Activity Five: Environment

Educator Notes

Learning Objectives

Students will be able to

- Compare and contrast the environments of Earth, the Moon, and Mars
- Design to scale an enclosed, self-sustainable habitat for astronauts on a deep space mission
- Create charts or diagrams of the life support systems or cycles within the habitat and explain how they function

Challenge Overview

After watching a video on the fifth hazard for deep space astronauts, Hostile/Closed Environments, students will examine various celestial bodies to compare and contrast the environments. Students will work in teams to design ways to mitigate the dangers of a hostile environment. They are then challenged to create a conceptual habitat and identify ways to make it self-sustaining.

Suggested Pacing

120 to 180 minutes

National STEM Standards

Science and Engineering (NGSS)	
Disciplinary Core Ideas • LS2.A: Interdependent Relationships in Ecosystems: Predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared. • LS2.B: Cycle of Matter and Energy Transfer in Ecosystems: Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. *Science and Engineering Practices* • 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. • Constructing Explanations and Designing Solutions: Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.	*Science and Engineering Practices (continued)* • MS-ESS1-3: Analyze and interpret data to determine scale properties of objects in the solar system. [Clarification statement: Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences among solar system objects. Examples of scale properties include the sizes of an object's layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models.] • MS-LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. [Clarification statement: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.] • MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. [Clarification statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.] [Assessment boundary: Assessment does not include the use of chemical reactions to describe the processes.]
Mathematics (CCSS)	
Mathematical Practices • CCSS.MATH.CONTENT.6.RP.A.1: Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.	

Challenge Preparation

The educator should

- Read the introduction and background information and Educator Notes.
- Determine whether students will fill in the Comparison of Earth, Moon, and Mars handout or use the filled-in version; make copies as needed. (Both versions of the handout are located after the Student Handout.)
- Provide reading and video links to students to save time during the activity and prepare students for discussion.
  - "Growing Plants in Space." www.nasa.gov/content/growing-plants-in-space
  - "Can Space Gardening Help Astronauts Cope With Isolation?" www.nasa.gov/feature/can-space-gardening-help-astronauts-cope-with-isolation

- Hazards of Human Spaceflight: Hazard 5: Hostile Closed Environments. (3:05) www.youtube.com/watch?v=LgGt03MjHfA&feature=youtu.be
- Apollo 13: 'Houston, We've Had a Problem.' (7:00) www.youtube.com/watch?v=MdvoA-sjs0A&pbjreload=101
- Real World: The Carbon Cycle – Essential for Life on Earth. (5:43) nasaeclips.arc.nasa.gov/video/realworld/real-world-the-carbon-cycle-essential-for-life-on-earth
- Real World: Environmental Control on the International Space Station. (5:07) nasaeclips.arc.nasa.gov/video/realworld/real-world-environmental-control-on-the-international-space-station
- Real World: Lunar Power Plant. (6:28) nasaeclips.arc.nasa.gov/video/realworld/real-world-lunar-power-plant

- Have videos preloaded for presentation.

Materials

- ☐ Paper
- ☐ Graph paper
- ☐ Pencil
- ☐ Markers
- ☐ Scissors (optional)

Safety

- Students should be aware of their surroundings and move carefully throughout the room when viewing another team's work.
- Students should follow safe scissor protocol when using scissors.

Introduce the Challenge

- Explain to students that life as we know it has adapted to the conditions on Earth. There are many natural systems working together to keep the conditions on Earth regulated so that we can continue to maintain life. The Moon, Mars, and other places in the solar system have different conditions that humans cannot adapt to without protection. Astronauts who travel beyond Earth are leaving their natural life-support system. Both their spacecraft and their eventual base must be designed to keep them alive, because their destination will have an environment that is not conducive to life as we know it.
- Have students watch and discuss the video "Hazards of Human Spaceflight: Hazard 5: Hostile/Closed Environments." Explain that the best chance of long-term survival, whether in a spacecraft or on a celestial body, will be to keep the environment as similar to Earth as possible. Have students discuss the following questions:
  - What are important characteristics of long-term survival on Earth?
  - What modifications are necessary for survival on another celestial body like the Moon or Mars?
- Share the video "Apollo 13: 'Houston, We've Had a Problem'" and have students discuss the following questions:
  - What essential element are the astronauts quickly running out of in this situation?
  - How could this situation be avoided in the future?
  - Why is it important to be for an environment to be self-sustaining?
  - Is it possible to be completely self-sustaining?

Brain Booster

Aquaponics is a self-contained lunar plant growth chamber that can provide both protein and vegetation to astronauts. Fish living in the bottom provide nitrogen and phosphate for the plants, while the plants provide beneficial bacteria to convert ammonia and filter the water.

Learn more: spacescience.arc.nasa.gov/microecobiogeo/research/space-exploration-technologies/biology-is-the-technology-microbial-ecology-of-space-food-production/

On Location

Growing Beyond Earth is an educational outreach and citizen science program that reaches over 170 middle and high schools from Florida, Colorado, and Puerto Rico. NASA's Kennedy Space Center plant production scientists Gioia Massa and Trent Smith train teachers who then receive plant growth chambers that mimic Veggie, the space garden residing on the International Space Station.

Learn more: blogs.nasa.gov/kennedy/2019/05/09/students-show-off-plant-research-at-symposium-in-miami/

- Explain that in this activity students will be faced with a hostile environment. They will have to strategize ways to make the environment less hostile and utilize renewable resources to create a self-sustaining habitat in that new environment. Students will demonstrate their idea by designing a self-sustaining conceptual habitat and explain how elements necessary for life will be renewed, recycled, or created.
- Review the following criteria and constraints of the activity with students:

Criteria	Constraints
Draw cycles you are planning to integrate in your habitat and ecosystem.	Keep your habitat design to the scale size, no larger than 4.5 by 4.5 meters.
Habitat should be drawn to scale.	
You must have all necessary parts of living quarters, including airlock chamber, in your final presentation.	
Habitat may have more than one level.	

Facilitate the Challenge

? Ask

- Display a picture of a person, reptile, plant, fish, or other living thing and ask students what is necessary for this living organism to survive (e.g., food, water, and air).
- Discuss with students: We all have different habitats that we live in. We can and have learned to adapt to changes within our environment.
  - Display pictures of different ecosystems and discuss what is living there. Discuss biotic and abiotic factors.
  - It may be helpful to have students observe self-sustaining ecosystems and the organisms and cycles within them.
  - Ask students:
    - Could the living things in the ecosystem adapt in a different latitude? For example, from the equator at 0 degrees to Antarctica at 82 degrees south?
    - What happens to the oxygen after we use it? The water? Nutrients? (Have students explain the complete cycles.)
- Do a quick review of the cycles ***if needed*** (water, oxygen, nutrients, nitrogen, and carbon).
  - At their tables, assign each table a different "cycle" to draw and label with as many parts as they can without researching (e.g., water cycle, oxygen/carbon dioxide, nutrients, nitrogen, carbon, etc.). Note: Cycles curriculum should have already been covered with students prior to this activity.
  - Teams can partner up to share cycle information and see if other teams are able to add to the cycle the group originally created.
  - Have students use resources to research the cycles and add to their initial drawing. If time permits, have students present their cycles, or post them in the room so that all groups have access to the information.
  - References, if needed:
    - The Water Cycle. gpm.nasa.gov/education/water-cycle
    - The Carbon Cycle. svs.gsfc.nasa.gov/10494
    - Why Is Carbon Important? climatekids.nasa.gov/carbon/
    - What Is the Water Cycle? climatekids.nasa.gov/water-cycle/

Imagine

- Ask students to imagine they were to go to a different celestial body. Is it possible to adapt and survive?
- Have students discuss with their table or neighbor whether they could survive on another planet or celestial body.
- Listen to some of their ideas (without commenting, so as not to restrict student creativity).

Plan

- Tell students that in order to decide whether (and how) we could adapt, we first need to examine the features of the celestial bodies. Introduce the Comparison of Earth, Moon, and Stars handout. Depending on available time and student ability:
  - Have students use science resources to fill out the chart (individually, as a team, or with the whole group); or
  - Provide students with the completed chart. Group them in small teams to review the differences between the three celestial bodies.
- Regroup and ask students if they think their original ideas from the **Imagine** phase would have kept them alive, now that they have done some research.
- Discuss the differences between Earth, Moon, Mars, and the other celestial bodies selected.
- Ask students the following questions:
  - What makes the environment hostile?
  - Could we grow food without intervention? Explain.
  - Are there some elements or features that can be useful? If so, what are they?
- Have students read the following articles:
  - "Growing Plants in Space." www.nasa.gov/content/growing-plants-in-space
  - "Can Space Gardening Help Astronauts Cope With Isolation?" www.nasa.gov/feature/can-space-gardening-help-astronauts-cope-with-isolation
- Share all or part of the video "NASA STEM Stars: Veggie." www.youtube.com/watch?v=7ukuCm7xrVY&t=44s

  Note: The excerpt from time stamp 11:45 to 15:50 is most important for student viewing.
- Ask students to explain why they think it is important to be able to grow vegetation in space.
- Have students get in their small teams to discuss the elements needed in a habitat for it to be self-sustaining.
- Come together and discuss as a whole group. Be sure to discuss what is needed.

Create

- Remind students that humans have adapted to life on Earth, but the environments on other celestial bodies are not conducive to life as we know it. To keep astronauts healthy, students need to create a habitat that is adaptable to the environment.
- Looking at the chart, have students choose a celestial body where they want to create a habitat that is self-sustainable.
- Remind students to check the criteria and constraints.
- Students will work in teams of no more than three and will be asked to do the following:
  1. Design and draw a habitat to scale that will sustain life on the celestial body of their choice.
  2. Explain and diagram the life support systems within the habitat.
  3. Create a diagram of how each of the following will be renewed, created, or recycled:
     - Oxygen
     - Water
     - Waste and garbage
     - Food
     - Power source
- Have students review their design with the whole group and talk things through to be sure that the habitat will be self-sustainable. Encourage them to review it with another educator or adult so that they can get another person's point of view and then make improvements as needed.
  - Ecosystem resource if needed: climatekids.nasa.gov/10-things-ecosystems/

Test

- Have students meet with the instructor to discuss how the habitat will be self-sustaining. Be sure the teams can explain how all essentials for life are being met, how food is being produced, what the source of power is, and where their waste and garbage is going.
- Make suggestions or point out areas of improvement.

Improve

- Have students return to their teams and adjust their habitat to address suggestions for improvement or missed objectives.
- Have students update their drawings and explanations as needed

Share

- Have each team present their design to the whole group and explain how they will establish the habitat to be self-sustainable.
- Optional: Share students' results on social media using #NextGenSTEM. Be sure to include the module and activity name.

Extensions

- Have students test their ideas for the habitat on an enclosed ecosystem and try to sustain the life of a Plant-stronaut. Have them create a table-top-size, sealed ecosystem to test their ideas. Put a plant in the ecosystem and test the sustainability of their habitat.
- Have students add additional levels to the ecosystem for their Plant-stronaut.
- Have the whole group collaborate by taking the best parts of each habitat to design a Super Habitat.

References

Life Support Systems
www.nasa.gov/stem-ed-resources/life-support.html

Living and Working in Space: Habitat
www.nasa.gov/pdf/176994main_plugin-176994main_HSE_TG2-1.pdf

Activity Five: Environment

Student Handout

Your Challenge

You will compare environments of different celestial bodies and decide which celestial body has the best conditions to support a self-sustaining habitat for astronauts. You will design or draw to scale a conceptual enclosed, self-sustainable habitat for astronauts on a deep space mission. You will draw diagrams that shows how you renew and recycle the needed items to sustain life.

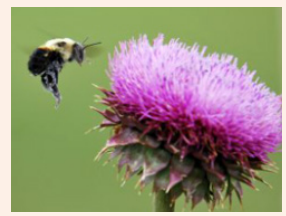
Criteria	Constraints
Draw cycles you are planning to integrate in your habitat and ecosystem.	Keep your habitat design to the size no larger than 4.5 by 4.5 meters.
Habitat should be drawn to scale.	
You must have all necessary parts of living quarters, including airlock chamber, in your final presentation.	
Habitat may have more than one level.	

? Ask

- Look at the pictures displayed. What is necessary for each of the following to survive:
  - Person?
  - Reptile?
  - Plant?
  - Fish?
  - Amphibian?
- Look at the pictures of the different ecosystems provided and discuss with your neighbor what you see. Talk about the biotic and abiotic factors.
- As you examine each picture, discuss the following questions:
  - What is needed for all the living things pictured to adapt to live in a different latitude?
  - How could the organism adapt to live in Antarctica if they were from a tropical environment?
  - What happens to the oxygen after the animals use it?
  - What happens to the water after it is consumed?
  - What happens to the nutrients that were taken in?
- As a team, draw the cycle your instructor has assigned and label as many parts as possible without researching.
- Partner and share cycle information with another team and see if you can add to each other's work.
- Research your cycle, using a credible science resource. See if there is any information missing and fill it in.
- Share your information as your instructor directs.

Fun Fact

Ultraviolet (UV) light has shorter wavelengths than visible light. Although UV waves are invisible to the human eye, some insects, such as bumblebees, can see them. This is similar to how a dog can hear a whistle just outside the hearing range of humans.



Learn more:
science.nasa.gov/ems/10_ultravioletwaves

Career Corner

Dr. Gioia Massa works on space crop production for the International Space Station and future missions at the NASA Kennedy Space Center. She led the science team for the in-space validation of the Veggie experiment hardware and now leads an interdisciplinary group studying how both fertilizer and light affect the flavor of crops grown in Veggie.

Learn more:
www.nasa.gov/content/veggie-plant-growth-system-activated-on-international-space-station

Imagine

- Imagine you were to go to a different celestial body. Is it possible to adapt and survive?
- Discuss with your table or neighbor whether you think you could survive on another planet or celestial body and how.

Plan

- In order to decide if you could adapt and how, you first need to examine features from other potential worlds. You will be provided with a chart of characteristics of the Earth, Moon, and Mars.
- After filling in or looking at the data with your team, answer the following questions:
  - What makes the environments hostile?
  - Could we grow food without intervention? Explain.
  - Are there some elements or features that could be useful? If so, what are they?
- Read the following articles:
  - Growing Plants in Space. www.nasa.gov/content/growing-plants-in-space
  - Can Space Gardening Help Astronauts Cope With Isolation? www.nasa.gov/feature/can-space-gardening-help-astronauts-cope-with-isolation
- Watch the excerpt of “NASA STEM Stars: Veggie” (11:45 to 15:50). www.youtube.com/watch?v=7ukuCm7xrVY&t=44s
- Why do you think it is important to have the programs that were talked about in the article and in the video?
- How can these programs benefit the space program and future missions?
- In your team, discuss and write your ideas regarding what environmental elements and other items are needed in a habitat for it to be self-sustaining.

Create

- Humans have adapted to live on Earth. The environments on other celestial bodies are not conducive to life as we know it. To keep astronauts healthy, you must create a habitat that is adaptable and self-sustainable.
- Choose a celestial body from the chart that you think will be the best for adaptation. You will be using this body to create a habitat that is self-sustainable.
- Check the constraints and criteria.
- Work in teams to do the following:
  1. Design and draw a habitat to scale that will sustain life on the celestial body of your choice.
  2. Explain and diagram the life support systems within the habitat.
  3. Create a diagram of how each of the following will be renewed, created, or recycled:
     - Oxygen
     - Water
     - Waste and garbage
     - Food
     - Power source
- Review your design with the team and talk things through to be sure that the habitat will be self-sustainable. Practice explaining your design to another adult or teacher and have them give you feedback.
- Review the feedback that you were given and make improvements as needed.

Test

- Meet with the instructor to discuss the how the habitat will be self-sustaining. Be sure you can explain how all essentials for life are being met (e.g., how food is being produced, the source of power, where the waste and garbage is going, etc.).

Improve

- Return to your team and adjust your habitat to address suggestions for improvement or missed objectives.
- Update your drawings and explanations as needed.

Share

- Present your design to everyone and explain how you will establish the habitat to be self-sustainable.

Comparison of Earth, Moon, and Mars (Fillable Chart)

Directions: Using science resources, fill in the chart to compare features of Earth, the Moon, Mars, and (optional) one other celestial body of your choice. Optional links to use for the chart:

- Mars Exploration Program: mars.nasa.gov/all-about-mars/facts/
- Planetary Data: nssdc.gsfc.nasa.gov/
- Temperature Variations and Habitability: icp.giss.nasa.gov/education/modules/eccm/eccm_student_1.pdf#page=3

	Earth	Moon	Mars	Other ________
Atmosphere composition				
Distance from Earth at closest point, km	N/A			
Distance from Earth at farthest point, km				
Air pressure, mb (millibars)				
Terrain composition				
Terrain texture				
Length of day				
Surface gravity, m/s^2				
Temperature range, °C				
Radiation or protection from radiation				
Water (evidence or states of water)				
Signs of life				
Volcanic activity				
Other storms or hazards				
Special features or areas to place your habitat in or near	----			

Comparison of Earth, Moon, and Mars (Completed Chart)

Resource links to use with the chart:

- Mars Exploration Program: mars.nasa.gov/all-about-mars/facts/
- Planetary Data: nssdc.gsfc.nasa.gov/
- Temperature Variations and Habitability: icp.giss.nasa.gov/education/modules/eccm/eccm_student_1.pdf#page=3

	Earth	Moon	Mars
Atmosphere composition	78 percent nitrogen 21 percent oxygen	Basically none. Some carbon gases (CO_2, CO, and methane), but very little of them. Pressure is about one-trillionth of Earth's atmospheric pressure.	95 percent CO_2 2 percent nitrogen 2 percent argon 1 percent oxygen
Distance from Earth at closest point, km	N/A	357,000	54.6 million
Distance from Earth at farthest point, km	N/A	407,000	401 million
Air pressure at surface, mb (millibars)	1,014	>1	4 to 9, depending on the season
Terrain composition	Oxygen, silicon, aluminum and iron are the elements that make up the crust. The terrain includes weathered crust material, organic material, and moisture.	Silicon and oxygen bound in minerals, glass produced by meteorite impacts, and small amounts of gases (e.g., hydrogen) implanted by the solar wind	Silicon and oxygen, iron, magnesium, aluminum, calcium, and potassium
Length of day, hour	24	27.3 Earth days	24.7
Surface gravity, m/s²	9.8	1.62	3.71
Temperature range, °C	10 to 20	–233 to 123	–60 to –125
Radiation or protection from radiation	Atmosphere and magnetic field block out most radiation.	Cosmic rays, solar flares, the lunar surface itself is radioactive	Solar and GCR radiation, no protection
Water (evidence or states of water)	Water in all states	Water ice	Traces of water, evidence of a watery past
Signs of life	Life!	no	
Volcanic activity	Yes	Yes	Yes, largest volcano in solar system, Olympus Mons, is 3 times larger than Mount Everest
Other storms or hazards	Earthquakes, floods, etc.	Meteorite strikes, water ice at South Pole	Dust storms, tornadoes
Special features or areas to place your habitat in or near	N/A	Answers may vary	Lava tubes beneath the ground Answers may vary