

# Homeostasis in Space Suits

## Companion Lesson to X-STEM All Access Episode “Returning to the Moon”

<b>Grade/ Grade Band:</b> High School		<b>Topic:</b> Homeostasis
<b>Brief Lesson Description:</b> 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.		
<b>Performance Expectation(s):</b> <b>NGSS HS-LS1-3:</b> Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. <b>[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.]</b>		
<b>Specific Learning Outcomes:</b> 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		
<b>Narrative / Background Information</b>		
<b>Prior Student Knowledge:</b> 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.		
<b>Science &amp; Engineering Practices:</b>  <b>Planning and Carrying Out Investigations</b> 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. <ul style="list-style-type: none"><li>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. <a href="#">(HS-LS1-3)</a></li></ul>	<b>Disciplinary Core Ideas:</b>  <b>LS1.A: Structure and Function</b> 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. <a href="#">(HS-LS1-3)</a>	<b>Crosscutting Concepts:</b>  <b>Stability and Change</b> Feedback (negative or positive) can stabilize or destabilize a system. <a href="#">(HS-LS1-3)</a>
<b>Possible Preconceptions/Misconceptions:</b> 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?

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



Lesson Created by Jess Noffsinger  
 For questions please contact [info@usasciencefestival.org](mailto:info@usasciencefestival.org)