



YELLOWSTONE FOREVER

MICROBIAL DIVERSITY OF YELLOWSTONE HOT SPRINGS

Itinerary & Details

FIELD SEMINAR – SUMMER 2024

INSTRUCTOR: Eric 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.

ACTIVITY LEVEL: This course is 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, through relatively flat terrain on maintained trails.

**All field activities will be conducted as a group. If participants cannot meet the activity level expectations during the program, they may be restricted from participation in daily outings. Program itineraries or activities will not be altered 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, June 1, 2024, and goes through Sunday, June 2, 2024, 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: This course is not catered. Participants will need to bring their own food; lunch should be able to travel in the field.

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

PROGRAM ITINERARY

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 you 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.

You will explore the subsurface geological processes that generate the dynamic hydrothermal system in Yellowstone, including its >10,000 surface springs, fumaroles, geysers, and mudpots. You 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 are identified 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, you will discover 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. The above framework of knowledge will be generated through a powerpoint presentation/discussion the night preceding our field day. You 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.

You 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, you 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.

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 Welcome

The program starts with an evening orientation. You will get to know one another and be introduced to the program. Throughout the evening, the itinerary and seminar key concepts will be discussed, as well as what to expect to pack for the field each day.

Day 2 Field-based Discussion in Norris Geyser Basin and Terrace Springs

You will apply what we have learned from our prior night's presentation to predict the chemical and physical properties (pH, temperature, sulfur content) of hot springs and how this can be used to predict how the microbial inhabitants are supported. You will examine the chemistry and microbiology of two of the three primary hot spring types in Yellowstone (acid and circumneutral/alkaline), and will touch upon how these differ from the third type of hot springs, carbonate springs that form the terraces at Mammoth. By identifying patterns and using these to form predictions, you will begin to examine the relevance of hot springs to our understanding of the origin of life on Earth and the search for life elsewhere in our Universe.

PROGRAM EQUIPMENT

For a full list of what is included in this course, in addition to recommended equipment check out the [Gardiner Field Seminars - Summer General Information](#) document.

RECOMMENDED READING

No prior reading is required, but participants might enjoy the following publications, that complement the program.

- National Park Service. *2023 Resource and Issues Handbook*. NPS, 2023.

WHOM TO CONTACT

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

- Program itinerary, health forms, payment, and general program 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.