LIMITS OF LIFE

LESSON 2 - TEACHER'S GUIDE

EYE
Extreme Yellowstone Expedition

LESSON SUMMARY

Students will learn about limits of life and environmental gradients through a progression of activities. Students will be introduced to gradients by analyzing photos of familiar landscapes (a beach and a valley). Students will then explore which forms of life on Earth can handle the most extreme conditions. Next, students will focus on learning about the extreme life of Yellowstone by meeting a few microbes, then analyzing photos of hot springs, and finally collecting data on the populations of several Yellowstone thermal features.

- **Activity 1: Identifying Gradients**
  (Estimated time ~ 25 minutes without the extension)

  Students will analyze and identify abiotic gradients in photos of two familiar environments.

  Extension Activity: Make your own temperature gradient (Estimated time ~ 30 minutes)

  Students can measure and graph data from a gradient outside, near their school or from a demonstration they create in the classroom.

- **Activity 2: Who's More Extreme? You, an Insect, a Plant or a Fish?**
  (Estimated time ~ 25 minutes)

  Through graphing temperature limits, students will discover which types of organisms on Earth can survive the most extreme temperature limits.

- **Activity 3: Yellowstone's Extreme Life**
  (Estimated time ~ 30 minutes)

  Students will graph the pH and temperature ranges for some of Yellowstone's extremophiles and investigate if microbes with different metabolisms sometimes have different niches.

- **Activity 4: Exploring Yellowstone's Gradients**
  (Estimated time ~ 20 minutes)

  Using the knowledge and experience they gained in activities 1-3, students will analyze the gradients of three different types of Yellowstone hot springs.

- **Activity 5: Sweet Population Sampling**
  (Estimated time ~ 45 minutes without the extension)

  Students will collect data from models (based on actual research) of the three thermal features they analyzed in Activity 4. Students will look at the population distribution of a subset of the microbes that live in these hot springs. The microbes will be represented by different colors of candy.

- **Extension Activity: Population Pie Chart**
  (estimated time ~ 25 minutes)

  Students will calculate the fraction, decimal and percent of each microbe in Mud Pot, Lemonade Creek and "Gabby's Spring," then create a pie chart of the microbes to discover which are most prevalent.

LESSON OBJECTIVES

- Students will learn that abiotic (nonliving) factors such as gradients can help determine the distribution and abundance of organisms in an ecosystem.
- Students will compare the metabolic processes of organisms in thermal features.
- Students will understand that most organisms on Earth derive their energy from light; however, some organisms are able to derive their energy from chemical sources.
- Students will learn the three domains of life that make up all living organisms on Earth: Archaea, Bacteria, and Eukaryota.
- Students will collect, organize, and record data.
- Students will graphically compare and analyze data points.

MONTANA STATE UNIVERSITY | Thermal Biology Institute

NEXT GENERATION SCIENCE STANDARDS

NGSS : Matter and Energy in Organisms and Ecosystems

- **MS-LS-1.** Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
- **MS-LS1-6.** Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
- **MS-LS2-4.** Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

NGSS: Growth, Development, and Reproduction of Organisms

- **MS-LS1-5.** Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

MATERIALS NEEDED

For each of these activities students will need pencils and **"Extreme Yellowstone Expedition – Lesson 2: Limits of Life Student Activity Book"** worksheets. The only activities that require other materials are as follows.

Activity 1 Extension

- Option 1 — measuring tape of 10m or up to 100m long; graph paper; clip boards; a sensor that measures one of the following: temperature, soil moisture, humidity, soil pH, light intensity, etc.
- Option 2 — 1 or 2 plastic tubs at least 1 foot long, 2 beakers, ice, a thermometer that can measure water and/or air temperature, graph paper, measuring tape as long as the plastic tub, red and blue pens

Activity 3

- Each student will need pens or colored pencils of two different colors to create a graph

Activity 5

- Tape that can be used directly on the floor such as painters tape or masking tape
- 7 different colors of candy such as Jolly Ranchers of different colors (for two of the colors 76 and 74 pieces are required, for the rest of the colors you will need approximately 50 of each)
- Each student will need pens or colored pencils of several different colors to create a graph

TEACHER INSTRUCTIONS

Activity 1: Identifying Gradients

1. Pass out the Identifying Gradients worksheet to each student
2. Tell the students that they will be analyzing the photos looking for gradients.
3. Ask the students to read the information on their worksheets then answer the questions.
4. Explain to the students that they should take into consideration sorting out the living environment, which we call biotic factors, from the nonliving environment, which we call abiotic (non living) factors.
5. You may want to have the class work together to identify one or two gradients so the students have some examples and understand the concept fully. See examples in the worksheet answer key.
6. When the students are finished, discuss the their findings in class using some of the background information. In your answer key, you will find background information provided only to the teacher that will help enrich your class discussion.

Extension Activity:
Make your own temperature gradient

Option 1: Have students create their own temperature gradient or measure one that already exists. For example, students could measure out a linear transect across the ground over different surface areas like grass, sidewalk, asphalt, sun/shade and measure surface temperature every meter. The transect could vary in length from between 10 meters and 100 meters. Have students take measurements at marked regular intervals of one abiotic factor, such as temperature (soil or ambient), soil moisture, relative humidity, light intensity, or soil pH. Have the students graph their results. If you use this approach, ask your students what differences in organisms seemed to mirror the abiotic changes along the transect (i.e. how did plant diversity or growth change with soil moisture levels).

Option 2: Alternatively, students could set up a small heat transfer transect in one or two large plastic tubs of water (at least a foot long) in the classroom. Give students directions and allow them to measure the transect and temperature. After collecting temperature data, students can graph results to show a visual representation of temperature gradient on surface, air or water. Here is an example in water.

1. Set a beaker of hot water in one end of a plastic tub and a beaker of cold ice water in the end of another plastic tub.
2. Fill both tubs with room temperature water up near the top of the beakers sitting in the tubs.

3. Take temperature of water surface temperature every 5 cm along the surface of the tub starting at zero right next to the beaker of hot or cold water.
4. Record data in a distance (cm) and temperature table for both hot and cold environments.
5. Using red for hot and blue for cold, graph the two environments temperature results on a coordinate graph putting distance (cm) on the x axis and temperature on the y axis.
6. Do you notice any trends in the temperature gradients as you increase distance from the hot or cold source?

Activity 2: Who's More Extreme? You, an Insect, a Plant or a Fish?

1. Pass out the Activity 2 worksheet to each student
2. Tell the students that they will be investigating which kinds of life on Earth can withstand the coldest and hottest temperatures.
3. Ask students to fill out the worksheets and when they are finished, discuss the their findings in class.

Activity 3: Yellowstone's Extreme Life

1. Pass out the Activity 3 worksheet to your students and ask them to complete it.
2. Ask the students to graph the temperature limits of organisms.
3. Make sure they graph the microbes using two colors: one for organisms that use photosynthesis and one for those who don't (the organisms in red on the table).
4. Tell the students whether you would like them to graph the data using Fahrenheit or Celsius.

Activity 4: Exploring Yellowstone's Gradients

1. Pass out the Activity 4 worksheet to each student
2. Ask students to fill out the worksheets and when they are finished, discuss the their findings in class.

Activity 5: Sweet Population Sampling

1. Create three grids in different parts of your classroom using tape on the floor to create a two foot by three foot rectangle of squares as pictured below. Each rectangle is going to represent a different thermal feature in Yellowstone. See the answer key for the Activity 5 worksheet to see the patterns you should replicate with the candy. The patterns in each virtual hot spring have the microbes (candy) distributed in patches based on the temperatures of the springs. *You will find it much easier to replicate the exact pattern and number of microbes (candies) from the worksheets than recalculating all the answers.* Also, if you follow the patterns, the distribution of microbes in the springs will match the temperature gradients of the hot springs in the photos of Activity 4.

2. Use seven different colors of Jolly Rancher or another type of candy to create an approximate copy of the grids below. Choose a color of candy to represent each of the following microorganisms.

Organism	Candy Color
Sulfolobus	
Caldisphaera	
Cyanidioschyzon	
Chlorella	
Thermus	
Chloroflexus	
Pseudoanabaena	

3. Pass out worksheets to each student and tell them they are going to collect samples of microbes from three Yellowstone thermal features.
4. Students will sketch what they see in each part of the grid and total the numbers of each kind of microorganism they find in each box. Once they have found a total of specimens for each box they should calculate the total number of specimens in the whole sample area (in other words in the whole grid).

Extension Activity: Population Pie Chart

Ask your students to use the worksheet to calculate the fraction, decimal and percent of each microbe in Mud Pot, Lemonade Creek and "Gabby's Spring," then create a pie chart of the microbes to discover which are most prevalent.

Note: This key features answers that correlate to the exact numbers of microbes/candies in the answer key for Activity 5. If you did not use the same numbers, you will have to recalculate the answers.