Extremophiles

An extremophile is an organism that thrives under "extreme" conditions. The term frequently refers to prokaryotes and is sometimes used interchangeably with *Archaea*. You will find that extremophiles come in all shapes and sizes, and that our understanding of the phylogenetic diversity of extreme habitats increases daily.

The term extremophile is relatively anthropocentric (regarding humankind as the central or most important element of existence).

We judge habitats based on what would be considered "extreme" for human existence. Many organisms, for example, consider oxygen to be poisonous. While oxygen is a necessity for life as we know it, some organisms flourish in anoxic environments. We call them *extremophiles*... but that is only one perspective. If they could think, what would they think of us? As you read through the list of terms below, consider how what we think of as normal may seem too *extreme* from the point of view of an extremophile.

Terms Used to Describe Extremophiles

Most terms used to describe extremophiles are generally straightforward. They are a combination of the suffix *phile*, meaning "lover of," and a prefix specific to their environment. For example, *acidophiles* are organisms that love (*phile*) acid (*acido*).

- **Acidophile:** An organism that grows best at acidic (low) pH values.
- **Alkaliphile:** An organism that grows best at high pH values.
- **Anaerobe:** An organism that can grow in the absence of oxygen.
    - **Facultative Anaerobe:** An organism that grows in the presence or in the absence of oxygen.
    - **Obligate Anaerobe:** An organism that cannot grow in the presence of oxygen; the presence of oxygen either inhibits growth or kills the organism.
- **Endolith:** An organism that lives inside rock or in the pores between mineral grains.
- **Halophile:** An organism requiring high concentrations of salt for growth.
- **Methanogen:** An organism that produces methane from the reaction of hydrogen and carbon dioxide, member of the *Archaea*.
- **Oligotroph:** An organism with optimal growth in nutrient limited conditions.
- **Piezophile (Barophile):** An organism that lives optimally at high hydrostatic pressure.
- **Psychrophile:** An organism with optimal growth at temperature 15 °C or lower.
- **Thermophile:** An organism with optimal growth at temperature 40 °C or higher.
    - **Hyperthermophile:** An organism with optimal growth at temperature 80 °C or higher.
- **Toxitolerant:** An organism able to withstand high levels of damaging elements (e.g., pools of benzene, nuclear waste).
- **Xerophile:** An organism capable of growth at very low water activity.

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Mars for Earthlings

In-Class Activity 1 – Extremophiles and 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.

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

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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Mars for Earthlings

In-Class Activity 2 - 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 that were discussed earlier].

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 on the back side of this paper was taken in Yellowstone National Park and is a hot spring with outflow channels (hydrothermal environment, similar to the hotsprings).

Look at the image your teacher has on the screen. Create your own color key based on the image and assign a hypothetical temperature range to each color.

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