Colonizing Space

Session Time: Three, 50-minute sessions

DESIRED RESULTS

ESSENTIAL UNDERSTANDINGS

Develop interest in one or more aviation/aerospace career pathways and learn what is required to pursue future employment in the industry. (EU3)

Aspire to the highest level of technical proficiency as it relates to flight operations and engineering processes. (EU5)

ESSENTIAL QUESTIONS

1. Will we ever be able to solve the challenges of colonizing space?
2. Will Mars have more people on it than Earth someday?

LEARNING GOALS

Students Will Know

- NASA's four driving questions for Mars exploration
- Futurists will look to colonizing other planets as a way to solve such issues as the overcrowding of Earth, depletion of natural resources, and sustaining life
- Challenges that exist for traveling to and living on Mars
- Current efforts underway to make traveling to and living on Mars a possibility for humans
- Mars' special attraction as a planet to colonize due to its relatively close proximity to Earth and similar environment

Students Will Be Able To

- *Describe* challenges that must be solved in order for the colonization of Mars to become a reality. (DOK-L3)
- *Design* a habitat that would allow humans to live on Mars. (DOK-L4)

ASSESSMENT EVIDENCE

Warm-up
Students will identify what they believe are to be the top three challenges of permanent human habitation on another planet.

Formative Assessment
In small groups, students will brainstorm questions that must be answered in order for humans to colonize Mars.

Summative Assessment

Students will deliver presentations that cover key features of the research they completed on the challenges of living on Mars.

LESSON PREPARATION

MATERIALS/RESOURCES

- Colonizing Space Presentation
- Colonizing Space Student Activity

Welcome to Columbia Hills, Mars! Activity

- Graph paper (per student)
- Poster board or rolled paper (per team)
- Markers (per team)

LESSON SUMMARY

Lesson 1: Colonizing Space

This lesson will begin by asking students to consider the challenges of living on another planet. Share with students that this lesson will focus on living in space and on Mars. Challenges about human habitation of Mars are issues currently being worked on by NASA and others.

After a short video that highlights all of NASA's missions to Mars, students will discuss what NASA has learned from previous Martian missions that will aid in the development of humans living on Mars someday.

Students will learn why many organizations, including NASA, are focused on exploring Mars. Students will learn NASA's four driving questions about exploring Mars that scientists are working to answer.

After further class discussion, students will be introduced to an activity in which they will work in small teams to solve challenges associated with an aspect of building and living on a Mars colony. Students will work on the activity during the second and third sessions of this lesson and reflect on what they have learned.

During the third session, students will deliver brief presentations describing highlights of their Mars colony.

BACKGROUND

This lesson introduces students to the concept of space colonization. Mars is the focus of international research as a future location for colonization due to its surface conditions and evidence of the past presence of water. It is considered the most hospitable planet in the solar system besides Earth and is in relatively close proximity (travel there can be accomplished in six to nine months.)

Many organizations, including NASA, are focusing their attention and resources on making human exploration of Mars a more likely possibility. The International Mars Society conducts public outreach to further the goal of human exploration on Mars. The Mars Institute seeks to further scientific research on Mars. Mars One selected 100 people to colonize Mars. Although timing and funding for this project is uncertain, it provides evidence of interest in further exploration of the "Red Planet."

Mars is thought to be the most Earth-like of all other planets in our solar system and has many resources that would be useful—ice in the ground and on polar ice caps, carbon dioxide in the atmosphere from which to generate oxygen, and much more. However, there are still many challenges to human exploration and colonization of Mars. Radiation is thought to be the biggest challenge, and no solution has yet been discovered to protect humans from long-duration exposure to solar flares and cosmic rays. Unlike Earth, Mars does not have a magnetic field protecting it, leaving it

exposed to harmful solar ultraviolet radiation. Another challenge is power supply. Very large solar panels would be needed to generate sufficient power to colonize, although dust storms every few years would present a significant challenge. Nuclear power could be a possibility in the future.

MISCONCEPTIONS

Students may think the challenge of going to Mars has been resolved. In reality, questions of radiation exposure, food and water sustainability, and many other challenges still exist.

Another common misconception is that outer space is cold, but in truth, space itself has no temperature. In thermodynamic terms, temperature is a function of heat energy in a given amount of matter, and space by definition has no mass. Furthermore, heat transfer cannot occur the same way in space because two of the three methods of heat transfer (conduction and convection) cannot occur without matter.

DIFFERENTIATION

If needed, print information from https://mars.nasa.gov/ to help provide additional guidance for the student activity.

LEARNING PLAN

ENGAGE

Teacher Material: Colonizing Space Presentation

Slides 1-3: Introduce the topic and learning objectives for the lesson.

Slide 4: Conduct the **Warm-Up**.

Warm-Up

During the Warm-Up, students will think individually about the possibility of living on another planet. Ask them to identify what they think are the three most significant challenges that must be overcome to allow for permanent human habitation on another planet.

When students are finished, ask volunteers to share their responses.

Possible responses include protecting humans from radiation; creating and storing power, water, and food supply; improving space suits, developing a way to regularly communicate back to Earth, creating oxygen to breath, etc.

[DOK L1; *identify*]

EXPLORE

Teacher Material: Colonizing Space Presentation

Slide 5: Students may not realize that NASA has been exploring Mars for more than 50 years. Nearly 20 robotic missions to Mars have laid the groundwork for the first human mission. Show students a video about the history of NASA's missions to Mars, including present-day missions.

- "50 Years of Mars Exploration" (Length 4:08)
  https://video.link/w/vWOnc

- For teachers unable to access Video.Link links, the video is also available here: https://www.youtube.com/watch?v=pwipxdQ74pU

Slide 6: After the video, ask students to explain in writing what NASA has learned from previous Martian missions that will aid in the development of humans living on Mars someday and how this knowledge will help us to complete this audacious goal.

Questions

What has NASA learned from previous Martian missions that will aide in the development of humans living on Mars? How will this knowledge help us complete this audacious goal?
Through exploration, NASA has gathered data; explored terrain; gathered soil samples; and tested various landing techniques. As a result, this will help us determine new landing sites and find the most habitable areas on the planet, find soil that offers resources useful for human dwelling, etc.

Slide 7: Mars' similarities to Earth are the most compelling when considering colonization. Explain to students why Mars continues to be a focus for space exploration and colonization.

Slide 8: Introduce students to NASA's four driving questions for Mars exploration using a discussion. Be sure to tell students that current NASA scientists are focused on these same questions when studying Mars. Answers are still unknown.

In looking for life on another planet, Mars is the most similar to Earth, so scientists are searching there first. Currently, there does not appear to be life on Mars. Mars has a very thin atmosphere, and that would have had to have been much thicker to support life at one time. Additionally, the most important requirement for life is liquid water. NASA has confirmed that liquid water has been found on Mars. Many missions have looked for signs of life by taking pictures of the surface to find evidence of water. In 2004, the Spirit and Opportunity rovers were specifically tasked with looking for past evidence on Mars that could have supported life.

EXPLAIN

Teacher Material: Colonizing Space Presentation

Slide 9: Through video, students will learn more about the challenges of living on Mars and the search for solutions to these problems.

- "Future of Human Space Exploration" (Length 3:16)
http://video.link/w/QSOf

Slide 10: A one-way trip to Mars could take five to six months, exposing astronauts to deep-space cosmic rays as never before. On Earth, we are protected from these harmful rays by our atmosphere. On the International Space Station, much of this radiation is deflected by Earth's magnetic field or blocked by Earth. Researchers are working to develop new materials and technology to protect astronauts from the much harsher environment of traveling in deep space.

Astronauts will be doing construction and research on Mars. Robotics, tools, and materials will be essential to this effort but will require a power source. Astronauts will need to be able to produce oxygen and water as they work and live on Mars. Communication will involve a nearly 30-minute lag, which, in the case of emergency, could be a matter of life and death. NASA is working to develop a laser communication system to operate at higher radio frequencies and delay lag time.

Slide 11: Nutrition and health are major concerns for traveling to Mars. Cardiac health, bone mineral density, and muscle mass are all impacted by long-duration space flight. Astronauts must participate in aerobic and resistive exercise to keep their bodies healthy and strong. Additionally, astronauts must learn how to produce food supplies with limited resources in order to maintain healthy levels of vitamins and minerals.

Slide 12: The discovery of liquid water greatly increases the ability for astronauts to dwell on Mars for long durations. The more astronauts learn about liquid water, Martian soil, and other resources available on the Martian surface, the more they learn about how life can be supported and what resources are needed in the future.

Companies are developing habitats for deep space. Some include concepts such as inflatable modules. The benefits of using expandable compartments is the ability to launch from Earth at a small volume and then expand them to a dwelling much larger once on Mars.

Slide 13: Show the following video to help students better understand how aerospace engineers are meeting the challenge of limited space on launches to account for much larger living habitats for astronauts. Although this video suggests this is for the International Space Station, the concept of inflatable habitats is being considered for deep-space missions and living on Mars.

- The Future of the International Space Station is Inflatable (Length 2:56)
  http://video.link/w/JmPf

Slide 14: Conduct the **Formative Assessment**. This will complete the first session of this lesson.

Formative Assessment

Tell the students they are being hired to plan a colony on Mars. Their work will begin by brainstorming challenges posed by different aspects of living and working on the Red Planet.

Divide students into small teams, and assign each team one topic from the following categories about colonizing space: living habitat, food and water, transportation, jobs, health and exercise, and oxygen supply.

Ask each team to write a list of five to 10 questions that would need to be answered in order address the challenge they've been assigned (e.g. for the food and water category, students may question what type of food will grow in Martian soil or what properties of Martian soil are similar to soil on Earth).

After five minutes, ask each group to share their responses, and allow for a brief discussion.

[DOK L3; *assess*]

Questions

The following responses serve as examples of questions for each category:

Living habitat – What type of materials would be needed to build a home on Mars? How would the materials differ from those used for buildings on Earth? What type of weather does Mars have? How would the weather impact living structures? What natural resources are available on Mars that could be used in construction?

Food and water – Would water be available on Mars' surface to drink? What food could grow on Mars? Are there any similarities between Martian soil and Earth's soil? What is needed from Earth to help plants grow on Mars? Is it possible to have animals on Mars for food? How would humans meet all their nutrition needs?

Transportation – How would people get to work on Mars? What kind of transportation would work best on Mars? What type of tire would be needed for the Martian surface? How would a vehicle run different on Mars than Earth? How could a person breathe while in a vehicle?

Job – To start a colony, what types of projects would need to be completed? What jobs would be needed to complete these projects? What types of supporting jobs would be needed? How would these jobs differ from those on Earth? What types of skills would be needed? What equipment would be needed to do these jobs?

Health and exercise – How would Martian residents stay healthy? How much would the residents need to exercise each day to maintain their health? What kinds of effects would Mars' harsh environment have on human health? What types of exercise are possible? What types of exercise equipment would be needed?

Oxygen supply – Where would oxygen be needed? Would residents need to carry oxygen with them at all times? How long would tanks of oxygen last? How would oxygen tanks be refilled? Where would the oxygen supply come from? How much oxygen would need to be stored? How much oxygen is used in one day?

EXTEND

Teacher Material: Colonizing Space Presentation
Student Material: Colonizing Space Student Activity

Slide 15: Over the next two sessions, students will complete an activity called "Welcome to Columbia Hills, Mars!" in which they will plan a Mars colony. Provide copies of **Colonizing Space Student Activity** to each student.

Using the same teams from the formative assessment, students will be asked questions pertaining to their assigned topics and complete research to answer the questions.The questions they formulated during the formative assessment are designed to help them focus their research. Tell students to answer the last question after all groups have completed their presentations.

Students will be assigned the questions in "Part 2 Analysis" as homework. Students will answer the following questions:

- What did you learn from this activity?
- What surprised you the most in this activity? Were there things about living on Mars that you had not considered before?
- In your opinion, what would be the most challenging part of living on Mars? How would you overcome it?

EVALUATE

Teacher Material: Colonizing Space Presentation
Student Material: Colonizing Space Student Activity

Slide 16: Conduct the **Summative Assessment**.

After the teams complete their presentations (described below), ask students to complete the questions in Part 3 – Student Presentations in **Colonizing Space Student Activity**, which are provided below:

- After hearing your classmates' presentations, what aspect of colonizing Mars do you think would be most challenging, and why?

- With all of the research now presented, is there any aspect that you feel requires more research? Is there an area that wasn't shared in the presentations that needs to be addressed? Describe this area and what challenges need to be overcome.

Summative Assessment

Each team of students will prepare five- to 10-minute presentations that should include key features of their research as it applies to their assigned categories. Presentations should include a brief description of the category, an explanation of considerations made in determining the answers to the questions posed, and solutions the team developed in order to solve for challenges associated with colonizing Mars. It will be useful if they have drawings or models to share. Other students may ask questions or offer suggestions.

Oral Presentation Scoring Rubric

Follows assignment instructions

Oral presentation shows evidence of one or more of the following:

- Demonstrate awareness of challenges the harsh, Martian environment presents, including the rocky surface and lack of essential needs such as oxygen, water, food, etc.
- Provide unique solutions to address the harsh conditions on Mars other than what we have on Earth.
- Acknowledge resources Mars has to offer as a potentially habitable planet, such as ways to generate oxygen, providing access to water, using nuclear and solar energy, and harvesting soil and other natural resources.
- Provide a thorough explanation to describe the team's aspect, including a drawing, model, or other illustration to provide a clearer picture.
- Include current efforts underway to make living on Mars a possibility for humans due to its close proximity to Earth, even with its harsh environment.

Oral presentation shows an understanding of the concepts covered in the lesson

Oral presentation shows an in-depth thinking, including analysis or synthesis of lesson objectives

Points	Performance Levels
9-10	Consistently demonstrates criteria
7-8	Usually demonstrates criteria
5-6	Sometimes demonstrates criteria
0-4	Rarely to never demonstrates criteria

GOING FURTHER

Assign one of NASA's four driving questions to individual groups to research what NASA or other organizations are doing to solve these questions.

Show students a video of the team responsible for landing the Curiosity Rover on Mars. http://video.link/w/SGQd (Length 22:19) or http://video.link/w/TGQd (Length 2:25)

If students have watched the movie "The Martian," this website provides nine real NASA technologies the movie used: https://www.nasa.gov/feature/nine-real-nasa-technologies-in-the-martian.

There are many opportunities for additional learning at https://mars.nasa.gov/ if students would like to continue studying Mars.

STANDARDS ALIGNMENT

NGSS STANDARDS

Three-dimensional Learning

- **HS-ETS1-1** – Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
    - Science and Engineering Practices
        - Asking Questions and Defining Problems
        - Constructing Explanations and Designing Solutions
    - Disciplinary Core Ideas
        - ETS1.A: Defining and Delimiting Engineering Problems
    - Crosscutting Concepts
        - Systems and System Models
        - Influence of Science, Engineering, and Technology on Society and the Natural World
- **HS-ETS1-2** – Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
    - Science and Engineering Practices
        - Constructing Explanations and Designing Solutions
    - Disciplinary Core Ideas
        - ETS1.C: Optimizing the Design Solution
- **HS-ETS1-4** – Use a computer simulation to model the impact of proposed solutions to a complex real- world problem, with numerous criteria and constraints on interactions within and between systems relevant to the problem.
    - Science and Engineering Practices
        - Using Mathematics and Computational Thinking
    - Disciplinary Core Ideas
        - ETS1.B: Developing Possible Solutions

- Crosscutting Concepts
  - Systems and System Models

COMMON CORE STATE STANDARDS

- **RL.9-10.2** – Determine a theme or central idea of a text and analyze in detail its development over the course of the text, including how it emerges and is shaped and refined by specific details; provide an objective summary of the text.
- **RL.9-10.4** – Determine the meaning of words and phrases as they are used in the text, including figurative and connotative meanings; analyze the cumulative impact of specific word choices on meaning and tone (e.g., how the language evokes a sense of time and place; how it sets a formal or informal tone).
- **RST.9-10.1** – Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
- **SL.9-10.1.C** – Propel conversations by posing and responding to questions that relate the current discussion to broader themes or larger ideas; actively incorporate others into the discussion; and clarify, verify, or challenge ideas and conclusions.
- **WHST.9-10.2** – Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
- **WHST.9-10.4** – Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
- **WHST.9-10.6** – Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.
- **WHST.9-10.8** – Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.
- **WHST.9-10.9** – Draw evidence from informational texts to support analysis, reflection, and research.

REFERENCES

https://mars.nasa.gov/
http://www.popularmechanics.com/space/moon-mars/a21330/nasa-wants-martian-resources-for-martian-colony/
https://mars.nasa.gov/all-about-mars/facts/
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