



YELLOWSTONE FOREVER

MICROBIAL DIVERSITY OF YELLOWSTONE HOT SPRINGS

Itinerary & Details

FIELD SEMINAR - SUMMER 2023

INSTRUCTOR: Eric S. Boyd, Ph.D.

INSTRUCTOR BIOGRAPHY: Dr. Eric Boyd is a Professor of environmental microbiology in the Department of Microbiology and Cell Biology at Montana State University in Bozeman, Montana. For the past 20+ years, Dr. Boyd has been studying the microbiology and geochemistry of hot springs in Yellowstone National Park to develop new understanding of the processes that support microbial life in high temperature environments. He has authored >160 scientific articles on extremophilic microorganisms and currently mentors three postdoctoral scholars and six doctoral students with diverse funding from the National Science Foundation, NASA, the Department of Energy, and the W.M. Keck Foundation. Dr. Boyd grew up with a fascination of minerals and microorganisms. Yet, it was not until he was an undergraduate student that he learned that microorganisms can breathe minerals, including those minerals that give hot springs their vivid yellow, orange, and red colors. He quickly exchanged his aspiration for a career in orthopaedic medicine to one in environmental microbiology and has never looked back. Dr. Boyd lives in the railroad town of Livingston, Montana with his wife and two dogs. When he is not busy with his research, Dr. Boyd can often be found hiking trails in and around the Greater Yellowstone Ecosystem with his wife and two dogs.

ACTIVITY LEVEL: This course is an activity **level 1** and students enrolled in this course are expected to be active participants. Be prepared to hike up to 1 mile per day, comfortably, with elevation gains up to 200 feet. Some off trail hiking possible.*

**All field activities will be conducted as a group. If you cannot meet the activity level expectations during your program, you may be restricted from participation in daily outings. We will not alter program itineraries or activities to accommodate participants who cannot meet the expectations of the stated activity level.*

LOCATION: Course begins at the Yellowstone Forever classrooms located in Gardiner, MT.

PROGRAM DATES & TIMES: The program begins at 7:00 p.m. on Saturday, August 19, 2023, and ends on Sunday, August 20, 2023, at 5:00 p.m.

LODGING CHECK-IN & CHECK-OUT: No lodging is provided for this course, however, there may be limited lodging available through Yellowstone Forever at the Yellowstone Field Overlook Campus. For more information, please contact the Institute at institute@yellowstone.org. You can also find more information on Gardiner based lodging here: [Gardiner, MT - Lodging](#). (Yellowstone River Motel will grant you 10% off their rooms if you mention that you are taking a Yellowstone Forever Field Seminar.)

MEALS: You will need to bring your own food; lunch should be able to travel in the field with you.

For general information about the facilities, preparing for classes, what to expect, cancellation policies, and more, please see the [Gardiner Field Seminars - Summer General Information](#) document.

FROM THE INSTRUCTOR

Among the major outstanding questions facing humanity is how life originated on Earth and whether we are alone in this universe. Hot springs and their microbial inhabitants provide unique insight into both of these intriguing questions. This field seminar will introduce participants to the Yellowstone super volcano and how it creates conditions similar to those that likely supported life on early Earth and how similar volcanic hydrothermal systems might support extraterrestrial life. We will explore the subsurface geological processes that generate the dynamic hydrothermal system in Yellowstone, including its >10,000 surface springs, fumaroles, geysers, and mudpots. Participants will learn basic information of how the Yellowstone supervolcano and hydrothermal system function, how geochemical variation is generated across hot springs (acidic versus basic), how this shapes the distribution of microbial life in hot springs, and how this informs our understanding of the processes that supported life on early Earth or that may support life on another planet. The patterns that we identify from the above information will be used to develop an ability to predict hot spring geochemistry (temperature, pH, sulfur content) and the types of microorganisms that inhabit those springs using basic sensory functions such as sight and smell. This information will then be used to predict the metabolic processes that allow microorganisms to survive in these extreme environments and how such processes set the stage for advanced life to develop on Earth. Further, we will discuss adaptations that enable the most extremophilic microbes on planet Earth, the Archaea, to thrive in boiling sulfur springs with pH values as low as battery acid. We will generate the above framework of knowledge through a powerpoint presentation/discussion the night preceding our field day.

Participants will then have an opportunity to "test" their ability to predict the pH, temperature, and chemical composition of hot springs and the processes that support microorganisms living in those hot springs by taking a guided field trip along the Upper Geyser Basin and Mud Volcano or Norris Geyser Basin boardwalks (specific locations to be determined), areas that exemplify major geological processes that underpin geochemical and microbial variation in hot springs. Finally, the pattern and prediction framework discussed during this field seminar will be used as a focal point for in field discussions of our search for life in our solar system. Participants will leave the field seminar with an appreciation for the variation of hydrothermal features preserved in Yellowstone, how such chemical and mineralogical variation (colors) are generated, and how microorganisms contribute to the generation of this variation. Further, participants will gain a first-hand understanding of the extremophilic microorganisms that inhabit Yellowstone hot springs and why NASA (and other funding agencies) invest in this research as the agency seeks to fulfill its mission of detecting life in the solar system.

- Eric

PROGRAM ITINERARY

The itinerary is designed to take advantage of the best opportunities in the park, but may be adjusted to adapt to weather conditions, wildlife activity, holidays, and road construction. *The details and timing of the agenda are subject to change.*

Day 1 Evening Orientation

- Welcome, introductions, and course objectives (both for instructors and for participants)
- Powerpoint-led discussion on the geology, geochemistry, and microbiology of Yellowstone, titled: "The Microbial Diversity of Yellowstone Hot Springs".

Day 2 In the Field

- Big Picture – the Yellowstone Hydrothermal System
 - Parking lot discussion of: Why is it here, what is its function, and how does it reflect the early Earth
- Big Picture – the all too important element sulfur
 - Board walk tour of Mud Volcano or Norris Geyser Basin to discuss acid-sulfate springs, colorful minerals, and their mineral-munching thermoacidophilic archaeal inhabitants
- Big Picture – 18000 year old glacial water and thermophilic Bacteria – what is the connection?
 - Boardwalk tour of Tour Upper Geyser Basin to discuss alkaline chloride springs and their thermophilic bacterial inhabitants

PROGRAM EQUIPMENT

For a full list of recommended equipment for all courses see the [Gardiner Field Seminars - Summer General Information](#) document.

Required:

- Notebook and pencil for observations

Optional:

- Magnifying glass or hand lens
- Camera
- Binoculars

RECOMMENDED READING

No prior reading is required, but participants might enjoy the following publications, that complement the program. Most publications are available at Yellowstone Forever's online store at shop.yellowstone.org Yellowstone Forever supporters receive a 15% discount and proceeds directly support the park.

- Science of the Springs: https://tbi.montana.edu/educationmaterials/scienceofthesprings_accessible.pdf
- Montana State University. 2013. Living colors: Microbes of Yellowstone National Park.
- R. B. Smith and L. J. Siegel. 2000. *Windows into the Earth: The Geologic Story of Yellowstone and Grand Teton National Parks*. Oxford University Press.

WHOM TO CONTACT

For any questions, concerns, or additional information please contact the following:

- Program itinerary, health forms, payment, and activity questions please contact Yellowstone Forever at institute@yellowstone.org or 406-848-2400
- Road updates, park conditions, and general park information please contact Yellowstone National Park Service at <https://www.nps.gov/yell/contacts.htm>
- If running late for a program, please contact 406-848-2400