Tardigrades
Middle School Science Lesson

Lesson Overview	Career Highlights
Students take on the role of a astrobiologist whose mission is to learn about extremophiles and the resiliency of tardigrades. After modeling the effects of radiation on tardigrade survival, students investigate the effect of temperature, hydration, or space vacuum on tardigrade survival using the experimental design process. Students will explore the scientific method through experimental design and will learn how to analyze their results to draw conclusions about tardigrade space resiliency and the potential advance of human space exploration.	Biologist Chemist Environmental Scientist Chemical Engineer Mechanical Engineer Electrical Engineer

STEM Course Connections	21st Century Skills	CTE Alignment
Middle School Engineering Middle School Life Science Middle School Earth and Space Sciences	Collaboration Communication Critical Thinking	Engineering and Design Industry Sector (ED)

Engineering Activity	
Science and Engineering Practice #3	Students will design a controlled tardigrade experiment using the experimental design process. Students will communicate their designs, discuss improvements to their design, and discuss results/insights with peers to draw conclusions on tardigrade space resiliency.

Materials

- Access for students to use computers/ tablets
- Google Slides/Powerpoint
- YouTube access for class videos
- Mission Brief
- Scientist Visitor Slide Deck - *share with scientist before class*
- Decision Tree
- Teacher Slide Deck
- Radiation Results
- Temperature Results
- Hydration (water) Results

- Vacuum Results
- Student Handout
- Tardigrades (optional)
- Foldscope for viewing tardigrades (optional)

Essential Questions

1. How can extremophiles on Earth, such as a tardigrade, advance human potential in space?
2. What space-like conditions affect tardigrade survival?
3. How do we test tardigrade survival in space-like conditions?

Prerequisite Knowledge

- Students understand the basics of experimental design
- Students understand independent variables, dependent variables, and controls
- Students understand how to carry out an experiment
- Students understand how to analyze experimental results

Mission Prep – Day 1
What are Tardigrades?

ENGAGE (10 mins) - *Mission Brief*

- Teacher shares the Mission Brief with students, shares Teacher Slide Deck (slides 2 and 3), and poses the following question to the class and allows students a few minutes to respond in their Student Handout (section A):
  - What does the Mission Brief **suggest** about your task to help The Aerospace Corporation?
- Students share their answers with a partner, then to the class.
- Teacher makes the connection that *the orange circles on the bottom move from the big picture to a more focused lens of the lesson goal. The current Sample Return Mission and future aspirations of human exploration of Mars rely on the exploration of organisms on Earth.*

ELABORATE (10 mins) - *Tardigrade Introduction*

- Students watch Tardigrade Video.
- Teacher poses the following question to the class and allows students a few minutes to respond in their Student Handout (section B):
  - **Why do space scientists study tardigrades?** List what variables they study.
- Students share their answers with a partner, then to the class.

EXPLAIN (10 mins) - *Vocabulary Development*

- Following the Student Handout (section C), students should use words and images to define words in their own way.
    - Look back to the Mission Brief and see what additional questions students have
- Students share their definitions with the class, as this vocabulary is central to the engineering goal and understanding the science behind tardigrades.

EXPLORE (40 - 60 mins) - *Tardigrade Lab Exploration*

- Students will view tardigrades under a microscope using a Foldscope or light microscope.
- Slides can be prepared ahead of class. If time allows, guide students in creating their own slide.
    - *Tips for Viewing Tardigrades Under the Microscope:*
        - Using a plastic pipette, take up approximately 2 - 3 drops of the tardigrade water mixture.
        - Place this onto the middle of a depression slide or microscope slide and locate the tardigrades.
        - Place the grid slide on the microscope stage and bring the graph paper into focus, using the lowest power.
        - Place the Tardigrade slide on the microscope and bring it into focus under the lowest power. Look closely at the Tardigrade.
    - If Teacher is unable to access tardigrades, Tardigrade Video Clips can be watched by students as an alternative to this hands-on lab.
- Teacher poses the following questions to the class and allows students a few minutes to respond to each in their Student Handout (section D):
    - Describe **the shape** of a tardigrade as seen under the microscope.
    - Describe the **movement** of a tardigrade.
    - If you can find one that is eating, **describe how a tardigrade eats.** Include the movements it takes to eat and **how the body changes with the addition of food**.
- Students share their answers with a partner, then to the class.

EXPLAIN (15 mins) - *Why Tardigrades?*

- Students watch Project Space Resilience Video.
- Teacher poses the following questions to the class and allows students a few minutes to respond in their Student Handout (section E):
    - **Why** is it worth studying tardigrades?
    - **What** variables will we be exploring?
    - **What** variables are most interesting to you?
    - **How** could results from our experiments help humans?
- Students share their answers with a partner, then to the class.

EVALUATE (15 mins) - *Variables for Experimental Design*

- Teacher shares the following variables in the Teacher Slide Deck (slide 9) for experimental design with students:
    - Temperature
    - Vacuum
    - Lack of water (dehydration)
    - Radiation - *this will be modeled by the teacher and not an option for student experimental design*
- Students write an exit slip identifying which variable they are most interested in exploring.

Launch – Day 2 *Why are Tardigrades Model Organisms for Experimental Study?*

ENGAGE (30 mins) - ***Modeling the Experimental Design Process***

- Teacher models the experimental design process using the variable of radiation.
- Teacher guides class through the following prompts in their Student Handout (section F): *model student responses below.*
    - Tardigrade Research Question: *How does radiation affect tardigrade survival?*
    - Independent Variable: *Radiation Exposure*
    - Dependent Variable: *Survival*
    - Experimental Set-Up: *There are two groups of tardigrades sitting in two separate dishes. One group will be exposed to radiation, while the other group will be kept in normal conditions with no added radiation exposure. The percent or number of tardigrades that survive after 20 minutes in these conditions will be recorded.*
    - Control Variables: *Temperature, hydration (all will start hydrated), light, atmospheric pressure, amount of food eaten before experiment, size of tardigrades, etc.*
- Opportunity for The Aerospace Corporation volunteer to use the Scientist Visitor Slide Deck to talk about their experience with the experimental design process.

EXPLORE (20 - 30 mins) - ***Student-Led Experimental Design***

- Teacher assigns each student group the variable they will be exploring during the experimental design process (*Temperature, Dehydration, or Vacuum)*.
- Students use the Student Handout (section G) to draft their experimental design.
- Opportunity for The Aerospace Corporation volunteer to use the Decision Tree to guide student thinking toward a *dependent variable of tardigrade survival and independent variable of either temperature, hydration or vacuum.*

ELABORATE (10 mins) - ***Modeling Results Analysis***

- Teacher uses Radiation Results to model the analysis of experimental results.
- Teacher guides class through the following prompts in their Student Handout (section H):
    - What is the **independent variable (x-axis)** on the graph? *Radiation dosage amount in grays (Gy)*
    - What is the **dependent variable (y-axis)** on the graph? *Percent of tardigrades survived*
    - What **pattern** do you see in the graph? *Stayed steady at 100 percent survival followed by decreased survival.*
    - Do tardigrades **survive** after being introduced to your variable? Yes or No. *Yes*
    - How does survivorship **change** when your variable is introduced to the tardigrades? *They can survive high doses of radiation, but at some point they will begin to die off. The amount of radiation they can survive is much more than humans.*

EVALUATE (20 - 30 mins) - ***Student-Led Results Analysis***

- Teacher hands out experimental results to each group after experiments are approved:
    - Temperature
    - Hydration (water)
    - Vacuum

- Teacher poses the following questions to the class and allows students a few minutes to respond in their Student Handout (section I):
  - What is the **independent variable (x-axis)** on the graph?
  - What is the **dependent variable (y-axis)** on the graph?
  - What **pattern** do you see in the graph?
  - Do tardigrades **survive** after being introduced to your variable? Yes or No.
  - How does survivorship **change** when your variable is introduced to the tardigrades?
- Students share their answers with a partner, then to the class.

Exploration – Day 3
Claim-Evidence-Reasoning

ENGAGE (15 - 20 mins) - *Results Class Discussion*

- Teacher gives each group of students 2-3 minutes for their group representative to share out results from the Student Handout (section I).
- *Suggested Share Out Protocol:*
  - State independent and dependent variables.
  - State how the tardigrades survived after being exposed to your variable and state **how this data compares to humans**.

EXPLORE (10 mins) - *Modeling Claim-Evidence-Reasoning*

- Teacher uses Radiation Results to model how to write a claim based on their results.
- Teacher guides class through the following prompts in their Student Handout (section J):
  - What **pattern** did you notice when looking at your data? *Tardigrades can survive after being exposed to very high levels of radiation.*
  - Make a **claim** about how tardigrades responded to your variable compared to humans. *Tardigrades can survive high levels of radiation up until a certain point, more than humans that can only survive 0.05 Gy.*
  - What was the most important **observation** you made that made you sure your claim is correct? (This must just be what you noticed. Do not explain what it means or why it supports your claim yet, just say what you saw). *The percent of tardigrades that survive is steady around 100% after being exposed to high levels of radiation (up until 4000 Gy).*
  - What is another **observation** you made that makes your claim correct? (This must just be what you noticed. Do not explain what it means or why it supports your claim yet, just say what you saw). *At 4000 Gy, the tardigrades begin to die and surviving is not guaranteed.*
  - What is one last **observation** you made that makes your claim correct? (This must just be what you noticed. Do not explain what it means or why it supports your claim yet, just say what you saw). *Almost no tardigrades are alive at 7000 Gy.*
  - **Explain** how what you observed (from section D) means that your claim is correct. What does your **data** mean about how tardigrades will behave in space-like environments? Use words like *resiliency/resilient*. *My data shows that tardigrades are able to survive high levels of radiation, but only until a certain point. In conclusions, tardigrades are resilient and most likely will survive in space when exposed to radiation.*

ELABORATE (20 - 25 mins) - *Writing Claim-Evidence-Reasoning*

- Teacher allows class to answer the following prompts in their Student Handout (section K) with their group:
  - What **pattern** did you notice when looking at your data?
  - Make a **claim** about how tardigrades responded to your variable compared to humans.
  - What was the **most important observation** you made that made you sure your claim is correct?
  - What is another **observation** you made that makes your claim correct?
  - What is one last **observation** you made that makes your claim correct?
  - **Explain** how what you observed (from section D) means that your claim is correct. What does your **data** mean about how tardigrades will behave in space-like environments? Use the word like *resiliency* or *resilient*.

EXPLAIN (10 mins) - *Claim-Evidence-Reasoning Share Out*

- Teacher poses the following question to the class and allows students a few minutes to respond in their Student Handout (section L):
  - *Claim: Make a **claim** about how tardigrades responded to your variable.*
  - *Evidence: What observational **evidence** from your lab experiment and/or the discussions you've had in class support this claim?*
  - *Reasoning: **Explain** how your evidence supports your claim and connect to humans.*
- Teacher asks each group to share their Claim-Evidence-Reasoning with the class.

EVALUATE (20 - 30 mins) - *Reflection Questions*

- Teacher poses the following question to the class and allows students a few minutes to respond in their Student Handout (section M):
  - Now that you understand how tardigrades respond to space-like conditions, why are tardigrades **necessary** to study when it comes to humans traveling in space?
  - What else are you interested in studying about tardigrades? What other variables could be explored? **Explain** what you would hope to learn from these variables.
- Teacher leads fishbowl discussion or whole class discussion about reflection questions.

Distance Learning Suggestions
Teachers can use Google Slides, Google Docs, Zoom breakout rooms, Menti, Jamboards, Padlet, or Pear Deck to collect responses, or create visuals for lessons. Turn on Closed Captions for YouTube videos.

CA NGSS Standards
MS-LS1-1. Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells **MS-LS1-8**. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories. **MS-LS1-4**. Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively. **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.

CTE Alignment
2.3 Interpret verbal and nonverbal communications and respond appropriately. **2.4** Demonstrate elements of written and electronic communication, such as accurate spelling, grammar, and format. **3.1** Identify personal interests, aptitudes, information, and skills necessary for informed career decision making. **3.3** Explore how information and communication technologies are used in career planning and decision making. **4.1** Understand past, present, and future technological advances as they relate to a chosen pathway. **5.1** Identify and ask significant questions that clarify various points of view to solve problems. **5.2** Solve predictable and unpredictable work-related problems using various types of reasoning (inductive, deductive) as appropriate. **5.3** Use systems thinking to analyze how various components interact with each other to produce outcomes in a complex work environment. **5.4** Interpret information and draw conclusions, based on the best analysis, to make informed decisions. **7.5** Apply high-quality techniques to product or presentation design and development.

Resources

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