conclusion

- Discuss the answers to the Food for Spaceflight Student Section questions.
- Have the students update the LEARNED column in their KWL chart.
- Have students write a conclusion by restating their hypothesis and explaining how the results do, or do not, support their hypothesis.
- Ask students to compare their individual data to the class data. What patterns can be found?
- Ask students what they wonder now? Encourage them to design other tests and food packaging.

Assessment

- Assess student knowledge through questioning.
- Observe and assess student performance throughout the activity using the attached Scientific Investigation Rubric.

Activity Alignment to National Education Standards

National Science Education Standards

National Science Teachers Association/National Research Council (NSTA/NRC)

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry (K-8)
- Understandings about scientific inquiry (K-8)

Content Standard B: Physical Science Standards

- Properties and changes of properties in matter (5-8)

Content Standard E: Science and Technology

- Abilities of technological design (K-8)
- Understanding about science and technology (K-8)

National Health Education Standards

American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD)

Health Education Standard 3: Students will demonstrate the ability to practice health-enhancing behaviors and reduce health risks.

- identify responsible health behaviors
- Identify personal health needs

Standards for Technological Literacy

International Technology Education Association (ITEA)

Standard 3: Relationships among technologies and the connections between technology and other fields.

- Various relationships exist between technology and other fields of study (3-5)

Curriculum Explorations

To extend the concepts in this activity, the following explorations can be conducted:

Mathematics

Introduce students to sorting by using a Venn diagram to sort foods that are acceptable and not acceptable for spaceflight.

National Mathematics Education Standards

National Council of Teachers of Mathematics (NCTM)

Data Analysis and Probability Standard:

- Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them
 - collect data using observations, surveys, and experiments
 - represent data using tables and graphs such as line plots, bar graphs, and line graphs

Language Arts

Ask students to explain the tests they designed. How might students improve the tests? Where might there have been mistakes made? How might these mistakes have affected the results?

National English Language Arts Standards

National Council of Teachers of English (NCTE)

- Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and non-print texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience.

Sources and Career Links

Thanks to subject matter experts Dr. Scott Smith, Vickie Kloeris, Dr. Michele Perchonok, and Dr. Mark Ott for their contributions to the development of this education material.

Dr. Scott Smith is the lead for Johnson Space Center's Nutritional Biochemistry Laboratory. Find out more about Dr. Smith: <http://spaceflight.nasa.gov/shuttle/support/people/ssmith.html>.

Vickie Kloeris oversees nutrition requirements for astronauts and ensures that plenty of consumables are available for International Space Station missions as the ISS Food System Manager at Johnson Space Center. To find out more about her visit: http://www.nasa.gov/pdf/64770main_ffs_bio_kloeris.pdf.

Dr. Michele Perchonok is the Shuttle Food System Manager and the Advanced Food System Lead at Johnson Space Center. Read her biography, and other space food lab biographies, at: <http://www.nasa.gov/audience/formedia/presskits/spacefood/biographies.html>.

Dr. Mark Ott works with the microbiology lab at Johnson Space Center. You can find out about Dr. Ott's work at <http://sf.jsc.nasa.gov/EFO/microbiology.htm>.

Original lesson development by the NASA Johnson Space Center Human Research Program Education Outreach team.

Scientific Investigation Rubric

Activity: FOOD FOR SPACEFLIGHT

Student Name _____

Date _____

Performance Indicator	0	1	2	3	4
The student developed a clear and complete hypothesis.					
The student followed all lab safety rules and directions.					
The student followed the scientific method.					
The student recorded all data on the data sheet and drew a conclusion based on the data.					
The student asked engaging questions related to the study.					
The student conducted all food tests they designed according to the spaceflight criteria.					
Point Total					

Point total from above: _____ / (24 possible)

Grade for this investigation _____

Grading Scale:

A = 22 - 24 points

B = 19 - 21 points

C = 16 - 18 points

D = 13 - 15 points

F = 0 - 12 points