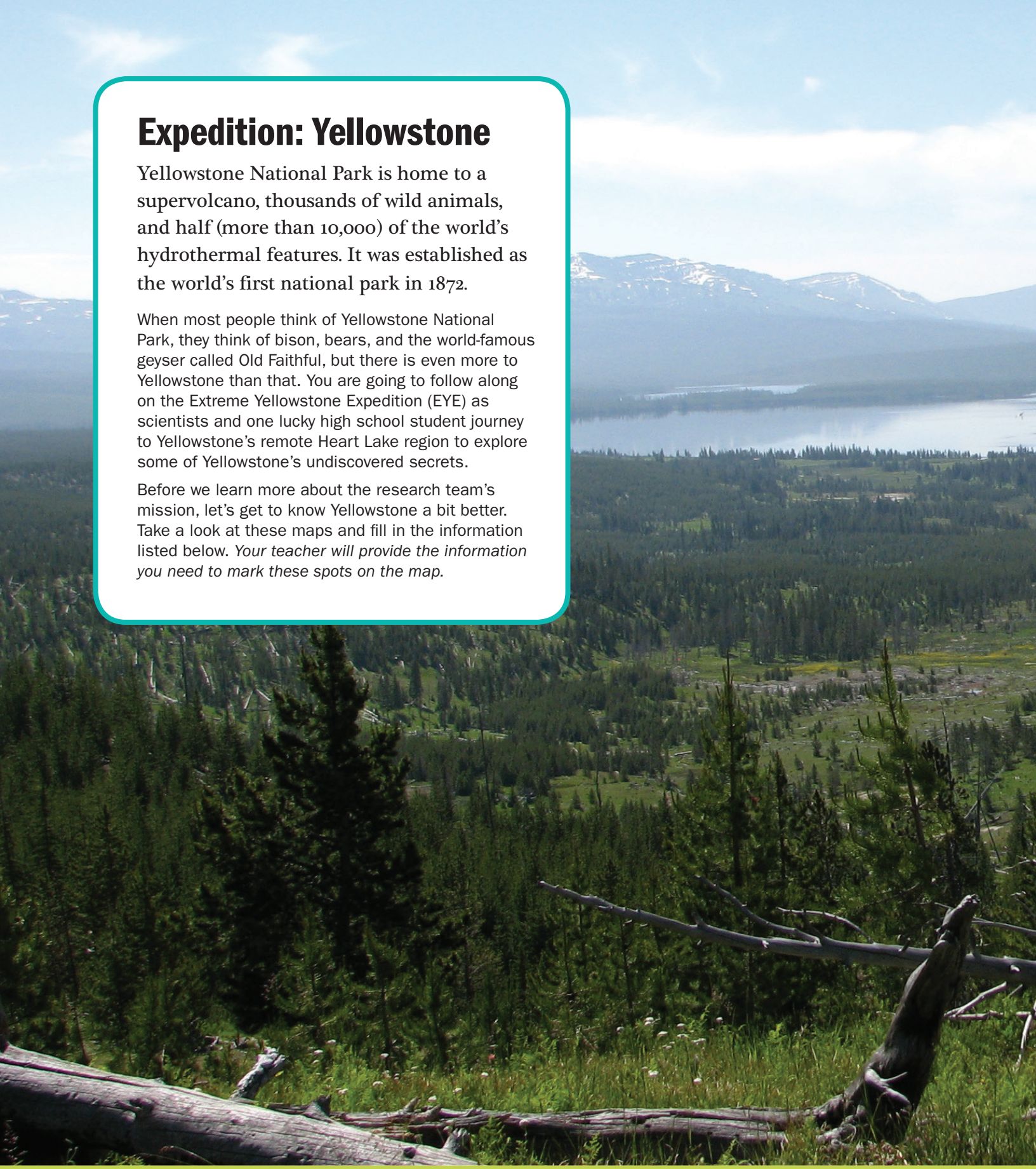
EYE

Extreme Yellowstone Expedition

LESSON 1

Instructor's Key

MONTANA STATE UNIVERSITY
Thermal Biology Institute



Expedition: Yellowstone

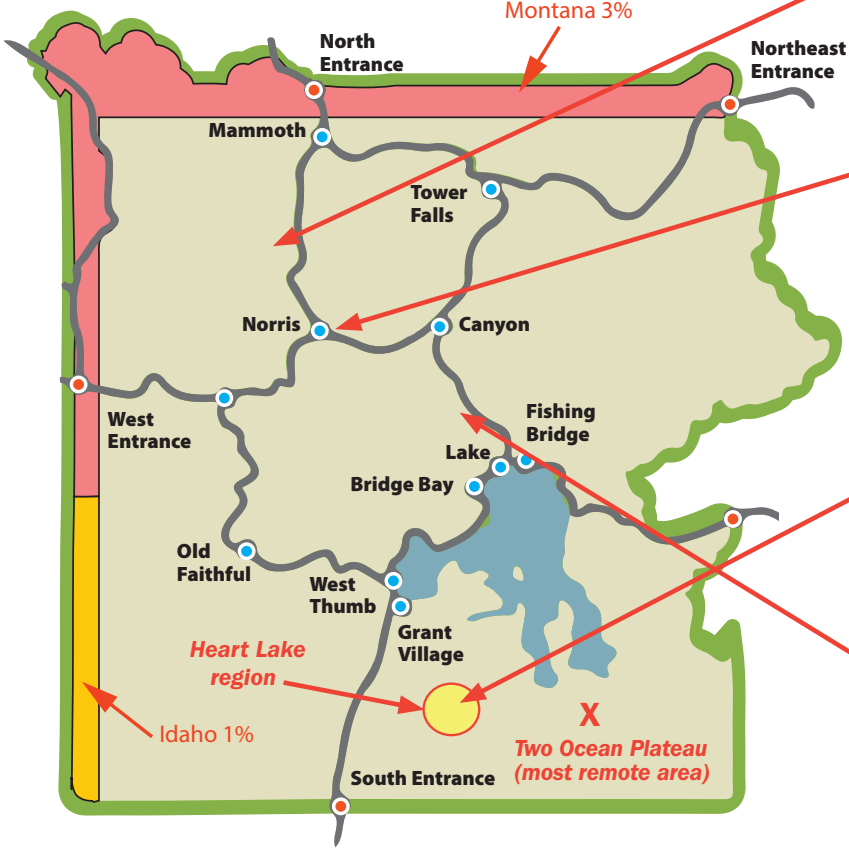
Yellowstone National Park is home to a supervolcano, thousands of wild animals, and half (more than 10,000) of the world's hydrothermal features. It was established as the world's first national park in 1872.

When most people think of Yellowstone National Park, they think of bison, bears, and the world-famous geyser called Old Faithful, but there is even more to Yellowstone than that. You are going to follow along on the Extreme Yellowstone Expedition (EYE) as scientists and one lucky high school student journey to Yellowstone's remote Heart Lake region to explore some of Yellowstone's undiscovered secrets.

Before we learn more about the research team's mission, let's get to know Yellowstone a bit better. Take a look at these maps and fill in the information listed below. *Your teacher will provide the information you need to mark these spots on the map.*

On the map of the continental US:

1. Color in and label the location of Yellowstone National Park.
2. Color in and label the location of Glacier National Park.




Lemonade Creek


Whirligig Geyser


"Gabby's Spring"


Mud Pot

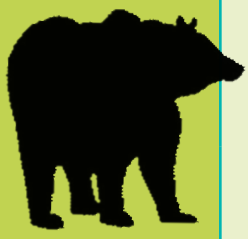
On the map of Yellowstone:

3. Using two colors, shade in and label the parts of Yellowstone in Idaho and Montana. Label the total percentage of the Park in those states – 3% in Montana and 1% in Idaho. The rest is in Wyoming.
4. Mark the Heart Lake region on the map.
5. Use a line to connect the photos of Whirligig Geyser, Mudpots, "Gabby's Spring," and Lemonade Creek to their locations on the Yellowstone map. You'll be studying these thermal features in depth in other lessons.
6. Place an X in the general vicinity of the most remote area in the lower 48 states.

Yellowstone by the Numbers

Yellowstone National Park is massive. At 3,472 square miles, it is larger than Rhode Island and Delaware combined. Here's a guessing game for you to get to know Yellowstone better.

Choosing from the mixed up numbers at left, enter your guesses for the correct numbers to complete the table of Yellowstone facts.



1,000–3,000	1,000–3,000	Earthquakes (annually)
~ 290	~ 290	Waterfalls
322	~ 1,600	Archeological sites
67	900+	Historic buildings
~ 1,000	67	Species of mammals
~ 1,600	322	Species of birds
900+	~ 1,000	Miles of back country trails

The Extreme Yellowstone Expedition (EYE) Mission

The EYE team consists of a group of Montana State University (MSU) researchers from the Thermal Biology Institute (tbi.montana.edu). They hiked into the extremely remote area of Heart Lake in order to collect samples and research the microbial organisms living in hot springs there.

Why study microbes?

Microbes are living organisms smaller than your eyes can see. They are the oldest form of life on Earth, and they live just about everywhere–including in, and on, your body. They can even live in really hostile environments like icy glaciers, the bottom of the ocean, and hot springs in Yellowstone National Park.

Microbes that live in extreme environments, called ***extremophiles***, play an incredibly important role in our ecosystems and in biodiversity. They also have many potential applications in biotechnology, medicine, and industry that are only beginning to be discovered.

Microbes also offer an amazing window into astrobiology (the search for life beyond Earth) and questions such as, *How did life form on Earth?*

Scientists at MSU are researching how microbes from Yellowstone may help us find

alternatives for gas and fossil fuels, clean up toxic waste, help to cure diseases, or help us find life on other planets.

NASA supports research on the extremophiles from Yellowstone and other places, because scientists think these organisms might resemble some of the first life on Earth. These microbes can help us understand how life started on our planet and how it might form on other planets, so NASA is using research from Yellowstone to help in the search for life on other planets and moons. Scientists think if we discover life elsewhere in the Universe, it's more likely to be an extremophile than, for example, a little green man.

Rare organisms hiding in Yellowstone

The researchers from EYE have traveled to the Heart Lake area many times, often bringing back water samples containing micro-organisms. Half of the organisms they find are so different from

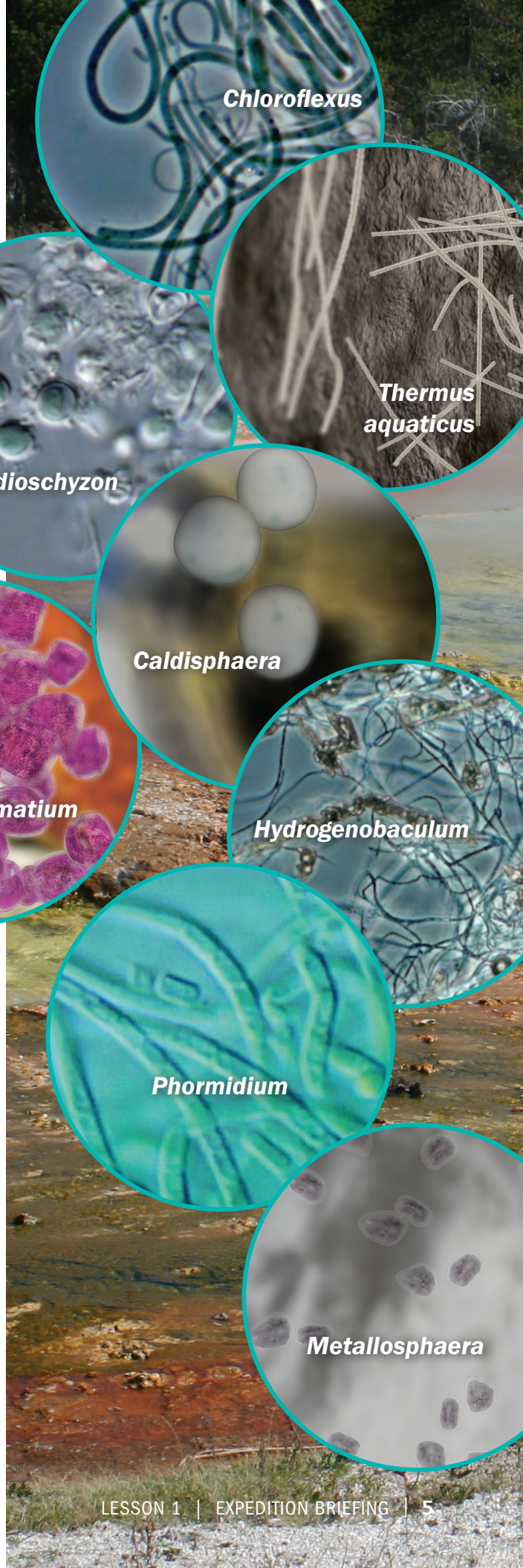
anything already discovered that scientists can't even name them yet!

In examining their samples, the team has found that less than 1 in 1,000 of the organisms they collect has even been grown in a lab. Expeditions to Heart Lake and other areas of Yellowstone have a high potential for the discovery of new microorganisms that will help us in ways we can't even imagine yet.

Scientists get excited about the discovery of ANY new living things, but extremophiles have caused more excitement, and more radical changes in science, than just about any other forms of life.

Why? After all, most extremophiles are single-celled creatures, measly microbes. What is it that makes them so fascinating to scientists?

It's because these microbes have adapted to live in environments of extreme temperatures, pH and toxicity, and the mechanisms they use to do that could unlock the secrets to all kinds of discoveries.



A CLOSER LOOK: Here are some pictures of real microbes that live in extreme environments such as Yellowstone National Park.

Check your expedition preparedness

What is a microbe?

(A microbe is a living organism smaller than your eyes can see.)

Why is it important to study microbes, specifically extremophiles? What kinds of problems might they help us solve?

- ***Because they are the oldest form of life, they provide clues to how life formed on early Earth.***
- ***Can help us find life on other planets.***
- ***To further understand the biodiversity on Earth.***
- ***Find alternative energy sources.***
- ***Clean up toxic waste.***
- ***Cure diseases.***
- ***They might help us in ways we can't imagine yet.***

Planning the expedition

Planning a trip to the Heart Lake region of Yellowstone is extremely tricky. Any time a scientific team goes to Yellowstone, they need a research permit that is issued from the National Park Service. Scientists must explain what research they are conducting and why it is important. They also must have training and obey special rules if they are going to collect any samples from hot springs.

Hot springs can be dangerous. If you fall into a hot spring, you have a high likelihood of dying. One of the hot springs in the Heart Lake Geyser Basin contained the carcass of an elk that had fallen in and died in the boiling water! *If you ever visit Yellowstone, make sure you stay on boardwalks or trails at all times.*

The researchers are not allowed to go to the Heart Lake region from April 1 through June 30. The area is closed every year during that time due to bear activity. The scientists have seen bears in the area many times and were evacuated once because of a bear that kept approaching people. All the researchers carry bear spray. The area can also be thick with mosquitoes, which can be extremely unpleasant.

The Heart Lake region is very remote. It's far from any roads, and cell phones don't work there, so if a member of the team got hurt, it would be dangerous. The hike to Heart Lake is approximately seven miles one way, so it is a long way to bring food, water and gear. Sometimes the researchers use horses to carry their equipment.

If you continue traveling east, past the Heart Lake region, you will reach the most remote area in the lower 48 United States. Located on the Continental Divide, it's called the Two Ocean Plateau and features an unusual site: some of the water that falls here as rain or snow flows to the west and ultimately the Pacific Ocean, and some flows easterly and eventually ends up in the Atlantic Ocean. (Glacier National Park has a site called Triple Divide, where water makes its way to *three* different oceans: the Atlantic, the Pacific and the Arctic.)

BEARS, BURNS AND BUG BITES: This is the arm of an EYE team member after only one day in the field. She was itching miserably for days!

Researchers traveling to Heart Lake must plan for all kinds of weather. It can be really hot or really cold. Once during a trip in September, the temperature was 24°F (-4°C) as the researchers began to hike to the lake. During the summer, they have encountered intense heat, sunburn, and even snow.

To guard against dehydration they must carry lots of water. As the research team reaches Heart Lake, they can use a water purifier to treat the water or boil it before drinking it, but along the trail to the lake, they can't drink any water from Witch Creek—even with a water filter—because it has high amounts of arsenic, which is highly poisonous to humans.

A perfect trip

When researchers plan a trip to Heart Lake they must take many factors into account. From the discussion of expedition planning that you just read, list as many factors as you can.

- ***Getting permits***
- ***The danger of sampling from hot springs***
- ***Wild animals, especially bears***
- ***Mosquitoes***
- ***Extreme weather from snow to uncomfortable heat***
- ***The area is very remote, far from roads, and has no cell service***
- ***Arsenic contaminated water***

If you were going on the expedition, which of the factors in the list above would worry you the most? Why?

(Any thoughtful answer would be acceptable)

Meet the team

Several Montana State University researchers and students traveled to Heart Lake on the EYE expedition. Here you can meet two of the scientists as well as the Montana high school student who assisted them.

Brent Peyton

Brent Peyton is director of the Thermal Biology Institute and professor of chemical and biological engineering at Montana State University. Dr. Peyton works on finding ways to clean up toxic waste with microbes and methods for creating biofuels – fuel made from living organisms like algae. He has published more than 95 scientific articles and book chapters on these topics. His dad was a chemist, so Dr. Peyton grew up being interested in science. Then Dr. Peyton's high school chemistry teacher, Mrs. Gilmore, suggested that he go into chemical engineering since he liked both math and chemistry, and he's never regretted it. Everything he does now is related to the engineering applications of biotechnology. As for hobbies, Dr. Peyton loves to hike (he tries to hike over 100 miles in the mountains each summer), fly fish, garden, raft, cross-country ski, and hunt antelope, deer and elk.

Dana Skorupa

Dana Skorupa is a post-doctoral researcher in Brent Peyton's lab. Dr. Skorupa hails from Wisconsin. She earned her PhD in microbiology at Montana State University and studied acid-loving algae that inhabit some of Yellowstone National Park's hot springs. Her current research looks at using microorganisms to clean up pollutants produced by the mining industry. During her senior year of high school, Dr. Skorupa took an advanced biology class that sparked her interest in microbiology. She was amazed at how important microorganisms were not only to the wellbeing of our planet but also to the health of our own bodies. When she's not working in Yellowstone or in her lab at MSU, Dr. Skorupa is outside training for 50-mile mountain bike races, skiing with her friends, or bagging peaks with her dog, Rumi.

Gabby Michel

Gabby Michel was born in the Chicago area but moved to Big Sky, Montana with her parents and twin brother when she was four years old. She is a senior at Lone Peak High School and has an interest in the outdoors and the Yellowstone Area. She enjoys her science classes and was very excited to have the opportunity to participate in this field study with Dr. Peyton and several other biologists and engineers. She is interested in pursuing a pre-med track in college, and is looking into becoming a surgeon. Gabby's favorite hobbies are reading, hiking, fly-fishing, and traveling.

Picture yourself as a Yellowstone scientist

Name any hobbies that you have in common with Dr. Peyton, Dr. Skorupa or Gabby Michel.

(Any thoughtful answer would be acceptable)

Would you be willing to travel on an expedition to the Heart Lake region of Yellowstone National Park?

Why or why not? ***(Any thoughtful answer would be acceptable)***

If you could ask the research team one question, what would it be?

(Any thoughtful answer would be acceptable)

EXTREMOPHILE HUNTERS: MSU researchers and Big Sky high school student Gabby Michel (center) pause during their hike to the Heart Lake region.

SCIENCE AND YOU...

The word ***science*** comes from an ancient Latin word that means knowledge. Science is more than just a class; it is a process—a way of thinking and learning about things—in which you test predictions about the world around you. Science usually leads to new questions and can never be finished, because there always will be more to discover.

Take a moment and think about science and your everyday life

Can you think of a scientific question or two that you would really like to know the answer to? For example, it could be a big question like, *Is there any such thing as alien life?* Or it could be a question with a smaller scope, like, *Whose mouth has more germs in it, mine or a dog's?*

(Any thoughtful answer would be acceptable)

Can you name a few movies, TV shows, websites, books or apps you like that feature science or science fiction? List a few here.

(Any thoughtful answer would be acceptable)

What scientific invention or breakthrough are you most thankful for, and why?

(Any thoughtful answer would be acceptable)

What science career interests you the most? Why?

(Any thoughtful answer would be acceptable)