# Thermal Biology in Hot Springs National Park, Arkansas

# Mark Meredith Microbiology 11th-12th Grade 5 Days Microbial Anatomy and Physiology Unit

Lesson Topic**:**

Students will study the diversity and metabolism of microbial life in the thermal springs of Hot Springs National Park (HSNP) in Hot Springs, Arkansas. The microbes of HSNP will be compared to thermophiles found in Yellowstone National Park.

National Science Standards**:**

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| HS-LS2-3**.** | Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions. |
| HS-LS2-5**.** | Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. |
| HS-LS1-7**.** | Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. |
| HS-LS2-6**.** | Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. |

Learner Objectives/Goals**:**

Students will…

* identify water properties important for microbial life.
* sample microbial diversity and stream gradients.
* predict metabolic pathways of observed organisms.
* explain correlations between water chemistry and observed biotic gradients.

Background Content**:**

Students will be exposed to lessons on diverse types of metabolism including aerobic/anaerobic, carbon sources, electron sources, and metabolic products. A study of microbial metabolism will also include a focus on extremophiles found in the thermal springs of Yellowstone National Park. These organisms will be used for comparison when observing the organisms in the Hot Springs thermal waters.

Materials and Supplies**:**

*Field*

Dissolved Oxygen Snap Kit and Vernier Probes

Conductivity Vernier Probes

pH Papers and Vernier Probes

Temperature Guns and Probes

Microscope, slides, oil, pipets, containers

TBI Color Wheel Tool & Book, Notebooks

*Lab*

Specimen Sample Containers

Notebooks

Laptops

Microscopes, slides, immersion oil

Incubator and Water Baths

Growth Media

Anticipatory Set**:**

After reviewing standard forms of aerobic and anaerobic metabolisms including fermentation, students will be introduced to chemosynthesis and the microbes of Yellowstone. Views of the various thermal springs will be used to capture their attention, and students will be asked to brainstorm explanations for the different colors observed in the waters.

Activity Outline**:**

1. Day 1 (In class) - Students will be taught the basics of thermal biology with a focus on known microbes of Yellowstone. Those microbes with the associated environmental gradients will be used for comparison when studying the organisms in the HSNP thermal waters.
2. Day 2 (In class) – A plan for our visit to HSNP will be established. Sampling procedures will be assigned and practiced where necessary, and protocols for sampling in the park will be discussed.
3. Day 3 (HSNP) – Students will attend an orientation to the thermal springs given by the park personnel. (approx. 45 min.) Sampling of thermal organisms and water conditions will begin with student teams fulfilling their assigned recording roles. Water temperature, dissolved oxygen, conductivity, pH, and temperature will be collected at each site. In addition to water condition details, organism samples for viewing with the microscope will be collected. Samples for returning to the lab will be collected in sample containers at each spring.
4. Day 4 (In class) – Data collected at springs will be displayed and analyzed. One of the focuses of the analysis should be the correlation of sampled organisms and the water conditions at the sample site. Further microscopic observations may be necessary for forming a working description of each organism. Using materials from Yellowstone such as the color wheel, the associated book, and the text *Seen and Unseen*, students will search for similarities between the organisms of Yellowstone and the thermal springs of Hot Springs National Park.
5. Day 5 (In class) – Students will split the data collected from the different springs into four sets. Four student groups, each working on one of the sets of data from the springs, will do a final analysis of their findings to form a working description of the microbes found in their springs. They will be expected to use correct terminology for classifying organisms based on their environmental conditions, possible metabolisms, and cell types. Student groups will use their conclusions to form presentations to be presented to their classmates. Students will also be expected to write a report on their findings. Joint work on the report will be allowed as long as each student is confirmed as being contributory to its completion.

Closure and Assessment**:**

Student group presentations and reports will be used for closure of the exploration into thermal biology. An exam based on terminology, types of metabolism, and the ability to predict organismal characteristics given certain environmental details will be given after reports have been submitted.

Resources**:**

Seen and Unseen: Discovering the Microbes of Yellowstone

***Living Colors: Microbes of Yellowstone National Park* and Color Wheel**

***Drinking the Water* – US Department of the Interior (Used for chemical data and locations of springs)**

*Follow the Water* – National Parks Service (Document used to explain the geology behind the hot springs of HSNP)

Vocabulary**:**

**aquifer** - a water-bearing stratum of permeable rock, sand, or gravel.

**autotroph** - an organism that produces complex organic compounds from simple substances present in its surroundings, generally using energy from light or inorganic chemical reactions.

**calcareous** - resembling calcite or calcium carbonate especially in hardness; consisting

of or containing calcium.

**chemosynthesis** - the biological conversion of one or more carbon molecules and nutrients into organic matter using the oxidation of inorganic molecules or methane as a source of energy, rather than sunlight, as in photosynthesis.

**chert** - rock resembling flint and consisting of quartz and amorphous silica.

**cyanobacteria** - a phylum of bacteria that obtain their energy through photosynthesis.

**fault** - a fracture in the crust of the Earth accompanied by a displacement of one side of

the fracture with respect to the other, usually in a direction parallel to the fracture.

**filamentous** - a type of bacteria, archaean, or algae, defined by its filament-like or rod-like shape.

**fissure** - a narrow opening or crack of considerable length and depth usually occurring.

from some breaking or parting.

**gradient** - change in the value of a quantity (as temperature, pressure, or concentration) with change in a given variable and especially per unit distance in a specified direction.

**halophile** - organisms that live in high salt concentrations.

**heterotroph** - an organism that cannot fix carbon and uses organic carbon for growth.

**hydrothermal** - of or relating to hot water.

**isotope** - any of two or more atoms of a chemical element with the same atomic number and nearly identical chemical behavior but with differing atomic mass or mass number and different physical properties.

**magma** - molten rock material within the Earth from which igneous rock results by cooling.

**novaculite** - a very hard fine-grained siliceous chert used for whetstones.

**photosynthesis** - a process used by plants and other organisms to convert light energy, normally from the sun, into chemical energy that can be later released to fuel the organisms' activities.

**psychrophile** - are extremophilic organisms that are capable of growth and reproduction in cold temperatures, ranging from −20°C to +10°C.

**seismic** - of, subject to, or caused by an earthquake; or relating to an earth vibration.

**siliceous** - of, relating to, or containing silica.

**thermophile** – an organism — a type of extremophile — that thrives at relatively high temperatures, between 45 and 122 °C.

**tufa** - a porous rock formed as a deposit from springs or streams