Lesson 19: Extremophiles

Summary
This learning module and related laboratory exercise exposes students to extremophiles, their habitats, and the potential to find habitable environments on Mars.

Learning Goals

Students will be able to:

- Understand the environment in which the *Tardigrade* can survive.
- Explore hydrothermal environments on Earth and Mars.

Context for Use
This learning module is meant for adaptation in an introductory earth science course and/or planetary science course.

Description and Teaching Materials
In-Class Activity
In-Class Activity 1: *Tardigrades: Living extremely*
Homework
Homework 1: *Sea Monkey Experiment*
Homework 2: *The Color of Temperature*

Teaching Notes and Tips

1. Students must be familiar with Mars environments of deposition, surface processes and climate.
2. To be successful in Homework 2 students need to have exposure and instruction in making contour maps.

Assessment
Each *In-Class Activity* and *Homework* has its own measure of Assessment.

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References and Resources

1. Image File: Extremophiles
2. Gale Crater Habitability via Curiosity: http://www.youtube.com/watch?v=oHLbXTOaw7w&feature=relmfu
3. Tardigrades video from SciShow on YouTube: http://www.youtube.com/watch?v=6H0E77TdYnY&continue_action=r7OE3bLJMHT8fAwevwnX9Oh_0zzl6Ajt2P3129QN588gcYR6MkEN_obkOAtaq5MUvFV4Yiq09ljbJDp8wedzPE1U417RionrJuPdT2CAALc=
4. Additional Tardigrade link: http://serc.carleton.edu/microbelife/topics/tardigrade/index.html

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In-Class Activity 1
Extremophiles 1_MFE
Tardigrades: Living extremely

Purpose: Become acquainted with the Tardigrade ("water bear") extremophile, its living conditions, and importance of its scientific study.

Preparation:

Have Internet access in your classroom.

Resources:

1. Tardigrade YouTube video: http://www.youtube.com/watch?v=6H0E77TdYnY&continue_action=r7OE3bLJMHT8fAwevwnX9Oh_0zzl6Ajt2P3129QN588gcYR6MkEN_obkOAtaq5MUvFV4Yiq09ljbJDp8wedzPE1U417RionrJuPdT2CAALc=
2. SERC definition of Extremophiles: http://serc.carleton.edu/microbelife/extreme/extremophiles.html

Engage

Watch the following You Tube Tardigrade video from the SciShow: http://www.youtube.com/watch?v=6H0E77TdYnY&continue_action=r7OE3bLJMHT8fAwevwnX9Oh_0zzl6Ajt2P3129QN588gcYR6MkEN_obkOAtaq5MUvFV4Yiq09ljbJDp8wedzPE1U417RionrJuPdT2CAALc=

As students watch the video have them answer the following questions:

1. What is a *Tardigrade*?
2. What type of environments can *Tardigrade* live in?
3. What is its importance to science?

Explore

Have students briefly "explore" other extremophiles and answer a few questions about their characteristics and report back to the class.

Explain

As students discuss *Tardigrade* and the type of environment in which it can survive, share the following terms related to types of extremophiles. Ask students to classify *Tardigrade in one of these groups:*

1. Acidophile- high pH
2. Alkaliphile- low pH
3. Anaerobe- no need for oxygen
4. Endolith- lives inside rocks
5. Halophile- requires salt
6. Piezophile/Barophile- requires high pressures
7. Thermophile- lives in 40°C or higher
8. Xerophile- limited water supply
9. Psychrophile- lives in 15°C or lower

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Elaborate

Where could Tardigrade live on Mars?

1. Display a global Map of Mars so that all regions can be viewed (see Image File: Extremophiles)
2. Where could *Tardigrade* potentially live on Mars?
3. Is studying *Tardigrade*, and other organisms like it useful to space research? Why or why not?

Have students identify which extremophiles could live on Mars.

Also, possibly consider where they live on Earth for comparison.

Evaluate

Ask students what other Extremophiles classifications (see above) could be present on Mars and give a short presentation on a type of extremophile other than Tardigrade.

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Homework 1

Extremophiles 1_MFE

Sea Monkey Experiment (courtesy of Brain Hynek, University of Colorado-Boulder)

Starting thinking: What is an extremophile?

Resources:

On brine shrimp (see materials needed on these sites)

- http://wildlife.utah.gov/gsl/
- http://www.youtube.com/watch?v=kUN61qJtp6s (tutorial on raising brine shrimp)

On extremophiles

- http://www.spiritus-temporis.com/extremophile/types-of-extremophiles.html
- http://www.daviddarling.info/encyclopedia/E/extremophile.html
- Example: Deinococcus radiodurans can withstand 1,500,000 "rads". 500 rads can kill humans!

Introduction:

Sea monkey eggs (like Great Salt Lake brine shrimp) reportedly can survive dormant for > 20,000 years without water. They breathe through their feet and are born with 1 eye but develop 2 more. They are ideal for testing life's response to extreme conditions since they can survive (or remain dormant) in a wide variety of conditions (pH of 2-10, high salinity, various radiation environs, range of temperatures, etc.).

Experiment - Project Assignment:

1. Design a scientific experiment to examine some kind of extreme conditions (without destruction) on the revival and/or survival of dormant life forms (the brine shrimp eggs). The students might bake the eggs, drown them in their favorite soda, soak them in acidic lemon juice, or subject them to other extreme conditions or combinations!
2. Carry out a scientific experiment following the scientific method. Record all condition information of time, methods, amounts, solutions etc.
3. After this we will do a "blind test" and your sea monkey eggs will be given to someone else to raise (so the students are not tempted to bias the experiment).
4. Have students meet with the group that attempted to hatch their eggs. Discuss the results in terms of their hypothesis.
5. In a clear and concise write up of their experiment, discuss the results in the broader terms of astrobiology.

In-Class Discussion

Discuss the design of the students' experiment and outcomes with the class following the submission of their assignment.

Limits of the Brine Shrimp

Were there any conditions too extreme for the brine shrimp?

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Homework 2
Extremophiles_MFE
The Color of Temperature

Objective: Identify why an environment is considered "extreme" and draw inferences about life based upon the attributes/characteristics of these environments.

Extremophiles in Hot Water
Watch the following YouTube video created by GNC Science and answer the following questions: http://www.youtube.com/watch?v=VU-A6Sx7k-U

1. Why is this environment extreme? List characteristics of the environment that would classify this environment as extreme.

2. Given the list of characteristics you provided in #1, name the types of extremophiles that could exist there [refer to the list of extremophiles provided].

3. The colors of the hot spring have meaning. What do the colors represent? Which colors represent warmer water and, conversely, cooler water?

Yellowstone: An Earth case study
The photograph (Figure 1), taken in Yellowstone National Park, is a hot spring with outflow channels (hydrothermal environment, similar to above).

4. Determine how many colors the students observe and assign a hypothetical temperature range to each color.

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5. Using their temperature ranges, outline the area of each temperature range (at least three but no more than six) to create a temperature map of the photograph provided (this will look similar to a contour map). They students may use trace paper over the image to represent the changes they see in color.

Figure 1: A hot spring in Yellowstone National Park (Image Credit: nps.gov Source: http://earthobservatory.nasa.gov/Features/Zircon/zircon3.php)

Have the students draw their map below (be sure to have them annotate their outlines):

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Holden Crater, Mars

Holden Crater, a potential landing site for MSL Curiosity, is thought to have hydrothermal deposits similar to the Earth environments above. Below in Figure 2 is an example of the terrain provided by HiRISE.

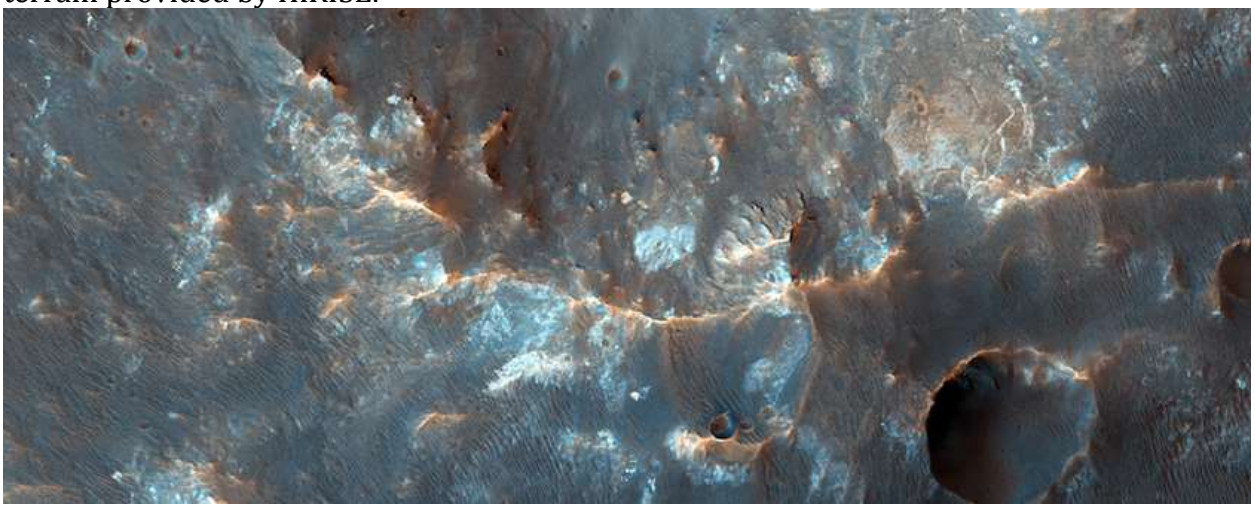

Figure 1: The Western Wall of Holden Crater, HiRISE Image ESP_021946_1535; (Image Credit: NASA/JPL/Univ of Arizona)

1. What do the students think the colors represent in the HiRISE image?

2. Using JMARS, capture one CRISM image that would infer a hydrothermal environment and paste below. Hints: (1) Review navigation in JMARS if necessary and investigate the crater walls/rims. (2) Think about what mineral assemblages would suggest a hydrothermal environment.