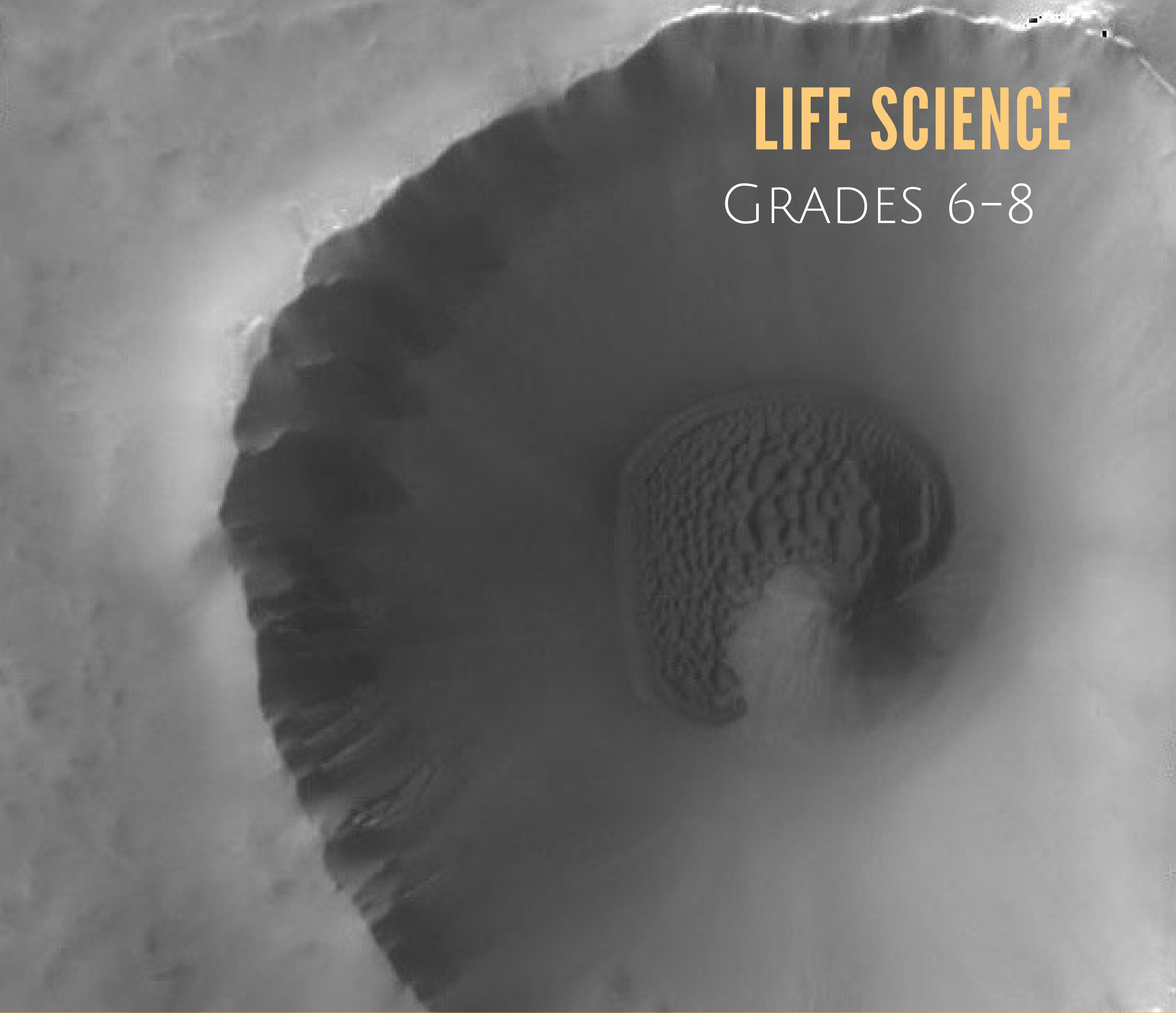
LIFE SCIENCE

GRADES 6-8



MARS MISSION OPERATIONS MANUAL

MARS BASE EAGLE

Cutting edge science lessons co-developed by teachers and NASA scientists

MARS BASE EAGLE

The first Martians are in school on Earth today, and NASA seeks students who are ready to start their Mars Colonist training today!

Mars Base Eagle, a simulated Mars colony, provides NASA Researchers' our most current understanding of how families will live, work and go to school on Mars. Life on this alien planet will be hard, and will require the skill of being able to figure out how to solve problems with the tools and supplies you already have on hand.

Have you ever solved a problem in a creative way, using only what you had available? That is what the first Martians must be able to do.

These lessons will give you a chance to start learning how to solve the kinds of problems families may face on Mars. Best wishes on your training and this important Mission.

WINGS *of* EAGLES
DISCOVERY CENTER
...imagine the possibilities

Mars Base Eagle Missions

Innovative Science Lessons Designed for Middle-level Students

Each Mars Base Eagle Mission is a set of compelling science lessons that are designed to engage all students in learning key disciplinary content with an engaging Mars context. Our collaborative teams combined expertise in typical middle school student interests, cutting-edge scientific knowledge and innovation associated with exploring Mars, and a commitment to engaging students firsthand in rigorous practices of science and engineering. Our vision is that all students who engage in Mars Base Eagle Missions--even those students who are typically underserved in schools--may become inspired to consider further science academics and careers. In addition, Mars Base Eagle Missions are designed with high rigor, so that students can learn through experience the satisfaction of figuring out plausible solutions to the barely-imaginable--in this case, sending humans to explore Mars.

Mars Base Eagle Interactive Exhibit at Wings of Eagles Discovery Center

Wings of Eagles Discovery Center teaches aviation history and space science through the lens of how situations with limited resources lead to human innovation. Notably, the NASA grant that made the Mars Base Eagle Project possible, simultaneously supported curriculum development and the design and development of a Mars exhibit at the Wings of Eagles Discovery Center in Horseheads, NY. Also collaboratively developed, this interactive exhibit was explicitly designed to support teachers and learners who engage in Mars Base Eagle Mission science lessons (as well as exhibit visitors of all ages and backgrounds). Therefore, students engaging in any of the three Mars Base Eagle Missions can use experiences with the Mars Base Eagle exhibit to develop appreciation for the Mars environment and the human ingenuity required to travel to and explore Mars. The Mars Base Eagle exhibit at Wings of Eagles can help students grasp how scientists and engineers rely upon creativity and extensive knowledge to anticipate and find solutions for challenges. Further, students can discover how challenges facing those working to put humans on Mars can be sometimes similar to and sometimes entirely unlike those challenges we face on Earth.

Science Standards Alignment

In addition, the design of the lessons in Mars Base Eagle Missions aligns with the *Next Generation Science Standards* and *New York State Science Education Standards*. This includes close alignment with the vision that science teaching and learning should reflect the interconnected nature of science by integrating learning of Disciplinary Core Ideas Crosscutting Concepts, and Practices of Science and Engineering.

Expertise Behind the Mission Ops Manual

Design and development of the three Mars Base Eagle Missions was a collaborative effort, involving highly-qualified educators and noteworthy scientists and engineers. The outpouring of assistance from NASA researchers and engineers--both retired and current--as well as numerous experts in Mars exploration and exploration in remote Earth locations was phenomenal. As one collaborator noted, students who have the opportunity to learn with all three Mars Base Eagle Missions will be some of the very most knowledgeable individuals about Mars exploration because of the multidisciplinary input that went into designing the Missions. Perhaps those students will be some of the first to explore Mars...

Contributors Curriculum Design Pilot Program

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Mars Base Eagle's exhibit and curriculum focus on the many aspects of NASA science and engineering that are working on ways to support humans living on Mars. This includes Mars transit technology, Mars environmental research, and NASA Advanced Life Support (including plant growth, food production, biomedical, geology, and water & resource recovery topics). Without the contributions of NASA scientists and engineers--who donated time and valuable expertise--design and development of the Mars Base Eagle Missions would not have been possible. Similarly, these Missions are a reflection of the expertise and classroom testing conducted by Mars Base Eagle Curriculum Design Team members.

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Life Science Mission Standards Alignment

MS-LS2.A	Interdependent Relationships in Ecosystems • Organisms and populations or organisms, are dependent on their environmental interactions with other living things and with nonliving factors. (MS-LS2-1) • Growth of organisms and populations increases are limited by access to resources. (MS-LS2-1)

Science and Engineering Practices

Practice 1: Asking Questions and Defining Problems	Asking questions and defining problems in 6–8 builds on K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models.
Practice 2: Developing and Using Models	Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Crosscutting Concepts:

System and System Models: Models can be used to represent systems and their interactions—such as inputs, processes, and outputs—and energy and matter flows within systems. (MS-PS3-2)

Cause and Effect: Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS2-5)

Navigating the Mission

Each lesson in this Mission includes the following components:

Mission Snapshot Page: Pertinent information at a glance: driving questions, learning targets, preparations, materials needed, approximate timing, and basic implementation steps ("Mission Brief")

Lesson Outline: Detailed, step-by-step suggestions for implementing the lesson

Where applicable, lessons also include:

Teacher Spec Sheets: Background information, materials for the whole class, etc.

Student Spec Sheets: Master pages to be printed or copied for student use.

Printing the Mission

The PDF file for each Mission is formatted professionally to be printed **double-sided**. There are blank pages inserted that will cause the printed pages to orient correctly.

Mission Cumulative Assessment

Mars Base Eagle Missions include an assessment that was designed, piloted, and refined to assess key understandings related to the learning targets. Using the assessment for both pre- and post-assessment can reveal a combination of impact on students' attitudes about science academics and careers, as well as insights into what new disciplinary content they were exposed to and how it thoroughly it was understood. Both assessment and key are included at the end of this Mission Ops Manual.

MARS BASE EAGLE MISSION OVERVIEW

LIFE SCIENCE

MARS EXHIBIT CONNECTIONS

Mars Base Eagle Exhibit at Wings of Eagles Discovery Center

- A field trip to the Mars Base Eagle exhibit will greatly enhance this mission.
- Students gather Mars environment information and compare it to Earth.
- Students need to grasp an overall understanding of how challenging it is to transport supplies to Mars and how infrequently supplies from Earth can be delivered.

ENGAGE

Engaging students' prior knowledge. Connecting the Mission to students' lives and interests.

- Students consider the essential ingredients in their favorite foods.
- Student groups work to reach consensus about what are the essential ingredients of tacos.

EXPLORE

Exploration experiences provide students with a shared experience and opportunities to question, wonder, and conduct preliminary investigations.

- Introduce the Mission: How could we provide the essential ingredients for tacos to explorers on Mars for Taco Tuesdays?
- Students explore through hands-on experiments to learn what plant ingredients need to grow on Earth.

EXPLAIN

Explanations in science include relevant evidence that is linked directly to claims by sound reasoning. Students have opportunities to depend their explanations with guidance from the teacher, additional research, and/or a trip to the Mars Base Eagle exhibit.

- Students research what trade-offs and affordances are associated with shipping ingredients to Mars.
- Evidence is gathered from students' growing plants to explain what plants need to grow and develop.

ELABORATE

Elaboration provides an opportunity for students to apply the explanation learned (above) to a slightly different situation. This may also include applying science practices learned during this Mission to a new experience.

- Students design growth chambers that align with the class criteria for meeting plants needs and growing some taco ingredients on Mars.

EVALUATE

Students reflect on their own learning, and teachers conduct a summative evaluation to evaluate students' progress towards the target learning objectives.

- Students evaluate their own and others' design solutions for growth chamber that takes into account the conditions on Mars.

Navigating and Printing This Mission

Navigating the Mission

Each lesson in this Mission includes the following components:

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- *Lesson Outline*: Detailed, step-by-step suggestions for implementing the lesson

Where applicable, lessons also include:

- *Teacher Spec Sheets*: Background information, materials for the whole class, etc. (varies)
- *Student Spec Sheets*: Master pages to be printed or copied for student use (varies)

Printing the Mission

The PDF file for each Mission is formatted professionally to be printed **double-sided**. There are blank pages inserted that will cause the printed pages to orient correctly.

Mission Cumulative assessment

Mars Base Eagle Missions include an assessment that was designed, piloted, and refined to assess key understandings related to the learning targets.
The test is included in the pages that follow this description and is followed by an answer key.

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MISSION 1

MAKING A MARS TACO

MISSION QUESTIONS

- What are the essential ingredients in a taco?
- What might be the essential ingredients for a taco to be made on Mars?

LEARNING TARGETS

- I can create a list of ingredients that I think are important to have in a taco.
- I can work in a group to reach consensus on the "esential" ingredients in a taco.
- I can design and label a model "basic" taco.

08:30 Approximate Time Needed: 45-60 min

PREPARATIONS

- Gather and prepare materials and copies for the lesson.
- Notice while prepping for this lesson that the focus is on food and tacos, initially, for relevance and to connect to students' prior knowledge. The Mars mission is established last in this lesson.

MATERIALS

- Equipment to project "The Mission" in #7 (optional)
- Markers, chart paper/white boards (1 per group of 3-4 students)
- Sticky notes
- Copies of Student Spec Sheet: Consensus Protocol (1 per student)

MISSION BRIEF

1. Begin with a quick-write: **"How can eating something familiar or eating a favorite food affect you?"** Summarize in a class list volunteer student responses.

2. Use a think-pair-share strategy for students to discuss: "If you had limited resources to make your favorite food, how could you modify your ingredients list?" Use the whole-class discussion of this to shift thinking to the essential ingredients that define various foods.

3. Create groups of 3-4 students, and direct groups to make on chart paper an initial list of ingredients that all group members like in tacos.

4. Reference the task in #2, and direct student groups to come to consensus about the "essential/cannot live without" ingredients for a taco, using Student Spec Sheet: Consensus Protocol. Have groups draw a star next to the ingredients they agree are the most necessary.

5. Have students use the materials provided (markers, clip art, glue sticks...) to construct and label their group's taco. Post finished taco models around the room.

6. Give each student two sticky notes. Conducta "Gallery Walk" in which students list their Notices on one sticky and their Wonders on the other as they observe all the taco models. Collect students' stickies on a central Notice/Wonder T-Chart.

7. Conclude the lesson by introducing students to their "Mars Mission."

The Situation: Your class is being sent to colonize and study Mars. You are the Supply Procurement Specialist for Intergalactic Tacos LLC. It is your job to purchase the supplies for Mars Base Eagle's chef to make meals on Mars. The chef wants to have "Taco Tuesday" every Tuesday during the month of May to bring a little taste of home to you, your classmates and your teacher.
Your Mission: Make it happen on Mars! You must procure and supply ingredients in order for "Taco Tuesday" to take place every week for the month of May.

TEACHING PROMPTS

1. Ask the class to quick-write a response to the following prompt: "How can eating something familiar or eating a favorite food affect you? Have students share responses while the teacher makes a list on the board or on chart paper.

2. Prompt students to discuss with a partner: "If you had limited resources to make your favorite food, how could you modify your ingredients list?" Ask pairs to share with others around the room, using a Think Pair Share protocol. Call on a few groups to share their thinking aloud.

3. Break students into groups of 3-4. Using chart paper and markers direct students to make an initial list of ingredients that they each like in tacos. This list may be a long list of ingredients that the students do not necessarily agree upon at the current time.

4. Ask students to recall their responses from the previous prompt: "If you had limited resources [to make a taco] how could you modify your list?" Once students have recalled the various responses, direct them to come to consensus about the "essential/cannot live without" ingredients for their taco, using Student Spec Sheet: Consensus Protocol. Ask students to prioritize these ingredients by placing a star next to the ingredients that they can agree are the most necessary for making their taco.

5. Have students use the materials provided (markers, clip art, glue sticks...) to construct and label their group's taco. When students have finished, have them post their taco models around the room.

6. Give each student two sticky notes. Conduct a "Gallery Walk" and have each student list their *Notices* on one sticky and their *Wonders* on the other as they observe all of the taco models. When students have finished this process, invite them to place their sticky notes on a central Notice/Wonder T-Chart in the room. (The teacher may use this information as a formative assessment to gauge students' understanding of the concept of prioritizing.)

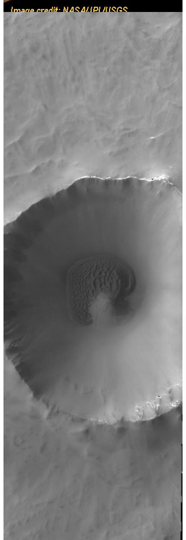
7. Conclude the lesson by introducing students to a "Mars Mission" which they will investigate. This can be shown to students on a slide, "announced" via teacher-made video, or handed out like an actual "Mission", depending on student interests/needs, time and teacher preference.

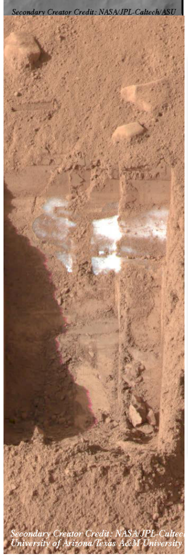
    The Situation: Your class is being sent to colonize and study Mars. You are the Supply Procurement Specialist for *Intergalactic Tacos LLC*. It is your job to purchase the supplies for Mars Base Eagle's chef to make meals on Mars. The chef wants to have "Taco Tuesday" every Tuesday during the month of May to bring a little taste of home to you, your classmates and your teacher.

    Your Mission: Make it happen on Mars! You must procure and supply ingredients for "Taco Tuesday" to take place every week for the month of May.

STUDENT SPEC SHEET

MISSION 1: CONSENSUS PROTOCOL





Step 1: Check that everyone understands the goals - to reach consensus about the essential ingredients for making a taco.

Step 2: Explore the goal and look for ideas. Gather all group members' initial ideas.

Step 3: Look for trending ideas. Start with the ingredients that are easiest to agree on, then work on those ingredients that are harder to agree about.

Step 4: Discuss and explain concerns. Look for amendments that can make the group's list even more acceptable to all.

Step 5: **Test for agreement. Do you have agreement? Check for the following**:

BLOCKS: I disagree so much we need to go back to the list.

STAND ASIDES: I disagree, but I don't want to stop our group, so I'll let the decision happen without me.

RESERVATIONS: I have some disagreement, but I'm willing to go with our list.

AGREEMENT: I support the list..

CONSENSUS: No blocks, not too many stand asides or reservations.

We have a decision!

MISSION 2

EXPLORING OPTIONS

MISSION QUESTIONS

- What are the two most practical methods for supplying ingredients for tacos to humans on Mars?
- For growing ingredients on Mars, what can we know about what plants on Earth need to grow?

LEARNING TARGETS

- I can determine the various ways for getting ingredients to the chef at Mars Base Eagle.
- I can know what it takes to successfully grow plants on Earth and infer from this what may be needed to grow plants on Mars.

Approximate Time Needed: 2-3 class periods plus ~10 min every-other-day for about 10 days to make observations of the experiments started during this Mission

08 : 30

PREPARATIONS

- Read Mission 2 Teacher Prompts, Spec Sheets, and additional handouts thoroughly well in advance. Before teaching this lesson, you'll need to decide how you want to conduct the hands-on plant investigation. In addition, you'll need to prepare appropriate classroom lights and gather all necessary planting materials (see Teacher Spec Sheet and Bottle Growing System Handout.

MATERIALS

- Plant light bank or box (see www.fastplants.org)
- Planting materials and seeds (see Teacher Spec Sheet and Bottle Growing System Handout)
- Copies of KWL chart handout (optional)

MISSION BRIEF

1. Ask volunteer students to summarize Mission 1 accomplishments. Review the Mission explained at the end of Mission 1. Then, have teams review their "Mars Taco" supply list.

2. Ask teams to brainstorm how they might supply their taco ingredients to a Mars Colony. Chart all teams' responses as they share their ideas in an interactive discussion.

3. Ask students to look for patterns. Prompt: Are there any trends in the suggested for supplying ingredients?

4. Guide students to deduce the (two) most practical methods for supplying ingredients for tacos on Mars: shipping and growing ingredients. Explain these two methods will be the focus for further exploration.

5. Explain that the first method to investigate is the option of growing plant-based ingredients. Use a prompt such as: "To explore what it would take to grow plants on Mars, we need to first understand what it takes to grow plants on Earth. What do you already know about what plants need in order to grow, here on Earth?" List student responses.

6. Explain your plan for how students will learn what plants need to grow (on Earth) through hands-on experimentation. Describe the materials you are making available and how teams will design and conduct experiments.

7. Group students in teams of 4, and guide the process of identifying and refining a question about what plants need on Earth. Then, guide students to design an experiment with Fast Plants to gather evidence useful in answering their question.The included KWL chart can be used to help guide students' thinking.

8. Conclude by having students plant their Fast Plants so that they may begin observing their plants as soon as possible. Explain that for the next 10-12 days, as the Fast Plants grow, students will make and record observations during the first minutes of class.

TEACHING PROMPTS

In the previous mission, Students explored what the essential ingredients would be for a "Mars Taco." In Mission 2, students must figure out how to successfully supply the necessary ingredients for Taco Tuesday every week for the Month of May. To do this students will need to:

- Determine the various ways of getting your ingredients to the chef at Mars Base Eagle. How might you accomplish this? (Shipping vs. Growing)
- Consider first, growing the ingredients on Mars: What does it take to successfully grow plants on Earth? How might this differ on Mars? (soil composition, hydration sources, temperature, light, air, radiation)

Exploring Options

1. Ask individual students to summarize what the class accomplished in Mission 1. Review the Mission explained at the end of Mission 1. Then, have teams review their "Mars Taco" supply list.
2. Direct teams to now consider all the ways they might supply these ingredients to a Mars Based Colony. Have teams share their ideas in an interactive discussion, while the teacher collects responses on the board or chart paper.
3. Ask students to look at the class list of responses for similarities in team-thinking. Prompt: *Are there any methods in-common for supplying ingredients?* Highlight, underline, or circle any commonalities that students identify. Where possible, begin to emphasize shipping or growing ingredients as viable options.
4. Guide students to deduce the (two) most practical methods for supplying ingredients for tacos on Mars (shipping of certain ingredients and growing of certain ingredients). Explain that these two primary methods will be the focus for further exploration in this Mission.
5. Explain that the first method the class will consider is the option of growing plant-based ingredients, and point out in groups' essential taco ingredients any mention of lettuce, tomatoes, and the corn in tortillas. Use a prompt such as:
    - *To explore what it would take to grow plants on Mars, we need to first understand what it takes to grow plants on Earth. What do you already know about what plants need in order to grow, here on Earth?* (List student responses).

6. Explain that a good way to learn what plants need to grow is to test what students think they know about growing plants in a controlled growing experiment. For this Mission, students will design experiments, using the model organism, Wisconsin Fast Plants®.

    - Teacher Spec Sheet: Investigating What Plants Need on Earth provides guidance and links to resources for supporting students to design investigations with Fast Plants.

    - Wisconsin Fast Plants Bottle Growing Systems handout is also provided in Mission 2 resource materials. These simple growing systems are constructed from recycled bottles. Also, this handout includes the standard planting instructions for Fast Plants.

7. Group students in teams of 4, and tuide student groups through the process of identifying and refining a question about what plants need on Earth. Then, guide students to design an experiment with Fast Plants to gather evidence useful in answering their question.

    - The included KWL chart can be used individually, in student experiment groups, or as a class chart to guide planning for a relevant investigation.

8. Conclude by having students plant their Fast Plants so that they may begin observing their plants as soon as possible. While their plants grow, students will simultaneously explore the options for growing plants on Mars and shipping ingredients to Mars.

    - For the next 10-12 days, as students' Fast Plants grow, plan for students to make and record observations during the first 8-15 minutes of class.

    - Alternate days when students have more or less time for observations as needed for the other lessons.

KWL Chart

MISSION 2

What do plants need to grow & produce food on Earth?

I know that...

I want to know about...

I learned that...

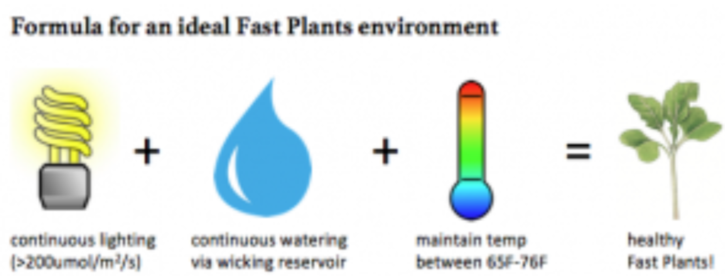
Learning what plants need through Wisconsin Fast Plants® Investigations

We know it is important to "help students make sense of the natural world by designing and carrying out authentic, student driven investigations (Wingert & Bell, 2015)." Compared to other living organisms, Wisconsin Fast Plants are easy to manage and very responsive to factors in their environment. In addition, many easy-to-observe Fast Plant phenotypes show evidence from which we can make inferences about the environment. Therefore, growing Fast Plants in controlled and varied environmental conditions is very effective for teaching through investigations what plants need to grow and develop. Also, varying the experimental environment is a valuable way to learn about natural selection and the relationships among genotype, phenotype and variation.

What kinds of investigations can be done in my classroom with Wisconsin Fast Plants?

Whether you're planning for student-centered investigation design or more guided inquiry, the Wisconsin Fast Plants Program offers online and in our digital library growing protocols for students of all ages. In addition, Carolina Biological Supply sells Wisconsin Fast Plants seeds and kits (see kit options listed below). In the following sections, we suggest some tried-and-true questions for investigations into what plants need and preparations for designing environmental investigations.

Investigations to learn about what plants need to grow and develop



Investigations into what plants need can be designed to learn about plants need at all stages of growth and development. In fact, Next Generation Science Standards specify that even Kindergarten students ought to observe and describe patterns of what plants need to survive. For example, investigation into plants needs, for example, can begin with questions such as:

- What do seeds need to germinate?
- How do seedlings develop strong stems and large, green leaves?
- What do roots need for plants to develop a dense root structure?
- How do environmental needs effect flowering and reproduction?

Keep in mind, investigations are accessible to all students when we differentiate the rigor of the underpinning questions. Similarly, we can differentiate the options available for experimental design.

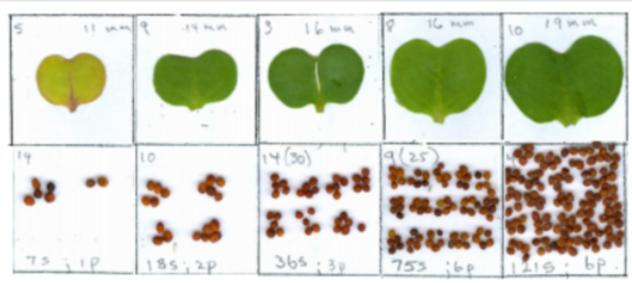
What Fast Plants kits are available that focus on the plant life cycle and investigations into what plants need?

- Wisconsin Fast Plants Elementary Exploration of Plant Life Cycles
- Reading Green: Investigating the Life Cycle and Growth of Flowering Plants
- Wisconsin Fast Plants Growth, Development, and Reproduction Advanced Student Kit
- Wisconsin Fast Plants Independent Research Kit

Investigations designed to learn about causal relationships between environmental factors and Fast Plants growth and development

Understanding how environmental factors effect growth, development, and variation in populations is fundamental to learning the big ideas in life sciences. Therefore, using Fast Plants as a model organism to investigate the effects of environmental factors is powerful for learners of all ages. Whether you're guiding students investigations or planning for open-ended, student-centered investigation design, consider the following:

- Learn more about factors of the physical, chemical, and biological environments.
- Then, learn about chemical factors and effects caused by adjusting fertilizer levels.
- Also, learn about measuring the effects of physical factors on plants grown in high and low light, or light and dark.
- Equally important, learn about observing biological/ecological interactions in competition experiments.
- In addition, consider the interactions of Fast Plants with other organisms. Such as:
    - Fast Plants & Bees
    - Brassica Butterflies



COTYLEDON SIZE AND SEED YIELD ARE INFLUENCED BY THE CHEMICAL FERTILIZER ENVIRONMENT.

What Fast Plants kits are available that focus on environmental investigations?

- Plant Nutrition Kit
- Salt Damage Kit
- Tropism: Plant Growth in Response to a Stimulus Kit
- Irradiated Seed Kit

Bottle Growing System

The Bottle Growing System (BGS) is a low-cost growing system ideal for growing Wisconsin Fast Plants. Made from recycled soda bottles these growing system are easy to build, use, and can be cleaned and reused for multiple years.

Size of Bottle	Recommended Number of Plants	Number of fertilizer pellets
16.9 ounces (0.5 liter)	4 plants	8
24 - 33 ounces (~.75 -1 liter)	8 plants	12
2 liter	12 plants	16

Materials

- one water or soda bottle
- one bottle cap or aluminum foil and rubberband to cover bottle opening
- wicking material (fabric interfacing or cotton string)
- planting medium (a soilless seed starter mixture)
- fertilizer: Solid pellets (Osmocote™)—added during planting
- Wisconsin Fast Plants® seeds
- water

Bottle System Construction

(detailed bottle preparation instructions are at www.bottlebiology.org)

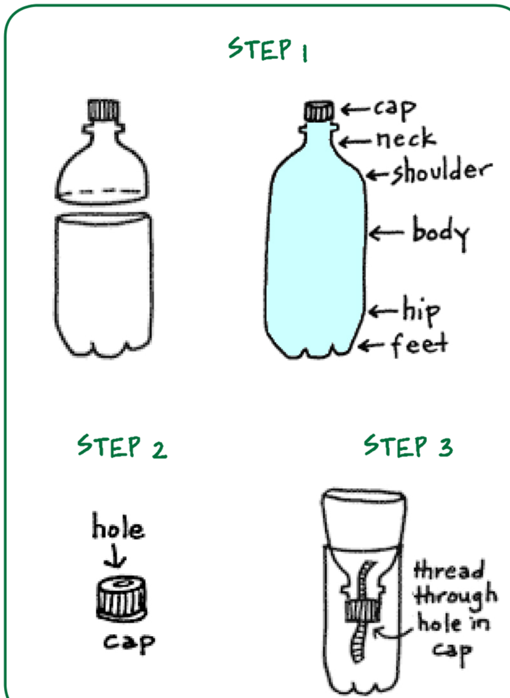
Step 1 – Remove label from the bottle. Cut bottle 1 cm below shoulder.

Step 2 – Poke or drill a 1 cm hole in bottle cap.

Alternatively, rubberband several layers of aluminum foil across the opening and poke a hole in the foil.

Step 3 – Thread a thoroughly wet wick strip through bottle top, invert top, and set into base. Wick should reach bottom of reservoir and thread loosely through cap (or aluminum foil). To be effective, the wick should run up into soil, not be plastered along a side of the bottle and not extend above the soil.

Step 4 – Fill reservoir with water.

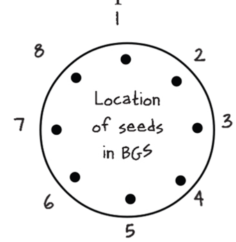


Planting Your Seeds

Step 5 – Moisten the potting mix if needed (it ought to be moist enough to hold a loose ball if compressed). Add growing mix until ¼ full.

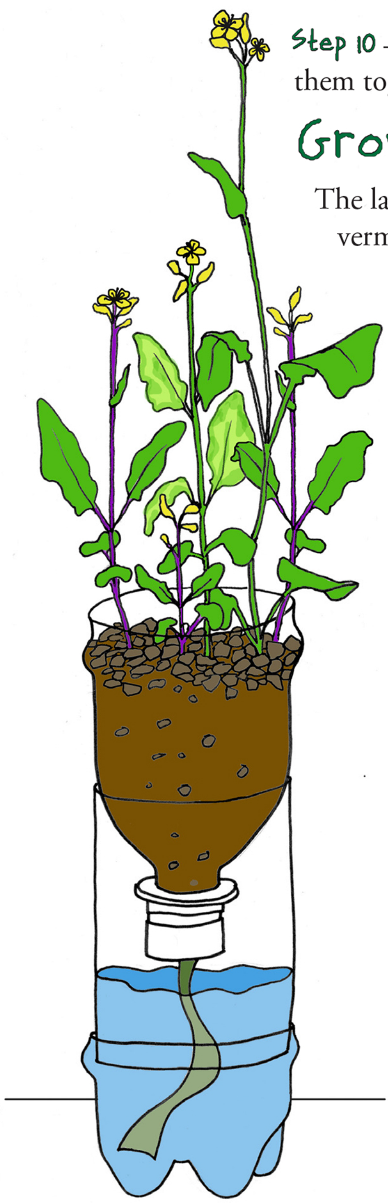
Step 6 – Scatter 12 Osmocote pellets on the surface of the potting mix then fill with additional potting mix until the bottle is filled with mix.

Step 7 – Lightly sprinkle water over the surface of the potting mix until water drips from the wick. The potting mix may drop ¼ to ½ inch after watering.



Step 8 – Place 8 seeds, evenly spaced, on top of the potting mix in a circle that is near the edge of the bottle.

Step 9 – Cover the seeds and soil with a layer of vermiculite approximately 1 cm deep. Lightly sprinkle water to moisten the vermiculite. If you do not have vermiculite, cover the seeds in potting mix.



Step 10 – Place the bottle on its water reservoir, and tape the shoulder to the reservoir to keep them together.

Growing Your Plants

The last step is to place your Bottle Growing System in a lightbox with the surface of the vermiculite or soil mix approximately 10 cm from the light bulb.

NOTE: As your plants grow, you may begin to see algae growing in the water reservoir. Two solutions to this that we recommend:

1. Cut a piece of black plastic trash bag into strips the width of the height of your water reservoir and tape plastic around the reservoir to prevent light from getting to the water.

2. Rinse and clean out the water reservoirs approximately once a week to prevent a build up of the algae.

For more information about growing and learning with Wisconsin Fast Plants visit the Fast Plants Program of UW-Madison at *www.fastplants.org*

MISSION 3

SHIPPING VERSUS GROWING

MISSION QUESTIONS

- What can we learn about traveling to and living on Mars that could help us make inferences about how we might get taco ingredients to a Mars Based colony?

LEARNING TARGETS

- I can describe the general factors and costs associated with shipping taco ingredients from Earth to Mars.
- I can know what it takes to successfully grow plants on Earth and infer from this what may be needed to grow plants on Mars.

08 : 30 Approximate Time Needed:
3-4 class periods

PREPARATIONS

- Read the Teacher Prompts for Mission 3, and decide if you will provide students with hard copies of the readings, or make the readings available online, or use a combination of print and digital reading materials.
- Make copies of the Student Spec Sheet: A/D Quad Graphic organizer

MATERIALS

- Print copies or digital access to 3 texts: (1) ***Student Spec Sheet: 5 Hazards***, :(2) "Here's how much money it actually costs to launch stuff into space" **https://tinyurl.com/y7huwgwl** and (3) "NASA Plant Researchers Explore Question of Deep-Space Food Crops" **https://tinyurl.com/y7qpfe8s**
- ***Student Spec Sheet: A/D Quad Graphic Organizer*** (1 per student)

MISSION BRIEF

1. Revisit students' KWL charts and accomplishments from Mission 2.

2. Hand out or assign online, the **Informational Text #1**: *Student Spec Sheet: Hazards of Space Travel* (Available online: https://www.nasa.gov/hrp/5-hazards-of-human-spaceflight)

3. Guide students to **interact with the text three times**, as follows:
- **First Read:** Get the Gist – Teacher reads aloud.
- **Second Read**: Mark It Up – Students read independently.
- **Third Read:** GAP and KWL -- Students read with small Group, Alone or with a Partner and update their KWL chart from the previous lesson.

4. Repeat reading activities (from step #5) with **Informational Text #2**:*"Here's how much money it actually costs to launch stuff into space"*-- http://www.businessinsider.com/spacex-rocket-cargo-price-by-weight-2016-6 and **Informational Text #3**: *"NASA Plant Researchers Explore Question of Deep-Space Food Crops"* -- https://www.nasa.gov/feature/nasa-plant-researchers-explore-question-of-deep-space-food-crops

5. As a class, complete Student Spec Sheet: A/D Quad Graphic Organizer, listing advantages and disadvantages to growing food on Mars and shipping food from Earth. Post class' quad after completion.

6. Conclude by assigning students to individually create a T-Chart, listing which ingredients they have found sufficient evidence about to conclude if it would be best to TRANSPORT or GROW it on Mars.

TEACHING PROMPTS

In Mission 3, students continue to explore options for getting the necessary ingredients for tacos to Mars. At this point in the Mission, students have determined the non-negotiables for their Mars-tacos. Students have also begun to consider their options for getting these ingredients. Students are now ready to start gathering data and information about Mars and about space travel in order to create a plan for what they might ship vs. what they believe they could successfully grow if they were in an established Mars habitat.

At this point in the Mission, the teacher should give students access to various points of information (see appendix). This information can be explored and shared in a number of ways and the teacher will want to determine the best way for students to immerse themselves in this part of the study. This is the longest lesson in the unit and can either be expanded or scaled-back depending upon student needs and time-restrictions. Because this is an inquiry unit, it is important to let students explore the information presented in order to both understand and question the information before them. If possible, the teacher should vary the approaches and provide a wide variety of reputable informational sources.

The three articles referenced in this lesson are essential to the Mission; they contain critical information, so must be followed closely. However, the intention of this lesson is two-fold: 1.) To give students the time to explore and understand the possibilities for growing on and shipping to Mars beyond these articles, and 2.) To allow time for students Fast Plants to grow and to be observed. Students will read and discuss deeply and should be allowed to explore and share findings from a variety of sources. Because our explorations and knowledge of Mars are changing rapidly, we recommend that you research and provide opportunities for students to learn from additional, fresh articles. Stations or a Jigsaw activity may be useful methods of exploring additional materials.

1. Use a review strategy to revisit students' KWL charts and accomplishments from Mission 2. Provide additional KWL charts as needed--these are used in Mission 3, also.

2. Hand out or assign online, the informational text #1: *Student Spec Sheet: Hazards of Space Travel* (Available online: https://www.nasa.gov/hrp/5-hazards-of-human-spaceflight)

3. Guide students to interact with the text three times, completing the following activities:

    - **First Read: *Get the Gist* – Teacher reads aloud.** After each paragraph or short section, students briefly summarize what the section is *mostly* about.

    - **Second Read: *Mark It Up* – Students read independently.** As students read a second time, they highlight, underline, or take notes about (if working with digital text) any information that may be evidence of factors or considerations relevant to growing food on Mars or shipping food supplies to Mars.

    - **Third Read: GAP and KWL -- Students read with small Group, Alone or with a Partner.** As students read the text aloud a third time, they add to their KWL Chart (from the previous lesson).

4. Repeat reading activities (from step #5) with **Informational Text #2**:"Here's how much money it actually costs to launch stuff into space"-- http://www.businessinsider.com/spacex-rocket-cargo-price-by-weight-2016-6 and **Informational Text #3:** "NASA Plant Researchers Explore Question of Deep-Space Food Crops" -- https://www.nasa.gov/feature/nasa-plant-researchers-explore-question-of-deep-space-food-crops

5. As a class, have students complete the **A/D Quad Graphic Organizer,** listing the advantages and disadvantages to both growing food sources directly on Mars and shipping food sources from Earth. Post the class' quad after completion.

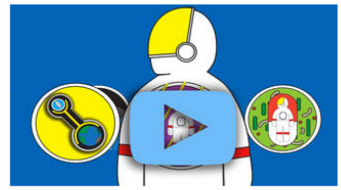
6. Conclude Mission 3 by assigning students to individually create a T-Chart, listing which ingredients they have found sufficient evidence about to conclude if it would be best to **TRANSPORT** or **GROW** it on Mars.

    Additionally, for each item listed, direct students to provide a brief, evidence-based justification for why it should either be shipped or grown on Mars (e.g. *seasonings may be shipped as they would likely be light enough to transport with little cost associated.*) This list will be used in Mission 4 during a team discussion, and can be collected and formatively assessed either before or after Mission 4.

STUDENT SPEC SHEET

MISSION 3: HAZARDS OF SPACE TRAVEL

5 Hazards of Human Spaceflight



A human journey to Mars, at first glance, offers an inexhaustible amount of complexities. To bring a mission to the Red Planet from fiction to fact, NASA's Human Research Program has organized hazards astronauts will encounter on a continual basis into five classifications. Pooling the challenges into categories allows for an organized effort to overcome the obstacles that lay before such a mission. However, these hazards do not stand alone. They can feed off one another and exacerbate effects on the human body. These hazards are being studied using ground-based analogs, laboratories, and the International Space Station, which serves as a test bed to evaluate human performance and countermeasures required for the exploration of space.

Various research platforms give NASA valuable insight into how the human body and mind might respond during extended forays into space. The resulting data, technology and methods developed serve as valuable knowledge to extrapolate to multi-year interplanetary missions.

1. Radiation

The first hazard of a human mission to Mars is also the most difficult to visualize because, well, space radiation is invisible to the human eye. Radiation is not only stealthy, but considered one of the most menacing of the five hazards.

Above Earth's natural protection, radiation exposure increases cancer risk, damages the central nervous system, can alter cognitive function, reduce motor function and prompt behavioral changes. To learn what can happen above low-Earth orbit, NASA studies how radiation affects biological samples using a ground-based research laboratory.

The space station sits just within Earth's protective magnetic field, so while our astronauts are exposed to ten-times higher radiation than on Earth, it's still a smaller dose than what deep space has in store.

To mitigate this hazard, deep space vehicles will have significant protective shielding, dosimetry, and alerts. Research is also being conducted in the field of medical countermeasures such as pharmaceuticals to help defend against radiation.

2. Isolation and confinement

Behavioral issues among groups of people crammed in a small space over a long period of time, no matter how well trained they are, are inevitable. Crews will be carefully chosen, trained and supported to ensure they can work effectively as a team for months or years in space.

On Earth we have the luxury of picking up our cell phones and instantly being connected with nearly everything and everyone around us. On a trip to Mars, astronauts will be more isolated and confined than we can imagine. Sleep loss, circadian desynchronization, and work overload compound this issue and may lead to performance decrements, adverse health outcomes, and compromised mission objectives.

To address this hazard, methods for monitoring behavioral health and adapting/refining various tools and technologies for use in the spaceflight environment are being developed to detect and treat early risk factors. Research is also being conducted in workload and performance, light therapy for circadian alignment, phase shifting and alertness.

3. Distance from Earth

The third and perhaps most apparent hazard is, quite simply, the distance. Mars is, on average, 140 million miles from Earth. Rather than a three-day lunar trip, astronauts would be leaving our planet for roughly three years. While International Space Station expeditions serve as a rough foundation for the expected impact on planning logistics for such a trip, the data isn't always comparable. If a medical event or emergency happens on the station, the crew can return home within hours. Additionally, cargo vehicles continual resupply the crews with fresh food, medical equipment, and other resources. Once you burn your engines for Mars, there is no turning back and no resupply.

Planning and self-sufficiency are essential keys to a successful Martian mission. Facing a communication delay of up to 20 minutes one way and the possibility of equipment failures or a medical emergency, astronauts must be capable of confronting an array of situations without support from their fellow team on Earth.

4. Gravity (or lack thereof)

The variance of gravity that astronauts will encounter is the fourth hazard of a human mission. On Mars, astronauts would need to live and work in three-eighths of Earth's gravitational pull for up to two years. Additionally, on the six-month trek between the planets, explorers will experience total weightlessness.

Besides Mars and deep space there is a third gravity field that must be considered. When astronauts finally return home they will need to readapt many of the systems in their bodies to Earth's gravity. Bones, muscles, cardiovascular system have all been impacted by years without standard gravity. To further complicate the problem, when astronauts transition from one gravity field to another, it's usually quite an intense experience. Blasting off from the surface of a planet or a hurdling descent through an atmosphere is many times the force of gravity.

Research is being conducted to ensure that astronauts stay healthy before, during and after their mission. NASA is identifying how current and future, FDA-approved osteoporosis treatments, and the optimal timing for such therapies could be employed to mitigate the risk for astronauts developing premature osteoporosis. Adaptability training programs and improving the ability to detect relevant sensory input are being investigated to mitigate balance control issues. Research is ongoing to characterize optimal exercise prescriptions for individual astronauts, as well as defining metabolic costs of critical mission tasks they would expect to encounter on a Mars mission.

5. Hostile/closed environments

A spacecraft is not only a home, it's also a machine. NASA understands that the ecosystem inside a vehicle plays a big role in everyday astronaut life. Important habitability factors include temperature, pressure, lighting, noise, and quantity of space. It's essential that astronauts are getting the requisite food, sleep and exercise needed to stay healthy and happy.

Technology, as often is the case with out-of-this-world exploration, comes to the rescue in creating a habitable home in a harsh environment. Everything is monitored, from air quality to possible microbial inhabitants. Microorganisms that naturally live on your body are transferred more easily from one person to another in a closed environment. Astronauts, too, contribute data points via urine and blood samples, and can reveal valuable information about possible stressors. The occupants are also asked to provide feedback about their living environment, including physical impressions and sensations so that the evolution of spacecraft can continue addressing the needs of humans in space. Extensive recycling of resources we take for granted is also imperative: oxygen, water, carbon dioxide, even our waste.

Human research essential to space exploration

NASA has already gone beyond simply identifying five challenges of human spaceflight to facilitate a focused and organized effort to reach Mars. Within the agency, there are entities dedicated to the evolution of spaceflight in all five of these areas.

NASA's Human Research Program remains committed to preserving the health and vitality of the crew that will someday touch down upon Mars. While these five hazards present significant challenges, they also offer opportunities for growth and innovation in technology, medicine and our understanding of the human body. One human challenge explored, one step closer to Mars.

Melanie Whiting, NASA Johnson Space Center; Laurie Abadie, NASA Johnson Space Center; NASA Human Research Strategic Communications
Retrieved from: https://www.nasa.gov/hrp/5-hazards-of-human-spaceflight

A/D Quad

	Advantages	Disadvantages
Transporting taco ingredients to Mars		
Shipping taco ingredients to Mars		

Considerations and Questions:

MISSION 4

DESIGNING A GROWTH CHAMBER

MISSION QUESTIONS

- How could we design a growth chamber to make it possible to grow plants on Mars?

LEARNING TARGETS

- I can use what I know about what plants need on Earth and what is currently known about conditions on Mars to propose a plausible design for a growth chamber to grow plants on Mars.

Approximate Time Needed:
2-3 class periods

PREPARATIONS

- Read the *Teacher Spec Sheet: Scientific Explanation Scaffold* in preparation for coaching students to develop scientific explanations about what plants will need to survive on Mars.
- Make copies of the *Student Spec Sheet: Evidence-based Explanation*
- Prepare for showing the video, *Your kids might live on Mars.*

MATERIALS

- Projector or other equipment and Internet access to show Your kids might live on Mars. **https://tinyurl.com/y75yy5nh**
- ***Student Spec Sheet: Evidence-based Explanation*** (1 copy per student)
- ***Student Spec Sheet: Engineering Design Process*** (1 copy per student)

MISSION BRIEF

1. Assign students to partner groups and give pairs two minutes to summarize the previous lessons. Call randomly for student pairs to briefly share.

2. Show and briefly discuss the TED2015 video, "Your kids might live on Mars. Here's how they'll survive." **https://tinyurl.com/y75yy5nh** Briefly discuss how human travel to Mars is a priority for both public and private organizations.

3. Give each student a copy of Student Spec Sheet: Evidence-based Explanation, and use a think-aloud strategy to model how to use evidence to support a claim (seeTeacher Spec Sheet: Scientific Explanation Scaffold). Then, assign students to work individually to write claims, using evidence and inferences to support each claim.
Collect the claims, and randomly draw several to read aloud anonymously. Discuss as a class whether others agree or not and why, using evidence & inferences.

4. Pair students to review and revise their claims. Then, assign students to work individually, synthesizing an explanation with all of their claims.

4. Work as a class to develop a list of all the challenges that will need to be addressed for humans to grow plants on Mars.

5. Unpack this Mission's learning target; specifically focus on the words "plausible" and "growth chamber."
I can use what I know about what plants need on Earth and what is currently known about conditions on Mars to propose a plausible design for a growth chamber to grow plants on Mars.
Discuss how student-team solutions must be designed, using the evidence we currently have about Mars and growing plants.

6. Explain, using Student Spec Sheet: Engineering Design Process, the design steps students are following to engineer an energy solution.

7. Guide students to record a summary of the list made by the class in Teacher Prompt #4 as the criteria for their designed solutions.

8. Give a minimum of 40 minutes for teams to design their solution, draw an energy flow model on chart paper, and prepare a presentation for the class.

9. Exit slip: "How will we know if the design of your energy solution is successful?"

TEACHING PROMPTS

1. Begin by assigning students to partner groups. Direct pairs to take two minutes to develop a brief summary of Missions 2 and 3. Then, call randomly for student pairs to briefly share their summaries.

2. Transition to Mission 4 by watching and discussing the TED2015 video, "*Your kids might live on Mars. Here's how they'll survive.*" https://www.ted.com/talks/stephen_petranek_your_kids_might_live_on_mars_here_s_how_they_ll_survive?utm_campaign=tedspread&utm_medium=referral&utm_source=tedcomshare

   Use this video to confirm that human travel to and exploration of Mars is plausible and being actively pursued. The video also serves as an additional source of information about challenges that will need to be resolved for humans to survive and thrive on Mars.

3. Provide each student with a copy of *Student Spec Sheet: Evidence-based Explanation,* and use a think-aloud strategy to model how to use evidence to support a claim. Relevant sample claims, evidence, and reasoning are given in *Teacher Spec Sheet: Scientific Explanation Scaffold*.

   Then, assign students to work individually to write claims, using evidence and inferences to support each claim. Students should draw on their recorded Fast Plants observations, Mission readings, other research, and class discussions for evidence.

4. When students are done writing individual claims, collect their responses, and randomly draw several to read aloud anonymously. Facilitate a whole-class discussion about whether other students agree or disagree with the claim that was read, and prompt for students to thoroughly explain why or why not, citing evidence.

5. Pair students to review each other's claims and revise or make additions to strengthen each claim. Then, assign students to again work individually to synthesize all of their claims into a final explanation. At this point, the Student Spec Sheets can be collected to receive individualized feedback and may be used as a graded assessment.

6. Work as a whole class to develop a list of all the challenges that will need to be addressed to grow food on Mars. Write the class list on the board or chart paper, while holding an interactive discussion.

7. Unpack this Mission's learning target; specifically focus on the words "plausible" and "growth chamber."

   I can use what I know about what plants need on Earth and what is currently known about conditions on Mars to propose a plausible design for a growth chamber to grow plants on Mars.

Discuss how student-team solutions must be designed, using the evidence we currently have about Mars and growing plants. In addition the solution must address the challenges described in the class list.

8. Explain, using *Student Spec Sheet: Engineering Design Process,* the design steps they are following to engineer a growth chamber solution.

9. Guide students to record a list of each criterion their solution needs to meet; this list can be recorded in a science journal or on their copy of *Student Spec Sheet: Engineering Design Process*. The list of criteria should be a summary of the list made by the class in Teacher Prompt #6.

10. Assign teams to work for a minimum of 40 minutes, designing their growth chamber solution, drawing a model of their solution, and preparing to present their solution to the class.

    Use professional judgment to set milestones that student-groups must complete, holding them accountable to producing their solution with explicit references to evidence and explanations.

11. Begin the transition to the final Mission with an exit slip that asks: “How will we know if the design of your growth chamber solution is successful?”

TEACHER SPEC SHEET

MISSION 4: SCIENTIFIC EXPLANATION SCAFFOLD

Question: If we grow the ingredients for tacos on Mars, what will we have to be able to provide from Earth and/or get from Mars for the plants that make up the ingredients to grow?

Evidence *(what I observed or found out through research)*	**Claim** *(what I think)*	**Reasoning (why I think what I think)**
Fast Plants look like other plants we have seen before	What other plants need to grow and develop is like what Fast Plants need to grow and develop	We are using Fast Plants as a model for all plants because it grows quickly and easily in our classroom and in space. Fast Plants share many similar characteristics with other plants.
Observations of Fast Plants grown from seed in a completely dark closet, in the window, and with LED grow lights showed a big difference in size and color of leaves. Those grown in dark had tiny, pale green leaves.	Plants need light energy to produce healthy leaves, and that light energy can come from sunlight or electric lights.	The lighter, smaller leaves on the plants grown in the dark look sick compared to the large, dark leaves on the plants grown in the light shows that not having light made a big difference in how plants grow.
Observations of Fast Plants grown from seed with different amounts of fertilizer in a soil that has about as little nutrients as the regolith on Mars.	Plants need to have nutrients to grow and develop into healthy plants.	The lighter, smaller leaves on the plants grown without fertilizer compared to the large, dark leaves on the plants grown with fertilizer shows that not having added fertilizer made a big difference in how plants grow.
Observations of Fast Plants grown from seed in different temperatures showed a big difference in germination and growth rates.	Plants need to grow in controlled, warm temperatures	If plants don't germinate or grow in the cold temperatures of Mars, they're of no use for tacos.
Observations of Fast Plants grown from seed at different densities....	Plants need space...	

Teacher Spec Sheet: Scientific Explanation Scaffold (continued)

Evidence *(what I observed or found out through research)*	**Claim** *(what I think)*	**Reasoning** **(why I think what I think)**
Research about the dirt, or regolith, on Mars: we learned that there is no organic matter in the regolith.	Nutrients or fertilizer will have to be transported to Mars to support growing plants there.	Nutrients in the soil on Earth comes from decomposing plants and animals, and there are no plants or animals or decomposers on Mars to do this.
Research about the dirt, or regolith, on Mars: Regolith contains super-oxides that go through chemical reactions when liquid water is added, producing hydrogen peroxide and other chemicals--not like what happens when we water soil on Earth. **&** Observations that Fast Plants when hydrogen peroxide is in the soil, Fast Plants seeds do not germinate. **&** Hydrogen peroxide label warns not to swallow it.	Until a solution is developed for changing the chemicals in the regolith on Mars, we will have to bring soil from Earth to grow plants in or grow them without soil.	I know from experience that hydrogen peroxide is used to clean wounds and prevent infection, and the bottle says it can be fatal if swallowed, too, so it must kill most living things, including plants--which is why i think they didn't grow.
Research about payload costs and the anticipated frequency of deliveries on Mars from Earth.	Delivering taco ingredients to Mars wouldn't happen often enough to count on that for Taco Tuesdays. Delivering soil to grow in on Mars would be too expensive.	I calculated costs, using the NASA info sheet and our Taco ingredients list, and I compared those costs to what NASA now spends on food, and it was way more expensive.

Explanation *(An answer to the question that was driving my investigation, built from all my claims put together logically and supported with evidence.)*
To grow plants on Mars that can be used to make tacos, we will need to have a space where the plants get light from the sun or electrical lights and provide them with nutrients that come from Earth. We will have to provide a controlled environment where they have the right temperature and amount of space to grow, and we will either have to bring seed from Earth or grow our own seed on Mars. Our use of space, light energy, heat, and nutrients will have to be very efficient because it is hard to get these things to Mars from Earth or produce them on Mars.

STUDENT SPEC SHEET

MISSION 4: EVIDENCE-BASED EXPLANATION

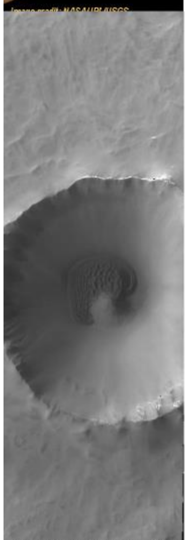
Question: If we grow the ingredients for tacos on Mars, what will we have to be able to provide from Earth and/or get from Mars for the plants that make up the ingredients to grow?

Evidence *(what I observed or found out through research)*	**Claim** *(what I think)*	**Reasoning** *(why I think what I think)*

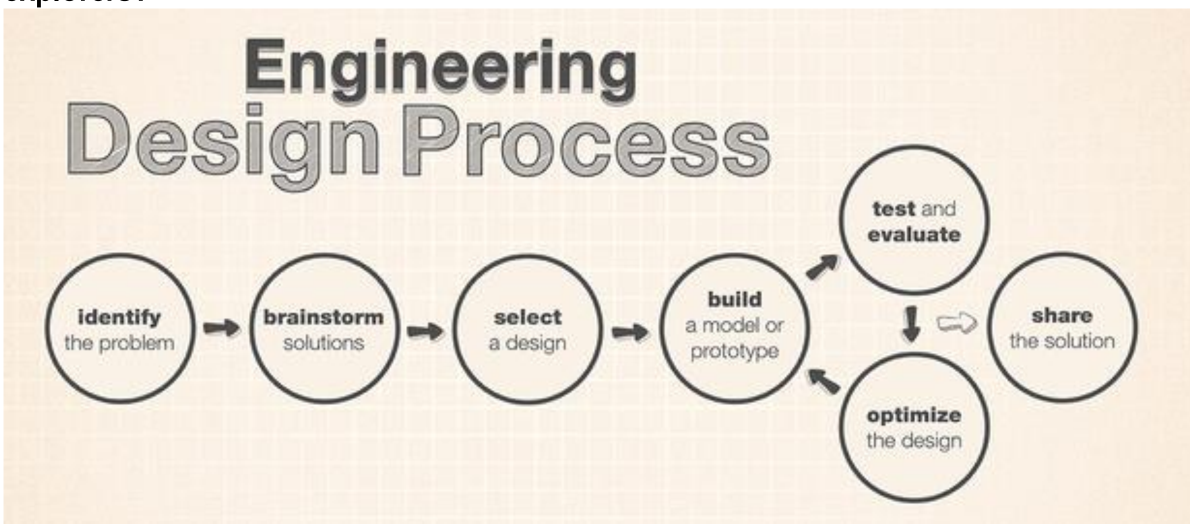
Explanation *(An answer to the question that was driving my investigation, built from all my claims put together logically and supported with evidence.)*

STUDENT SPEC SHEET

ENGINEERING DESIGN PROCESS



Use the engineering design process to design and evaluate your growth chamber solution. How well does it meet our criteria for a successful growth chamber solution for Mars explorers?



Our design criteria for a successful growth chamber:

Reflections

- **What changes could you make to the design of your growth chamber to make it better and why?**

- **What do you think are the strongest features of your design? Explain.**

MISSION 5

EVALUATING GROWTH CHAMBER DESIGNS

MISSION QUESTIONS

- How well do our proposed growth chamber solutions meet the criteria we developed for a successful solution for growing plants for food on Mars?

LEARNING TARGETS

- I can evaluate design proposals, using the criteria developed by the class and the guidelines for engineering processes to determine a proposal's strengths and recommend improvements.

Approximate Time Needed:
1 class period

PREPARATIONS

- Plan the timing for this lesson in advance to allow each team sufficient presentation time and follow-up discussion about their proposed energy solution.
- If your students are not accustomed to this type of interactive discussion and critique, you may wish to post sample sentence stems that are appropriate for questioning, agreeing, and disagreeing with ideas.
- Plan for showing "Engineering Design Process: A Taco Party" video **https://www/youtube.com/watch?v-MAhpfFt_mWM**

MATERIALS

- All students need to bring the ***Student Spec Sheet: Engineering Design Process*** from the previous lesson. Plan to have a few extra on hand for students who were absent or forget.
- Smartboard or projector to show "Engineering Design Process: A Taco Party"

MISSION BRIEF

1. Transition to Mission 5 by collecting students' exit slip responses from the end of Mission 4: "How will we know if the design of your growth chamber solution is successful?" Randomly choose several exit slips to read aloud without judgment.

2. Show the video "Engineering Design Process: A Taco Party" on YouTube to provide a quick review of the engineering design process: https://www.youtube.com/watch?v=MAhpfFt_mWM

3. From the previous lesson, have students retrieve Student Spec Sheet: "Engineering Design Process" to use as a guide.

4. Use a think-pair-share strategy to lead the class in reviewing the criteria for a good solution design.

5. In a whole class discussion, randomly call on students to give examples from experiences designing their energy solution that align with stages in the design process.

6. Provide ~1 minute per team for presentations, followed by class discussion. Check for understanding during discussion time, and hold students accountable for referring explicitly to the class criterion and the engineering design process.

7. Direct students to work individually and respond to the reflection questions on the *Student Spec sheet.: Engineering Design Process.*

8. Hold a whole-class, concluding discussion about what students learned through their Mars Missions experiences and what was most powerful and/or challenging in the learning.

TEACHING PROMPTS

1. Transition to Mission 5 by collecting students' exit slip responses from the end of Mission 4: "How will we know if the design of our growth chamber solutions are successful?"

Randomly choose several exit slips to read aloud and discuss without judgment.

2. Revisit how the process of designing a growth chamber solution that could be successfully used by Mars explorers is a good example of an engineering design challenge.

> Share the short video "Engineering Design Process: A Taco Party" on YouTube for an overview of engineering design processes: https://www.youtube.com/watch?v=MAhpfFt_mWM

3. Have students retrieve their individual copies from the previous lesson of *Student Spec Sheet: "Engineering Design Process"* to use as a guide while reflecting on their group's design process.

4. Use a think-pair-share strategy to lead the whole class in reviewing the criteria for a good solution design. Hold students accountable to cite evidence from what they have learned about the environment on Mars, the way humans will likely have to live on Mars, and what plants need to grow and develop on Earth. Unpack the learning target:

- I can evaluate design proposals using the criteria developed by the class and engineering processes to determine its strengths and recommend improvements.

5. In a whole class discussion, randomly call on students to give examples from experiences designing their energy solutions that align with design stages (shown on the Student Spec Sheet).

6. Provide ~1 minute per team for presentations, followed by class discussion. Check for understanding as students discuss to be sure they are referring explicitly to the class criterion list, what is known about plants' needs, and the engineering design process.

7. Direct students to work individually and respond to the reflection questions on the Student Spec sheet:

- *What changes could you make to the design of your growth chamber to make it better and why?*
- *What do you think are the strongest features of your design? Explain.*

8. Hold a whole-class, concluding discussion about what students learned through their Mars Missions experiences and what was most powerful and/or challenging in the learning.

Mars Base Eagle Mission Assessment

Name: ______________________________

1. I enjoy science activities and classes.
   Mark only one oval.

   ⬭ Yes
   ⬭ No

2. I enjoy research.
   Mark only one oval.

   ⬭ Yes
   ⬭ No

3. By the time I'm an adult, many people from Earth will be traveling to Mars.
   Mark only one oval.

   ⬭ Agree
   ⬭ Disagree

4. Have you ever heard of NASA?
   Mark only one oval.

   ⬭ Yes
   ⬭ No

5. If yes, what do you know about NASA

6. NASA has sent robotic research equipment to Mars.
   Mark only one oval.

   - [ ] True
   - [ ] False

7. NASA has sent a person to Mars.
   Mark only one oval.

   - [ ] True
   - [ ] False

8. Would you want to travel to Mars some day?
   Mark only one oval.

   - [ ] Yes
   - [ ] No

9. Why or Why not?

10. When you think about your future career, what do you think you would like to be?
Check all that apply.

- ☐ Farmer
- ☐ Firefighter
- ☐ Forester
- ☐ Inventor/Entrepreneur
- ☐ Journalist
- ☐ Lawyer
- ☐ LIbrarian
- ☐ Marine Biologis
- ☐ Mechanic
- ☐ Medical/Health Care(Doctor, Nurse, Technician
- ☐ Musician Park
- ☐ Ranger Pilot
- ☐ Police Officer
- ☐ Politician
- ☐ Teacher
- ☐ Veterianarian
- ☐ Video Game Developer
- ☐ Writer
- ☐ Zoologist/Zookeeper
- ☐ Other: ______________________

11. From the careers you checked, which are your top 3 choices?

1. ______________________

2. ______________________

3. ______________________

Physical Science Mission Questions

12. Which of the following would be a challenge on Mars when using solar panels to convert energy in light into electrical energy?

    Mark only one oval.

    - ◯ Mars receives less intense light from the Sun than we receive on Earth.
    - ◯ Dust carried in frequent dust storms on Mars will often shade the solar panels.
    - ◯ High levels of radiation on the surface of Mars will make constructing solar panels there challenging.
    - ◯ All of the above

Wind Turbines

13. The wind turbines shown in the photo do not run on batteries. They are operated by wind blowing against and turning the blades. Which sequence best identifies the energy transfers that take place:

    Mark only one oval.

    - ◯ Chemical energy in wind--->Energy transformation by a generator---?electrical energy and heat
    - ◯ Energy transported in sunlight--->Energy transformation--->Electrical energy and heat
    - ◯ Kinetic energy in wind--->Energy transformation by a generator--->Electrical energy and heat
    - ◯ Kinetic energy in wind--->Chemical energy transformation--->Energy in light

14. What is an advantage to relying on electrical energy generated using solar on Mars?

15. What is a disadvantage to relying on electrical energy generated using solar on Mars?

16. What is an advantage to relying on electrical energy generated using wind on Mars?

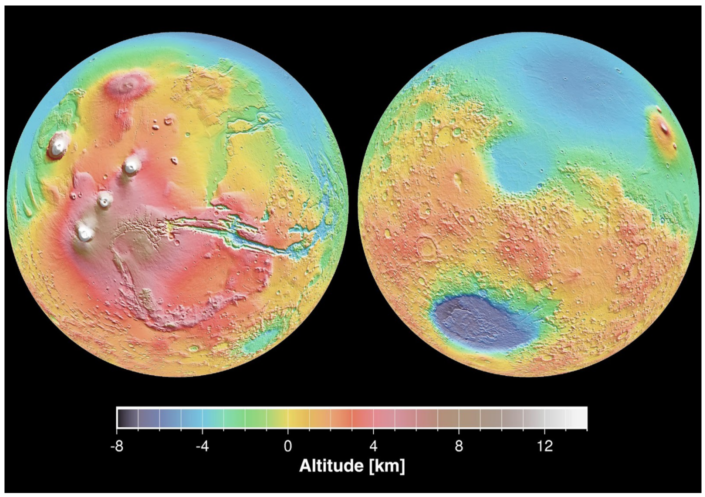
17. What is a disadvantage to relying on electrical energy generated using wind on Mars?

Earth Science Mission Questions

18. Why would humans on Mars need to use Oxygen tanks to help them breathe?
Mark only one oval.

- At high elevations on Mars the ozone layer draws oxygen out of the atmosphere.
- The atmosphere is less dense on Mars so there is less oxygen available.
- Oxygen is heavier than the other gases in the atmosphere and sinks to lower elevations.
- The atmosphere on Mars is made up primarily of carbon dioxide, with only traces of oxygen.

Mars Craters



19. The surface of Mars is covered with craters, as shown. How are most of these craters formed? **Mark only one oval.**

- By eruptions of active volcanoes.
- By impacts of many meteoroids.
- By shifting rock on Mar's surface (Marsquakes).
- By tidal forces caused by Earth and the Sun.

20. Which of these are reasons why scientists think a human colony on Mars most likely will live underground? **Mark only one oval.**

- The Sun will be too bright on Mars to live on the surface.
- Radiation levels will be too high on Mars to live on the surface.
- The surface of Mars will be too hot for humans to live there.
- The easiest way to build housing for humans on Mars will be to dig buildings underground.
- None of the above.

Life Sciences Mission Questions

21. What parts of the food web are currently missing on Mars?
Mark only one oval.

- Producers
- Consumers
- Decomposers
- All of the above
- None of the above

22. What will a human colony on Mars need to get from plants that they grow on Mars?
Mark only one oval.

- Oxygen
- Food
- Shelter
- Both A and B
- None of the above

23. When humans bring seeds of plants to Mars, will the plants they grow have the same environmental requirements plants on Earth? (light, carbon dioxide, water, minerals)
Mark only one oval.

- Yes
- No

24. Why or Why not?

Mars Base Eagle Mission Disciplinary Content Assessment Keys

Physical Science Mission Questions

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14. What is an advantage to relying on electrical energy generated using solar on Mars?

The intensity of sunlight on Mars is less, and there are frequent dust storms, and dust could shade solar panels. Given our current technologies, it would be too expensive and probably not possible to transport the number and size of solar panels and batteries necessary to support human explorers on Mars.

15. What is a disadvantage to relying on electrical energy generated using solar on Mars?

If we could develop a way to capture and use the energy in wind on Mars, it would be a form of energy that is already available on Mars, so we wouldn't have to transport that energy source.

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17. What is a disadvantage to relying on electrical energy generated using wind on Mars?

Wind on Mars is too light to move the blades on any windmills or power wind turbines that we currently have available. Although wind--including large wind storms--are common on Mars, the atmosphere is extremely thin, so winds there are very light.

Earth Science Mission Questions

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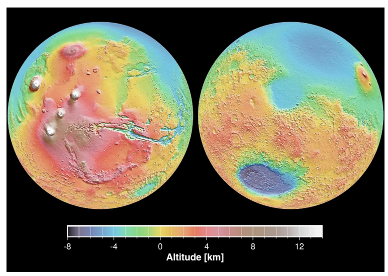

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23. When humans bring seeds of plants to Mars, will the plants they grow have the same environmental requirements plants on Earth? (light, carbon dioxide, water, minerals)
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- **Yes**
- No

24. Why or Why not?

Plants have needs that must be met for them to survive and grow, wherever they may live (like other living things). If any one of those environmental requirements is missing, the plants will die.