INVESTIGATING HOT SPRINGS

LESSON 5 - TEACHER'S GUIDE

EYE
Extreme Yellowstone Expedition

LESSON SUMMARY

(Estimated time ~ 70 minutes)

Students will examine a simulated Yellowstone hot spring to determine temperature values of points at varying distances from the source. They will explore how the environmental factors of pH and temperature influence the growth of organisms in Yellowstone hot springs as well as various other organisms found in different environments.

LESSON OBJECTIVES

- Students will be able to define pH and learn about the pH scale.
- Students will learn how temperature and pH are critical variables that impact where certain types of life can thrive.
- Students will collect, organize, and record data.
- Students will graphically compare and analyze data points.

NEXT GENERATION SCIENCE STANDARD

- **MS-LS1-5.** Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
- **MS-LS2-4.** Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

LESSON PREPARATION

This lesson can be conducted in a variety of ways depending on the availability of resources, size of the class, and physical setup of the classroom. Students can do the lab in small groups or it can be done by the instructor with student assistance. Preparing simulated hot spring water in advance saves time and reduces the chance of spilling. Have clean-up materials available as necessary.

MATERIALS

- Student worksheets **"Extreme Yellowstone Expedition – Lesson 5: Investigating Hot Springs Student Activity Book"**
- Hot spring mat
- Large glass beakers - 4
- Hotplates - 3
- pH test strips
- Thermometers or infrared digital thermometer
- Glass stirring rod
- Water
- Borax
- Food coloring (blue, green, and orange)
- Three different colored pens or markers for students to use during the graphic exercise (ideally blue, green, and orange to match the colors of the spring)

Teacher Note: Students should use proper lab safety precautions including eye protection, aprons/ lab coats, and gloves.

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TEACHER INSTRUCTIONS FOR THE LAB

1. Before class follow these instructions to set up for the lesson.

a. Print out the following file in color: ***tbi.montana.edu/eye/lessons/docs/virtualspring.pdf*** Assemble the sheets and tape them to the floor just like puzzle pieces to create a virtual hot spring (or you can print them out and have the students assemble the pieces on the floor when you start class).

b. Mix 50 mL of borax with 350 mL of water in a glass beaker.

c. Add 5 to 10 drops of blue food coloring to the beaker, and stir. The borax should be dissolved in the water.

d. Pour some of the blue mixture into an additional beaker from which students can take pH measurements.

e. Set up three hot plates in an area of the room where students will not be able to knock them over.

f. Place the first beaker of the blue mixture onto a hot plate on the high setting. If the liquid begins to boil, back off the heat slightly.

g. Pour water into two more beakers and place green food coloring in one beaker and orange food coloring in the other beaker. Place the green beaker on medium heat and the orange beaker on low heat.

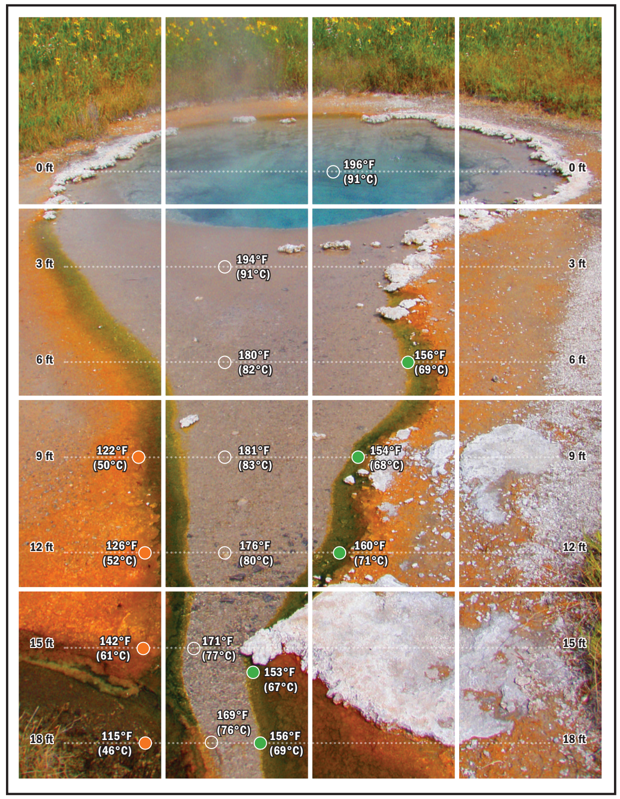
h. Test the pH of the blue mixture using pH strips before students conduct the experiment. Variables such as type of water, strength of borax, etc. can affect pH value. Try to ensure that the pH level is between 8 and 9 to match the pH of the actual spring in Yellowstone.

i. Ask your students to bring a liquid from home in a sealed container in order to test its pH.

When class begins...

2. Distribute worksheets and lab materials to students (safety equipment, pH test strips, and thermometers or infrared digital thermometer).

3. If students need a background on acids and bases, refer to Yellowstone ABC's Activity Guide (***http://www.abrc.montana.edu/outreach/***). As a part of measuring pH, have students bring a sealed liquid in from home to test its pH and plot it on a scale. Sample liquids can include drinking water, local pond water, local river water, drinks, etc. Have them plot the pH on the scale in their workbook.



4. Explain to students they will be collecting temperature and pH data from a virtual hot spring. Give them specific directions on how they will be getting temperature readings from the liquids on the three hot plates. Ideally, they will be using infrared thermometer guns to take the temperatures and will not have to touch the liquids. Review safety with students for when working with extremely hot liquids. Students should stand at a safe distance from the hot spring stations when taking a measurement.

Teacher Note: If using an infrared thermometer, note that they only give you the surface temperature of an object, not the internal temperature. Also, not all materials are created equally. Different surfaces yield different amounts of emitted infrared energy, called emissivity. Emissivity is measured on a scale from just about 0.00 to just below 1.00. The closer a material's emissivity rating is to 1.00, the more that material tends to absorb reflected or ambient infrared energy and emit only its own infrared radiation. Most organic materials, have an emissivity rating of 0.95. These are ideal surfaces for accurate temperature readings. Highly-polished metals tend to have low emissivity ratings because they reflect ambient infrared energy and are not very effective at emitting their own electromagnetic waves. For example, spraying a shiny metal pan with cooking oil before you measure its temperature with an infrared thermometer will yield a more accurate reading because you have compensated for its emissivity.

5. Ask the students which part of the hot spring they think will be warmest and which part will be coolest. Have students measure the temperature of the three parts of the hot spring (blue, green, and orange). Explain that the temperatures they take will not reflect the actual temperature of the hot spring but will mimic which parts of the spring are hottest and coolest, show that the temperature decreases as the distance increases from the source of the spring.
6. Turn off each hotplate and allow each hot spring to cool.
7. Students should fill in the table on their worksheets with the temperature values of each hotplate station.
8. Have students follow pH test strip instructions to test prepared blue liquid that is not on hotplates. Note: Students only need to determine the pH value of the blue sample. In the hot spring the pH values change very little in the different color zones.
9. Have students answer the relevant questions on their worksheets.
10. Have students return their safety materials before moving on.
11. Have students walk around the virtual hot spring image on the floor and collect and graph the real temperature data for each different color channel in the hot spring. Tell the students this data was collected by Gabby Michael, a student from Lone Peak High School in Big Sky Montana who went on a scientific expedition with researchers from Montana State University.
12. Have students answer the questions on their worksheets and discuss their answers with them when they are done.

Teacher Note: Help students understand that data is not perfect, and point out that the data in the orange channel increases at 5 meters from the center of the spring in temperature.

13. Clean up all the materials.
14. Have the students answer the questions in the Zones of Life and Exploring for Life sections of their worksheets.
15. Discuss their answers.

EXTENSION ACTIVITIES

Heat Transfer

You may wish to try some or all of these demonstrations of heat transfer:

1. Bring a beaker of water to a boil on a hot plate or Bunsen burner. Place a piece of copper tubing in the water with one end sticking out. Ask the students how many forms of heat transfer are happening in the demonstration?
   (Answer: Three. **1) Convection.** Convection is occurring as water transfers heat through itself and hot water rises and cold water falls. **2) Conduction.** Heat is conducted through the copper pipe from the submerged end to the exposed end. **3) Radiation.** Heat is being radiated from the burner and out from the beaker.
2. Place equally spaced marbles onto a copper pipe using candle wax. Suspend the copper pipe over a candle, with the candle in the middle and equal lengths of the pipe on each side of the candle. Have the students predict what will happen and explain their answer. As the candle heats the pipe, heat will be conducted and cause the marbles to fall off each side of the pipe in sequence.
3. Give a group of students a bowl of hot water with three spoons sticking out of the water: one metal, one plastic, and one wooden. Have the students predict which spoon will get warm first and which will get warm last. Then ask them to explain their answers.

Yellowstone ABCs

This three-part lesson ties together the concepts of pH, Yellowstone extremophiles, and the search for life beyond the Earth.

In Part 1, students conduct a laboratory activity in which they test several substances to determine pH.

In Part 2, students plot the pH values of Yellowstone National Park thermal features on a pH scale, then learn about extremophiles and the types of environments in which they are found.

In Part 3, a brief reading connects the concepts learned in Parts 1 and 2 and expands on this content. Mars and Europa are discussed as possible sites where extraterrestrial life may be found. Lastly, an exit quiz assesses student knowledge of the lesson and its major themes.

http://www.abrc.montana.edu/outreach/

Planet in a Bottle / Extreme Planet Project

In this activity, students learn the basic principles behind the Goldilocks zone, extremophiles, and astrobiology through a reading, two experiments, and a project.

In Part 1, students conduct experiments on three simulated planets in bottles and collect data on each planet's suitability for life.

In Part 2, students build their own simulated planet and explore changes variables to make planets more or less hospitable to life.

Lastly, students can design their own planet using NASA web resources then create an extremophile that would live on the planet.

Grades 5-12

http://www.abrc.montana.edu/outreach/