# Exploration Phase: Extreme Environments Lab

***MS-LS2-4***. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

***Driving Question***: Do changes to the physical components (e.g. water temperature or pH) of an ecosystem affect populations? Why or why not?

**Purpose:** The *Extreme Environments lab* is designed to provide students with an opportunity to go through some of the same scientific practices (e.g., collecting data, analyzing data, and engaging in argumentation) that Yellowstone scientists do in their investigations of microorganisms. In groups, students are tasked with determining the pH, temperature, and color of six different water samples from “Yellowstone’s” hot springs.

Equipped with the physical components (temperature and pH) of each hot spring’s water, student use information about thermophiles to determine which species of thermophile is likely to thrive in each hot spring.

**Background Information and Procedure.** During the *Thermometer Activity* in the Engagement Phase, students learned that multicellular organisms all have different optimal living temperatures. Students were also introduced to some of Yellowstone’s smallest organisms, called thermophiles. These unique organisms thrive in environments with much higher temperatures than is safe for bison, gray wolves, mountain lions, river otters, or ruffed grouse to survive. The *A Framework for K-12 Science Education* document suggests that by the end of grade 8, students should understand that, “organisms grow, reproduce, and perpetuate their species by obtaining necessary resources through interdependent relationships with other organisms and the physical environment. These same interactions can facilitate or restrain growth and enhance or limit the size of populations” (NRC, p. 150).

Students will work with vinegar/water solutions with pH ranges between 3 - 6, and baking soda/water solutions with pH ranges of 8 or 9. Below in this document, we provide you (the teacher) with a quick review on pH and an explanation of how to introduce pH to your middle-level students using a pH scale and a Khan Academy video. To further bring a safety awareness and then relevance of pH and water temperature to Yellowstone’s hot springs, we show a brief (3-minute) PBS video produced by the American Chemical Society, Yellowstone and Their Steaming Acidic Pools of Death,” that addresses the extreme temperature and pH environments of Yellowstone’s hot springs.

Begin the lesson by reviewing some of the questions students placed on the Driving Questions Board the day before. Then say, “Based on your questions, this is what we all seem to be interested in knowing, Do the physical components (e.g. water temperature or

pH) of an ecosystem affect which thermophiles live there? Let’s investigate to determine the answer to our question.”

During the *Extreme Environments Lab*, in addition to measuring the water temperature of six different “hot springs”, students are introduced to a second physical component of the environment, pH. As a qualitative measurement, teams also record the color of each hot spring’s water sample. Color serves to represent the bacterial mats generated when these individually invisible microscopic thermophiles clump together to form large, visible mats of various colors.

Using data generated from the investigation, each research team is provided with an “incomplete” Extreme Environments *Reference Page (StudentExplorationHandout2*\_ReferenceSheets) as a tool to help teams identify the thermophiles that could potentially live in each hot spring. However, each research team will only receive part of the necessary information to adequately place a thermophile with the correct hot spring. While all teams receive a list of the microorganisms, one team receives the organisms mat color but not the organisms’ optimal temperature or pH. Another team only receives the optimal temperature range of each thermophile but not the mat color or pH. Finally, another team receives the optimal pH of each thermophile but not the thermophile’s mat color, or optimal temperature. Do not let teams know that they do not have the same information.

Note: Use this opportunity to talk about the collaborative nature of researchers and how researchers often focus on different aspects of the research topic. But when researchers share data a bigger picture of the natural phenomena begins to appear.

Depending on the information provided to each research team and the accuracy in which teams collected their own data, frustration may set in, so monitor teams closely. Once each team has identified thermophiles that could potential live in each hot spring, based on their own data and data presented in their *Extreme Environment Reference Sheet*, merge two teams that received different data on their *Extreme Environment Reference Sheet*. Allow time for merged teams to share where they originally placed their thermophiles on their data table, time for teams to exchange data from their Reference Sheet, and then time for students to reconsider thermophile locations based on newly acquired data.

Ask teams, “Based on the new information that was presented to you from the other research team, did your team change the placement of any thermophiles in a hot spring, why or why not?”. Repeat this merger one more time by adding a third team with different data. Again, give teams time to compare data, modify the location of the thermophiles (if the new data warrants it) and then once again ask, “Based on the new information that was

presented to you from the new team(s), did your team change which thermophile could live in each hot spring, why or why not?”.

**Connection to Nature of Science**. This is a great time to talk about the tentative nature of science. Scientific knowledge can, and does, change. While science is durable, it is subject to change in light of new evidence, or the interpretation of existing evidence. Because science is a dynamic process, scientists cannot claim “absolute truth” in science. Instead, scientists provide the available evidence to support their claims.

As a closing assessment, ask teams to explain if, how, and why (or why not) the location of their thermophiles changed as they received new/additional information. Have each team respond to the writing prompt on the back of the student handout containing Data Table 1.

### Student Procedures: Part 1

**Determining a Hot Spring’s pH.** On the back of the clear plastic pH test paper packet are color bars. Instruct students to pull off a 2-inch strip of pH paper and dip it in the beaker’s “Hot Spring’s” water for 2-seconds. Instruct them to immediately match the color of the pH paper to one of the color bars on the back of the pH test paper packet. Because color is a qualitative measurement that may be interpreted differently, encourage students to gather team consensus on the color match. Remind students to record the pH value that corelates with the color of the pH paper in the Data Table 1 handout, found in *StudentExplorationHandout2- ExtremeEnvironmentLab\_DataTable1*.

**Determining a Hot Spring’s Temperature.** Each “Hot Spring” water sample is in a beaker and sitting on a hot plate. To record the temperature of the water, instruct students to put the thermometer in the water but do not let the bulb of the thermometer rest on the bottom of the beaker. If students use the type of thermometer that is anchored to the side of the beaker, instruct them to get eye level of the thermometer before trying to read the temperature. Once the liquid in the thermometer stops moving up or down, instruct them to record the temperature of the water in their data table. Remind them to include the unit that the temperature was measured in **°**F or **°**C.

**Determining a Hot Spring’s Water Color.** Color is a qualitative measurement that may be interpreted differently. As a team, students are to come to a consensus on the color of the water in the “Hot Spring” and record the color of the hot spring in their data table. They are transferring a qualitative observation into a quantitative value.

### Student Procedures: Part 2

Once data are collected from each of the six hot springs, provide each research team with one of the “incomplete” reference sheets (*TeacherExplorationHandout3-*

*ExtremophileLab\_IncompleteDataTables)*. Each team will receive the list of thermophiles they can select from, but will have different supporting information. Notice that there are more than six thermophiles listed on this table. Using the data collected from each of the six solutions: pH, temperature, and color, task students with identifying a specific thermophile that could thrive in each hot spring’s physical environmental conditions. Record the name of the matching thermophile in Data Table 1. Suggest that they record this information in pencil in case they want to change their responses.

**Researcher Teams Collaborate.** Analyzing and Interpreting Data to determine similarities and differences in findings is an important aspect of scientific research. To demonstrate the importance of collaboration in analyzing and interpreting data, merge two research teams who hold different information on their *ExtremeEnvironmentsLab\_IncompleteDataTables*. For example, one team may possess information about each thermophiles pH preference while another team may possess information about the color mats that each thermophile produces. Allow time for this newly formed merged team to share data, analyze, and discuss potential changes to the placement of their thermophile(s). Then add a third and final team, who possess new data, to form an even larger merged team. Follow instructions listed above. Providing students with additional data to analyze and interpret helps them to understand the tentative nature of science and the importance of collaboration.

**Researcher Teams Collaborate.** Analyzing and Interpreting Data to determine similarities and differences in findings is an important aspect of scientific research. To demonstrate the importance of collaboration in analyzing and interpreting data, merge two research teams who hold different information on their *ExtremeEnvironmentsLab\_IncompleteDataTables*. For example, one team may possess information about each thermophiles pH preference while another team may possess information about the color mats that each thermophile produces. Allow time for this newly formed merged team to share data, analyze data, and discuss potential changes to the placement of their thermophile(s). Then add a third and final team, who possess new data, to form an even larger merged team. As described above, allow time for this larger team to share and analyzed data, and discuss potential changes to the placement of their thermophile(s). Providing students with additional data to analyze and interpret helps them to understand the tentative nature of science and the importance of collaboration.

***TeacherExplorationHandout2-ExtremeEnvironmentLab\_ThermophileInformation*** document, provides additional information for each thermophile used during the *Some Like it Hot* lesson.

**Ticket out the Door**. The lesson concludes with each student submitting a Ticket out the Door. *StudentExplorationHandout3-ExtremeEnvironmentLab\_TicketOutTheDoor*

1. List the two physical components of the “hot springs” that you measured during the Extreme Environments Lab.
   1. *Temperature*
   2. *pH*
2. In four-five sentences, construct an argument supported by evidence as to whether or not the physical components listed above can affect the population of microorganisms that live in it.

*Answers will vary but should reference that organisms thrive in environments with specific physical components. Some thermophiles thrive in acidic environments and some thrive in alkaline environments. Depending on the species of thermophiles, they can thrive in warm, hot, or superhot water. Thermophiles that thrive in warm water may not be able to thrive in superhot water; Thermophiles that thrive in superhot water may not be able to thrive in lower temperature waters. Similarly, the organisms that thrive in waters with a pH of 7 may not be able to thrive in waters with a pH of 3. Therefore, the physical components of a hot spring affect the populations of organisms that live it in.*

Note to Teacher: To increase student success during this lesson, we encourage you to provide feedback to each student regarding their response to the above question. Question #2 serves as a formative assessment thus, it is important to address students’ misconceptions in identified in their responses.

### Materials for student Research Teams

* pH paper strips with color chart
* Thermometers (located at each Hot Spring lab station)
* Safety Goggles
* Lab Apron
* Latex Gloves (optional). We have found that wearing gloves may decrease touch sensitivity and glass equipment, such as beakers and thermometers, slip through students’ hands easier.

### Student Handouts

* *StudentExplorationHandout1-ExtremeEnvironmentLab* (one per research team)
* *StudentExplorationHandout2-ExtremeEnvironmentLab\_DataTable1* (one per research team)
* *StudentExploratinHandout3-ExtremeEnvironmentLab\_TicketOutTheDoor* (one per student)

### Teacher Handouts

* *TeacherExplorationHandout2-ExtremeEnvironmentLab\_ThermophileInformation*
* *TeacherExplorationHandout3-ExtremeEnvironmentLab\_IncompleteDataTables* (one “incomplete” FORMper research team – to be handed out after student data are collected)

### Materials

**Materials for teacher (lab preparation materials)**

* Six-500 mL beakers (solution preparations outlined below). We recommend using 500 mL beakers to avoid the possibility of thermometers tipping over smaller beakers.
* Hot Plates with varying temperature options. Each beaker will contain a different pH, temperature and/or color to simulate environments of various hot springs in Yellowstone National Park. While hot plates can run over $200.00 each, an inexpensive multi- temperature coffee cup warmer can be purchased for under

$25.00 on Amazon.

* pH paper strips (we recommend the Hydrion Insta-Check 0-13 pH Test Paper. This is a wide range, general purpose, pH paper that provides an immediate response time and displays a different bright color for each pH value from 0-13. While each packet costs around

$13.00, it will last a long time and provides student groups with a nice visual color display.)

Each of the 6 hot spring stations should have a pH check packet. This will avoid students carrying the pH packets from station to station and maybe misplacing the packets.

* Thermometers. For middle-level students, we recommend the metal- backed non-mercury thermometers that are securely fastened onto an

aluminum metal backing for added durability. They cost about $3.10 each. To decrease the chance of spills, we recommend that the thermometers be anchored to the glass beaker; students will still be able to read and record the water temperature without having to take the thermometer in and out.

* Food coloring is used to simulate pigments of selected thermophiles. A box of four colors can be purchased for less than $3.00 at any general store.
* Vinegar can be purchased for less than $2.00, at any general store. 
* Baking Soda (Sodium Hydrogen Carbonate) can be purchased for less than $2.00 at any general store.
* Distilled Water

**Hot Spring Solution Set Up.** Directions on how to make solutions for each beaker “hot spring”. Refer to Table 1 (see below for pH, temperature, and color of each beaker). As water solutions are prepared, label each beaker as “Hot Spring A”, “Hot Spring B”, “Hot Spring C”, etc. Do not include the name of the thermophile on the label of the Hot Spring.

1. **To obtain a pH of 3** (used for two of the six hot spring solutions).

Mix ¾ Tablespoon (Tbsp) of vinegar with 700 mL of water, stir. Both Hot Spring-A and Hot Spring-D have the same pH but contain a different temperature and a different color.

* + Pour 300 mL of this solution into a beaker and label the beaker as “**Hot Spring-A**”. Add yellow food coloring to create a **strong yellow** solution. **Hot Spring-A** represents the Hydrogenobaculum thermophile and should be placed on a hot plate at a temperature between 131-162**°**F (55-72**°** C).
  + Pour the 300 mL of the solution into a second beaker and label this beaker as “**Hot Spring-D**. To create a **dark purple or black** solution, add both blue and red food coloring but add more blue than red coloring. **Hot Spring-D** represents the Zygogonium thermophile and should be placed on a hot plate at a temperature between 90-131**°**F (32-55 **°**C).

### To obtain a pH of 6.

Mix ½ teaspoon (tsp) of vinegar with 500 mL of water, stir. Pour 300 mL of this solution into a beaker and label the beaker as “**Hot Spring-E**”. Create a red solution by adding **red** food coloring to the solution. **Hot Spring-E** represents the Thermus thermophile and should be placed on a hot plate at a temperature between 104-174**°**F (40-79**°**C).

### To obtain a pH of 7

Distilled water should have a pH at or close to 7. Pour 300 ml of the distilled water into a beaker and label the beaker as “**Hot Spring-C**”. Add green food coloring to the solution to establish a “**true green**” color. **Hot Spring-C** represents the *Synechococcus* thermophile and should be placed on a hot plate at a temperature between 125-165**°**F (52-74**°**C).

### To obtain a pH of 8

Mix 1-teaspoon (tsp) of baking soda (sodium hydrogen carbonate) to 500 mL of water, stir until the baking soda has dissolved. Pour 300 ml of this solution into a beaker and label the beaker as “**Hot Spring-F**”. To create an orange colored solution, add a drop or two of red food color to a yellow colored solution. **Hot Spring-F** represents the Oscillatoria thermophile and should be placed on a hot plate at a temperature between 97-113**°**F (36- 45**°** C).

### To obtain a pH of 9

Mix 2-teaspoons (tsp) of baking soda (sodium hydrogen carbonate) to 500 mL of water, stir until the baking soda has dissolved. Pour 300 ml of this solution into a beaker and label the beaker as “**Hot Spring-B**”. To create a **True Green** solution, add green food coloring to the water. **Beaker B** represents the Chloroflexus thermophile and should be placed on a hot plate at a temperature between 95-185**°**F (35-85**°**C).

***Data Table.*** Actual pH and temperature may vary with the solutions you create. If you use tap water instead of distilled water to make your solutions, you may have to “play” with the amount of vinegar or baking soda you add to your water samples. Depending on the type of hot plate you use, you may also have to “play” with regulating the water temperature.

However, the pH and temperatures of solutions in each beaker should fall within the ranges listed below. Keeping within the designated ranges will ensure that students can provide accurate evidence to support their claims.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Beaker** | **pH** | **Temp**  **°Fahrenheit** | **Temp**  **° Celsius** | **Color** | **Microorganism** |
| **A** | 3 | 131-162 | 55-72 | Yellow | *Hydrogenobaculum* |
| **B** | 9 | 95-185 | 35-85 | True Green | *Chloroflexus* |
| **C** | 7 | 125-165 | 52-74 | True Green | *Synechococcus* |
| **D** | 3 | 90-131 | 32-55 | Black/Dark Purple | *Zygogonium* |
| **E** | 6 | 104-174 | 40-79 | Red | *Thermus* |
| **F** | 8 | 97-113 | 36-45 | Orange | *Oscillatoria* |

**Beaker “Hot Spring” Station Set Up**. Set up beaker “Hot Spring” stations so each student research team can collect data (pH, temperature, and color) from each “Hot Spring” before moving to the next “Hot Spring” station. Maintaining only one team at a station at a time reduces the changes of accidents such as spills or glass breakage.

For Peer Review

**Safety.** The *Extreme Environment Lab* involves hot water and pH solutions that may be alkaline (basic) or acidic. As a precaution, before students begin the investigation, it is important to inform students about these liquids. Students should be equipped with safety goggles and laboratory aprons, with the option of using gloves. If students have not had prior laboratory experience involving basic or acidic solutions, we recommend that you engage them in a discussion involving applicable examples of pH. See pH chart below. To make this learning experience more interactive, we project a pH scale on the smart board (similar to the one below but without the examples), give students examples of common substances, and ask them where on the pH scale they think each substance is located. We also show our students the brief video on pH which is sponsored by Khan Academy: [https://www.khanacademy.org/science/high-school-biology/hs-biology-foundations/hs-](https://www.khanacademy.org/science/high-school-biology/hs-biology-foundations/hs-ph-acids-and-bases/v/introduction-to-ph) [ph-acids-and-bases/v/introduction-to-ph](https://www.khanacademy.org/science/high-school-biology/hs-biology-foundations/hs-ph-acids-and-bases/v/introduction-to-ph)



TeacherExplorationHandout2-ExtremeEnvironmentsLab\_ThermophileInformation

# Thermophile Information Covered in the Some Like it Hot Lesson

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Microorganism** | **Location** | **Color** | **Metabolism** | **Temp (°F) Temp (°C)** | **pH** |
| *Oscillatoria* | Mammoth Hot Springs, Chocolate Pots | Orange mats | Photosynthesis; oscillating moves it closer to or away from light | 97-113**°**F  36-45**°**C | 6-8 |
| *Synechococcus* | Mammoth Hot Springs, Upper, Midway, and Lower Geyser Basins | Green mats | Photosynthesis by day; fermentation by night | 126-165**°**F  52-74**°**C | 7-9 |
| *Chloroflexus* | Mammoth Hot Springs, Upper, Midway, and Lower Geyser Basins | Green mats | Anoxygenic photosynthesis | 95-185**°**F  35-85**°**C | 7-9 |
| *Hydrogenobaculum* | Norris Geyser Basin and Amphitheater Springs | Yellow and white streamers | Uses hydrogen, hydrogen sulfide, and carbon dioxide as energy sources; can use arsenic in place of hydrogen sulfide | 131-162**°**F  55-72**°**C | 3-5.5 |
| *Thermus* | Lower and Upper Geyser Basins | Bright red or orange streamers | Chemosynthesis; can obtain energy for growth from nearby photosynthetic organisms | 104-174**°**F  40-79**°**C | 5-9 |
| *Calothrix* | Mammoth Hot Springs, Upper, Midway, and Lower Geyser Basins | Dark brown mats | Photosynthesis by day; fermentation by night | 86-113**°**F  30-45**°**C | 6-9 |
| *Phormidium* | Mammoth Hot Springs, Upper, Midway, and Lower Geyser Basins | Orange mats | Photosynthesis | 95-135**°**F  35-57**°**C | 6-8 |
| *Sulfolobus* | Norris Geyser Basin, Lemonade Creek, Nymph Creek | Dark Green | Chemosynthesis | 104-131**°**F  40-55**°**C | 0-4 |
| *Cyanidioschyzon* | Norris Geyser Basin, Lemonade Creek, Nymph Creek | Bright green | Photosynthesis | 104-131**°**F  40-55**°**C | 0-4 |
| *Zygogonium* | Norris Geyser Basin, Lemonade Creek, Nymph Creek | Appears black or dark purple in sunlight | Photosynthesis | 90-131**°**F  32-55**°**C | 0-4 |

# Exploration Phase

**Extreme Environments Reference Sheet Form 1**

|  |  |
| --- | --- |
| **Thermophilic Microorganism** | **Color** |
| *Sulfolobus* | Dark Green |
| *Oscillatoria* | Orange mats |
| *Synechococcus* | Green mats |
| *Chloroflexus* | Green mats |
| *Hydrogenobaculum* | Yellow and white streamers |
| *Cyanidioschyzon* | Bright green |
| *Thermus* | Bright red or orange streamers; contains carotenoid pigments that act as a sunscreen |
| *Calothrix* | Dark brown mats |
| *Phormidium* | Orange mats |
| *Zygogonium* | Appears black or dark purple in sunlight |

StudentExplorationHandout2-EntremeEnvironmentsLab\_ReferenceSheets

# Exploration Phase

**Extreme Environments Reference Sheet Form 2**

|  |  |
| --- | --- |
| **Thermophilic Microorganism** | **Temp (°C)** |
| *Sulfolobus* | 40-55**°**C |
| *Oscillatoria* | 36-45**°**C |
| *Synechococcus* | 52-74**°**C |
| *Chloroflexus* | 35-85**°**C |
| *Hydrogenobaculum* | 55-72**°**C |
| *Cyanidioschyzon* | 40-55**°**C |
| *Thermus* | 40-79**°**C |
| *Calothrix* | 30-45**°**C |
| *Phormidium* | 35-57**°**C |
| *Zygogonium* | 32-55**°**C |

# Exploration Phase

**Extreme Environments Reference Sheet Form 3**

|  |  |
| --- | --- |
| **Thermophilic Microorganism** | **pH** |
| *Sulfolobus* | 0-4 |
| *Oscillatoria* | 6-8 |
| *Synechococcus* | 7-9 |
| *Chloroflexus* | 7-9 |
| *Hydrogenobaculum* | 3-5.5 |
| *Cyanidioschyzon* | 0-4 |
| *Thermus* | 5-9 |
| *Calothrix* | 6-9 |
| *Phormidium* | 6-8 |
| *Zygogonium* | 0-4 |

Science Scope

StudentExplorationHandout1-ExtremeEnvironmentsLab

# Exploration Phase Directions: Extreme Environments Lab

### Background Information:

Organisms interact with their natural surrounds known as an **ecosystem**. The living (biological) components of an ecosystem are called biotic factors, while non-living (physical) components of an ecosystem are called abiotic factors. Biotic factors might include animals, plants, fungi, or other living or once-living organisms. Abiotic factors refer to the non-living physical or chemical elements in the ecosystem such as water, air, soil, sunlight, and minerals.

For organisms to grow and reproduce they must obtain necessary resources both biological and physical. During the *Thermometer Activity*, you were introduced to a group of microorganisms called thermophiles which literally means “heat-loving”. These heat loving organisms can live in environmental temperatures beyond what is suitable for bison, gray wolves, mountain lions, river otters, or ruffed grouse. But, do all thermophiles thrives in the same environmental condition?

During the *Extreme Environments Lab*, you are going to conduct a scientific investigation similar to what Yellowstone scientists do when they investigate thermophiles. To learn more about a thermophile’s environment you are tasked with investigating various water samples, which represent some of the hot springs found in Yellowstone National Park. You will collect data on two abiotic factors: the water’s temperature and the water’s pH. You will also make note of the color of each hot spring’s water.

The question leading this investigation is: Do changes to the physical components (e.g. water temperature or pH) of an ecosystem affect populations that can thrive? Why or why not?

### Laboratory Materials:

* pH paper
* Thermometer
* Safety Goggles
* Lab Apron
* Latex Gloves

### Experimental Procedures:

**Safety First**: This investigation involves hot water and pH solutions that may be considered alkaline (basic) or acidic. So, before you begin the scientific investigation, it is

StudentExplorationHandout1-ExtremeEnvironmentsLab

important to protect yourself by wearing safety goggles and laboratory apron, and possibly gloves.

### Extreme Environments Lab Directions

**Determining a Hot Spring’s pH:** Each lab station is equipped with a pH test paper packet. Notice that the back of the clear plastic pH test paper packet are color bars. To determine the pH of each hot spring, pull off a 2-inch strip of pH paper and dip it in the water solution (Hot Spring) for 2-seconds. Be careful not to let your fingers get in the water. Immediately match the color of the pH paper to one of the color bars on the back of the pH test paper packet. Because color is a qualitative measurement that may be interpreted differently, gather team consensus on the matching color. Record the pH value of the hot spring’s water sample in your data table (Table 1).

**Determining a Hot Spring’s Temperature:** Each “Hot Spring” water sample is in a beaker and sitting on a hot plate. To record the temperature of the water, put the thermometer in the water but do not let the bulb of the thermometer rest on the bottom of the beaker. Once the liquid in the thermometer stops moving up or down. Record the temperature of the water in your data table (Table 1). Be sure to include the unit that the temperature was measured in **°**F or **°**C.

**Determining a Color of each Hot Spring’s Water:** As noted when you were determining the color of the pH strip, color is a qualitative measurement that may be interpreted differently. As a team, come to a consensus on the color of the water in the “Hot Spring.

Record the color of the hot spring in your data table (Table 1).

Repeat the above procedures for all six hot springs: Measure the pH, water temperature, and water color.

**Data Comparison:** Once you have collected all three data points for each of the six “Hot Springs”, your team will receive the *Extreme Environment Lab Reference Table* which contains information about ten different thermophiles. Based on the data you collected and the data provided in your *Extreme Environment Lab Reference Table*, identify which thermophile could thrive in each hot spring. Be prepared to provide evidence to support your claim.

StudentExplorationHandout2-ExtremeEnvironmentsLab\_DataTable1

# Extreme Environments Lab Data Table 1

**Student name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

Data Table 1: Extreme Environment Data Collection Table

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Hot Spring** | **pH** | **Temp (°C and °F)** | **Color of solution** | **Identify the Thermophilic Microorganism that Could Thrive in this environment** |
| **A** |  |  |  |  |
| **B** |  |  |  |  |
| **C** |  |  |  |  |
| **D** |  |  |  |  |
| **E** |  |  |  |  |
| **F** |  |  |  |  |

StudentExplorationHandout3-ExtremeEnvironmentsLab\_TicketOutTheDoor

Name - Date -

1. List the two physical components of the “hot springs” that you measured during the Extreme Environments Lab.
2. In 4-5 sentences, construct an argument supported by evidence as to whether or not the two physical components listed above can affect the population of microorganisms that live in it.