Pages 1-4 Homeostasis in Space Suits NGSS & CASEL lesson

Watch the Video Here

Materials Required for This Lesson/Activity	
Quantity	**Description**
1 per group	Thermometer
1 per group	Stethoscope
2 per group	Basin/Large Bowl for Water
n/a	Access to ice water and very warm tap water
1 per group	Hot pack
1 per group	Cold Pack
4-6 Per Class	Assorted diameter tubing
1 Per class	Thermometers (and/or temperature sensors)
3 per group	Baggies

Pages 5-7 Analyzing Tradeoffs for the Mars Sample Return Program NGSS & CASEL lesson

Watch the Video Here

Materials Required for This Lesson/Activity			
Quantity	**Description**	**Potential Supplier (item #)**	**Estimated Price**
	No Materials Needed for this Lesson		

Homeostasis in Space Suits

Grade/ Grade Band: High School	**Topic:** Homeostasis
Brief Lesson Description: Students will learn about the importance of working in space from Astronaut Zena Cardman. They will then plan and conduct an investigation to explain how human temperature is regulated by homeostasis in a space suit.	
Performance Expectation(s): **NGSS HS-LS1-3:Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. [Clarification Statement: Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels.] [Assessment Boundary: Assessment does not include the cellular processes involved in the feedback mechanism.]**	
Specific Learning Outcomes: Students will be able to…. -define homeostasis -explain how water cooling protects astronauts from overheating in a space suit -Plan and conduct an investigation to determine how the number of coils in cooling system affects the temperature of a system -Communicate the findings of the investigation to their peers	
Narrative / Background Information	
Prior Student Knowledge: Students should be familiar with designing investigations (including controlled experiments) based upon using a given testable question. Additional background knowledge includes understanding heat transfer by conduction.	

Science & Engineering Practices:	**Disciplinary Core Ideas:**	**Crosscutting Concepts:**
Planning and Carrying Out Investigations Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. ● Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-LS1-3)	**LS1.A: Structure and Function** Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (HS-LS1-3)	**Stability and Change** Feedback (negative or positive) can stabilize or destabilize a system. (HS-LS1-3)

Possible Preconceptions/Misconceptions:
Many students will come with the conception that homeostasis is a static process–once it is achieved it will be maintained–rather than a dynamic process that is continually adjusting. Additionally, students often over simplify the process and do not consider that there are many different mechanisms in play simultaneously within the body that are interrelated.

LESSON PLAN – 5-E Model

ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:
This lesson will begin by showing the video "X-STEM Return to the Moon featuring Zena Cardman."

After students watch the video, have students consider the question:
How would the human body be affected by doing the work that Zena describes in space?"

With a partner, have students generate a list of possible effects. Then share as a class to create a group list. Then explain to students that NASA must design equipment and protocols to help astronauts safely deal with each of these effects. Then explain that today we will explore one particular effect and consider how NASA might protect astronauts.

In this episode of X-STEM, Zena talks about the many different tasks that she has trained for to work in space. One of the biggest challenges of living and working in space is the extreme temperature changes that occur. While working in the sun, temperatures can reach 250 degrees Fahrenheit while in the dark temperatures can plummet to -250 degrees Fahrenheit.

Ask students the following question:
How might your body be affected by such extreme temperature changes? How might your body try to react to these temperature changes?

With a partner, have students consider their possible responses and then discuss as a class to generate initial ideas.

EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:
Next, tell students that today we will see how our body reacts to a much smaller temperature change.

Assign students to groups of four and instruct group members to record each other's body temperature with a thermometer and their heart rates with a stethoscope and stopwatch.

Instruct students to submerge their hands in a basin of ice water for 30 seconds and measure body temperature and heart rate after they step away.

Repeat the experiment with a basin of very warm water.

Discuss the results and explain that when subjected to colder temperatures, the human heart will slow in order to preserve oxygen levels within the body to achieve homeostasis.

EXPLAIN: Concepts Explained and Vocabulary Defined:

Show the Amoeba Sisters Homeostasis video. As students watch the video, they should take notes about homeostasis, positive, and negative feedback. (Alternatively, you can use the video handout from Amoeba Sisters provided in the comments of the video).

Discuss with students how homeostasis protects the body. Have students hypothesize how the body would regulate temperature in the extremes of space. Ask students to discuss: *"Do you think that the normal mechanisms of shivering/fevers/sweating would be sufficient for astronauts to deal with the heat extremes of -250 F to 250 F? Why or why not?"*

Then explain to students that the temperature extremes are too much for the human body to regulate on their own. Thus, NASA must engineer systems to help the body maintain homeostasis instead.

Next, show the first 1 minute and 45 seconds of NASA's Keeping Your Cool Video. After the video stops, have students discuss how the liquid cooling garment helps the human body to maintain homeostasis in space.

Vocabulary:
Homeostasis, Positive Feedback, Negative Feedback

ELABORATE: Applications and Extensions:
Explain to students that they will now design an investigation to test how different types of tubing will affect how temperature changes in a Liquid Cooling Garment.

Students will then be given the testable question:
"How does the type of tubing impact the temperature change in a system?"

Explain to students that today they will be given a set of materials and an initial demonstration idea to build their experiments with.
Next, show the rest of the NASA's Keeping Your Cool Video and then show them the following materials that can be used to design their experiment:

- Hot Water
- Cold Water
- Ice

- Hot Packs
- Cold Packs
- Baggies
- Thermometers
- Temperature Sensors (if locally available)
- Tubing of various sizes (Suggested sizes: Aquarium tubing (¼", ⅜" ½", ¾")*

*You may also add tubing made of different materials if your students are ready to work with confounding variables in their experimental design. Suggestions include PVC, Silicone, Nylon, etc.

Students should work in groups to design and conduct their investigations. You may use the Template for Experimental Design to guide students through the process.
Classroom Management Tip: Prior to students getting materials and starting their experiments, require teacher approval of the procedure. This ensures that you can provide feedback on any misconceptions and guide students if needed.

EVALUATE:

Formative Monitoring (Questioning / Discussion):
Questions throughout lesson in italics, Student notes from Homeostasis video

Summative Assessment (Quiz / Project / Report):
Experiments can be assessed using the Rubric. Additionally, students can present the findings of their investigations to the rest of the class to compare results and draw conclusions based on all information gathered.

Elaborate Further / Reflect: Enrichment:
Students can use the results of their experiment to propose a design for a new liquid cooling garment for travel to areas of space with more extreme temperature fluctuations. The design can be presented as an annotated sketch to their peers for feedback.

SOCIAL EMOTIONAL LEARNING ACTIVITY

CASEL Competency: Relationship Skills

In this X-STEM Video, Zena discusses how much she liked working in big teams in her field research and how this has carried with her to her work at NASA. Today we will do an activity to help us develop our teamwork skills.

Divide students into teams of four. To begin the lesson, have students generate a list of qualities that they appreciate in teammates. Give teams 5 minutes to generate a list and then share as a class. Create a class list of positive qualities.

Next, explain to students that they will need to use these positive teamwork skills to solve a problem. Hand out one copy of the **NASA Exercise: Survival on the Moon** to each team. (*Note: Make sure to not give them the answers found on page 3 or 4). Tell students that as a team they have 20 minutes to rank the items in order of importance if they were stranded on the moon. Remind students to use the positive skills they listed at the beginning of this activity.

At the end of the time, share the answers on page 4 with the students and then score their results using the explanation on page 4.

Then, as a class, discuss the following prompts:
-What positive skills were most helpful in this exercise? Why were they helpful?
-What positive skills were not as helpful in this exercise? Why were they not as helpful?
-What positive skills did you contribute to your team? How about other members?

INTERDISCIPLINARY CONNECTIONS/IDEAS

Physical Education: Have students compare the heat produced (as sweat and/or temperature change) for a variety of physical activities. Then determine how space suits should be designed differently based on the results.

CTE: For students in engineering/automotive/HVAC/Construction course: Compare the design of the cooling system in space suits with the cooling systems in cars or other devices. What are the similarities and/or differences? How could the design of existing devices inform a more efficient design in space suits?

English Language Arts: Conduct a word study for the prefix "homeo-" How are other words with this root related to the term homeostasis?

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n/a	Access to ice water and very warm tap water
1 per group	Hot pack
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4-6 Per Class	Assorted diameter tubing
1 Per class	Thermometers (and/or temperature sensors)
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Lesson Created by Jess Noffsinger
For questions please contact info@usasciencefestival.org

Analyzing Tradeoffs for the Mars Sample Return Program

Grade/ Grade Band: High School	**Topic:** Engineering

Brief Lesson Description: Students will consider how tradeoffs play a role in prioritizing criteria when selecting a solution to a problem by exploring the scientific goals of the Mars 2020 and Mars Sample Return program. Students will assume the role of various stakeholders, determine the criteria that best meet their needs, and then prioritize criteria as a group to determine how a solution will be selected.

Performance Expectation(s):
HS-ETS-1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Specific Learning Outcomes:
Students can use technical information to determine the goal of a mission and infer criteria that would meet this goal.
Students can communicate the needs of a specific stakeholder group and use these needs to prioritize criteria.

Narrative / Background Information

Prior Student Knowledge:
This lesson assumes that students are familiar with criteria as they relate to the engineering design process as a means to determine what solution is optimal. Additionally, students should have a basic understanding of signs of life), geological processes, and climate factors.

Science & Engineering Practices:	**Disciplinary Core Ideas:**	**Crosscutting Concepts:**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9-12 builds on K-8 experiences and progress to explanations that are supported by multiple and independent student generated sources of evidence consistent with scientific ideas, principles, and theories. ● Evaluate a solution to a complex, real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradoff considerations.	**ETS 1.B: Developing Possible Solutions** ● When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.	***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering and Technology on Society and the Natural World** ● New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Possible Preconceptions/Misconceptions:
-Complex decisions about multiple solutions require engineers to weigh the tradeoffs of multiple options, but these may be over simplified by students.
-There is a tendency for students to overemphasize the pros of their favored solutions and the cons of less favored solutions.
-Students often fail to organize their discussions/analysis of competing criteria in favor of going with their "gut"

LESSON PLAN – 5-E Model

ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:

NASA is currently working on the Artemis mission for humans to return to the moon. This program is the first step in the quest for people to travel to Mars.

"Would you want to be the first person to walk on Mars? Why or why not?" Have students discuss this question first with a partner and then as a whole class.

Explain that before this can happen, there are many scientific objectives that must be met and technological challenges that must be overcome. To learn more about this, introduce students to Dr. Moogega Cooper of NASA using the following biography:

"Dr. Moogega (pronounced Moo-ji-gae) Cooper received her B.A. in Physics from Hampton University in 2006. She then enrolled in Drexel University where she received her Masters and Ph.D. in Mechanical Engineering with a concentration in thermal fluid sciences. Her

dissertation studies involved non-equilibrium plasma sterilization of spacecraft materials so it was a logical transition to work for the Jet Propulsion Laboratory's (JPL) Planetary Protection Group. She has been at JPL for 11 years, working on spacecraft to include Mars Science Laboratory, In Sight, Mars 2020 as the Lead of Planetary Protection, and the Europa Lander concept. She is currently the 353N Group Supervisor of the Biotechnology and Planetary Protection Group. Her passion is education and outreach as well as developing sterilization capabilities that could potentially be applied to the returned sample from Mars."

Returning to the Moon with Dr. Moogega Cooper

After watching the video, ask students to share what they learned.

EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:

During the video, Dr. Cooper explained that the Mars Rover will be collecting samples on the surface of Mars to send back to Earth. Today, we will be learning about these samples and then consider how scientists at NASA should go about choosing the best samples to bring back to Earth.

Start by handing out the Student Answer Sheet if printed -or- posting the google document to a LMS.

Have students complete part 1: Sampling Mars. In this part of the activity, students will read a short summary explaining what the mission's science goals are and how samples are collected. They will then consider the samples that have been taken and how one might select which ones will come back from Mars.

After giving students time to work on this section, ***discuss prompts as a class.*** If you are limited on time, focus on the even numbered prompts in the class discussion.

EXPLAIN: Concepts Explained and Vocabulary Defined:

Tradeoff: *a balance achieved between two desirable but incompatible features; a compromise.*

Explain to students that after samples are collected by Mars 2020, NASA scientists will have to decide which of the 20 samples should return to Earth. This will require scientists looking at TRADE-OFFS to find the best possible samples to return.

What do you think the term trade-off means? Have students discuss with a partner and then share as a class. Come to a class consensus of what they think the term means. Have students record this in their notes.

Next show the Trade-Off video. After the video, have students discuss if there are any adjustments that should be made to the group definition. Make these changes as needed.

Based on this definition, ***What kind of trade-offs do you think that the NASA science team might have to make when selecting which samples to bring back from Mars? Why might these exist?*** Have students generate their own ideas first and then discuss with a partner and then the class.

In order to deal with trade-offs, one important strategy that teams use is to prioritize criteria. This allows them to make informed decisions about what solutions meet the criteria.

ELABORATE: Applications and Extensions:

Today we will practice working with trade-offs by completing a simulation.

Group students into groups of fours. Assign each member of the group one of the following roles:
1)Biologist
2)Climatologist
3)Geologist
4) Astronaut

Explain to students that they are going to look at the goals for each of these different roles and determine what criteria that they think should be used to determine which samples should be returned to Earth.

Direct students to complete Part two of the Student Answer Sheet. Provide sufficient time for each member of the group to complete their assigned section. Make sure that student's know that they will be responsible for sharing their findings with the rest of their team.
(*Differentiation note: you can have students regroup to work in roles if students need support, i.e. pair 2 biologists together)

Next, have teams collaborate to complete part 3. Each student will share their three criteria with clear reasoning as to why they matter.

After all team members have shared, have them work together to prioritize or rank their criteria and then complete the two analysis questions in part 3.

Discuss each group's results for part 3 as a class and then move on to the reflection questions.

EVALUATE:
Formative Assessment:
Formative questions throughout this lesson are found in ***italics***.

Summative Assessment:
Part 4 of the Student Answer Sheet provides students an opportunity to demonstrate their understanding of trade-offs by completing a constructed response question. These can be assessed using the rubric found here.

Elaborate Further / Reflect: Enrichment:
Students can be part of the Mars Sample Return Mission by sending their name on the rover/lander that will go to Mars. Students should visit this site to add their name to be sent to Mars.

Students may also explore current and future science missions by visiting the NASA Science Directorate site. Students can explore the wide variety of science topics and vehicles used to study space and Earth Science. Students can compete to have their own opportunity to develop a science experiment for NASA as part of the Future Engineers NASA Tech Rise Challenge.

SOCIAL EMOTIONAL LEARNING ACTIVITY

CASEL Competency Addressed: Relationship Skills/Social Awareness

During the XSTEM video, Dr. Cooper said her best advice for everyone is to surround yourself with people who you trust and have your best interests in mind.

To help students consider this idea, start by having students create a list on a sheet of paper of the humans that they have had interactions with over the past week. Tell them to think about people at home, school, their community activities, job etc. Give them several minutes to generate a complete list. Next, ask students to circle the names of people whom they trust. Finally, ask students to highlight the circled people who they think have their best interests in mind. The people who are both circled and highlighted are this student's support team.

After students have identified the members of their support team, ask them to reflect upon and then discuss the following prompts:

1) How did you decide whether or not you would circle (trust) someone on this list? What characteristics do they demonstrate?
2) How did you decide whether or not you would highlight (have your best interests in mind) someone on this list? What characteristics do they demonstrate?
3) What kinds of problems/situations would you go to these people for?

Finally, ask students to consider how they can keep track of this list for times when they feel like they need support. Possible ideas include a text thread, notes in a planner, social media, etc.

INTERDISCIPLINARY CONNECTIONS/IDEAS

Mathematics: Students can consider the mathematics associated with the Mars missions by using the Math Curriculum by NASA. In addition to the Mars Math resource, there are Mars related problems in volumes 2, 3, 6, 8, and 9.

Economics: Students can investigate the idea of trade-offs by studying the Allocation of Resources and Goods. Here is an example lesson for this concept.

Materials Required for This Lesson/Activity			
Quantity	**Description**	**Potential Supplier (item #)**	**Estimated Price**
	No Materials Needed for this Lesson		

Lesson Created by Jess Noffsinger
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