

Conservation of Microbial Diversity A Yellowstone Priority

Well-crafted agreements serve the conservation mission while encouraging research that may bring benefits to the park

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We came to a boiling lake about 300ft. in diameter forming nearly a complete circle.....The water was of a deep indigo boiling in an immense cauldron running over the white rock.....The stream which arose from it was of three distinct colors..... for one third of the diameter it was white, in the middle it was pale red, and the remaining third on the east side of light sky blue.....What a field of speculation this presents for chemist and geologist. (Osborne Russell, ca. 1840, at Grand Prismatic Spring in what became Yellowstone National Park; adapted from A.L. Haines (ed.), *Osborne Russell's Journal of a Trapper* [University of Nebraska Press, Lincoln, Neb., 1955], p.99).

One of the continuing lessons of Yellowstone National Park is how much and how differently various elements of society value it. When the park was set aside in 1872, human populations were relatively small, but wildlife populations were throughout North America. Thus Yellowstone was not seen as being particularly special for preserving wildlife species. Today, however, many more citizens live in cities, and wildlife populations are not nearly so abundant, making them one of Yellowstone's most popular attractions.

Since the 19th century, Yellowstone and other national park administrators have encouraged scientific activities involving resources of the parks. The expanding search for useful compounds in nature -- coupled with the spectacular discoveries associated with *Thermus aquaticus* and other thermophilic microorganisms first found in Yellowstone National Park -- has led officials there to rethink a potential dilemma. How can they maintain their important conservation mission while also encouraging research whose findings, some of which lead to valuable commercial products, can benefit the park?

17 August 1997 marked the 125th anniversary of Yellowstone being designated the world's first national park. On that occasion, officials announced that scientific and economic benefits resulting from private sector research involving biological specimens from Yellowstone would be used for resource conservation purposes. Park officials also signed a letter of intent with [Diversa Corporation](#) of San Diego, Calif., the first private entity to pledge such benefits.

Bioprospecting Agreement Pledges Reciprocal Benefits

Bioprospecting refers simply to the search for valuable biochemical and genetic entities in nature. In many cases, the owners or custodians of the biological resources that have been used in research were not compensated for those materials. In cases of unauthorized use bioprospecting becomes biopiracy, an issue of international concern. Such biopiracy undermines the conditions necessary to promote the conservation and sustainable use of valuable resources.

The bioprospecting agreement between Yellowstone and Diversa permits company scientists to conduct research on microorganisms sampled at the park, while pledging a portion of the company's future profits from such research to Yellowstone for conservation programs and related scientific and public education activities. Yellowstone will also receive data resulting from the company's park activities to benefit the Yellowstone biodiversity management program. The agreement with Diversa has generated interest within the wider conservation community, research institutions, and scientific and educational organizations that want to know how research-focused bioprospecting can benefit resource conservation activities.

Although such conservation-focused bioprospecting agreements have been pioneered in several tropical countries with abundant biodiversity, Yellowstone is the first U.S. National Park to develop similar benefit-sharing arrangements designed to conserve the biodiversity it protects and manages. The World Foundation for Environment and Development (WFED) helped Yellowstone and the Diversa Corporation negotiate this agreement, which is expected to become a model for similar agreements with different firms that officials expect to establish in the near future.

Outside of the United States, one of the best known approaches to bioprospecting was developed in Costa Rica. There, Biotechnology and other research firms must negotiate benefit-sharing agreements that provide for conservation-focused profit sharing and scientific training opportunities in exchange for biological samples obtained from Costa Rica's rainforests and other resource rich environments.

In addition, the International Cooperative Biodiversity Groups (ICBG) Program, jointly sponsored by the National Institutes of Health (NIH), the National Science Foundation and the U.S. Agency for International Development, is designed to stimulate bioprospecting partnerships abroad to provide models for conservation and the sustainable use of biodiversity. The ICBG Program promotes natural products research to improve human health while bringing both short- and long-term benefits to local communities that act as stewards of valuable biological resources. Benefit-sharing creates incentives for conservation by providing alternatives to competing destructive or consumptive uses.

Negotiated Agreements are Flexible, Fair

Properly negotiated cooperative research and development agreements between Yellowstone and the research community can provide the flexibility needed by the park to define conservation objectives. Several firms have advised that their willingness to negotiate benefit-sharing arrangements favorable to the park are contingent on the fact that benefits will be reinvested directly for resource conservation purposes at the park (an important underlying incentive).

By linking the scientific and economic incentives associated with research activities and new incentives for conserving the park's rich biological diversity, Yellowstone aims to strengthen research in ways that also contribute to the park's sustainable resource conservation efforts.

For example, through properly structured agreements with the research community, Yellowstone can obtain improved data relating to microbial distributions throughout the various thermal systems at the park from visiting researchers. Protection of these resources can be strengthened by directing scientists to thermal areas known to provide habitats for desired organisms found in less-frequented areas of the park while at the same time ensuring that the park's thermal resources are being protected.

In contrast to many tropical countries, where knowledge about useful natural compounds is often held by traditional healers and others in the community, very little is yet known about the resources that are associated with the thermal features at Yellowstone. However, the public expects firms that profit from research involving these resources to share some of these benefits with the park. This expectation is consistent with the legislation that established Yellowstone. It mandates that this resource be preserved and managed "for the benefit and enjoyment of the people...for this and future generations."

Biological Sampling Has Rich History

The term bioprospecting refers to the search for valuable biochemical and genetic compounds found in nature. While bioprospecting is often associated with biological resource sampling from tropical rain forests

and other biologically rich environments, The great concentration of rare geothermal environments found at Yellowstone provided habitat for a great diversity of life that is still largely unexplored. Because microorganisms represent the richest range of molecular and chemical diversity found in nature, research involving microbial samples provides a lead to potentially useful discoveries.

FIGURE 1



Fountain Geyser, one of many thermal features found in Yellowstone National Park. Most park visitors are attracted to spectacular features such as this, but the park's more subdued thermal sites are of even more interest to microbiologists for the extremophilic microbes that can be found there. Bioprospecting agreements will help ensure that resources will be preserved for all park users.

Bioprospecting is not new. For millennia, human populations around the world have searched for useful compounds in nature to improve crops and food production, to combat disease, and to enhance the overall quality of life. However, when coupled with new technologies relating to nucleic acids, computer science, and analytical chemistry, research-focused bioprospecting offers new dimensions for making discoveries. In contrast to harvesting or other consumptive uses of the biological resources themselves, research-focused bioprospecting also offers opportunities for new and potentially valuable research results that obviate the need for ongoing acquisition of additional samples from nature.

Like bioprospecting generally, the obtaining of biological samples from Yellowstone is not new. During the historic early 19th-century expedition through the territory just north of the area known as Yellowstone National Park, Lewis and Clark collected samples that were returned to President Thomas Jefferson for examination at the White House, some of which he later displayed at his home, Monticello.

In 1898, the first known research permit was issued at Mammoth Hot Springs in Yellowstone National Park for the collection of research specimens of microorganisms found near the park's thermal features; the permit was issued to W.A. Setchell from the University of California. While Setchell believed that he was studying thermophilic algae colonies rather than bacteria, he aptly noted that "all of the strictly thermal organisms are low forms, not even representing the high differentiation in the group in which they belong."

Now, a century later, there are approximately 50 microbial research projects currently permitted at Yellowstone. The park's thermal features are recognized as providing rare habitats for many forms of microscopic life only recently discovered -- life too small to see outside their sometimes richly colored colonies but reflecting biological diversity that rivals the tropical rainforests, and thriving in habitats once thought too extreme to allow life to exist.

Yellowstone's Modern Era of Microbiological Discovery

In 1966, Thomas Brock's discovery of *T.aquaticus* -- which lifted the ceiling on what biologists then thought was the upper temperature limit of life -- suggested that the diversity of life protected by the park was far greater than anyone previously imagined (see [Microbiology in Yellowstone National Park](#) article by Dr. David M. Ward). Research activities at Yellowstone now indicate that fewer than 1% of the

thermophiles living in the hot springs and other thermal features at the park have been identified. In addition, researchers from the National Aeronautics and Space Administration (NASA) and other institutions suggest that the park's thermal environments offer some of the world's best-preserved windows to understanding the origin of life on Earth as well as the possibility of life elsewhere in the universe.

Like the early explorers, many contemporary scientific researchers at Yellowstone are interested in the discovery of life never before described and in the valuable information that such research can provide about the world around us. During their historic expedition, Lewis and Clark are said to have identified 178 plants and 122 animals never before seen by inhabitants from east of the Mississippi. With tools of science not previously available, contemporary scientific researchers are opening windows on heretofore unexplored microbiological worlds found among the 10,000 thermal features at Yellowstone.

Biotechnology applications resulting from research involving *T.aquaticus* isolated at Yellowstone have revolutionized molecular biology and genetics and contributed to the accelerated growth and expansion of the biotechnology industry. For example, since the developers of the polymerase chain reaction (PCR) technology from the late 1980s began using a heat tolerant enzyme from *T.aquaticus*, this technology has generated revenues in excess of several hundred million dollars. Lacking an arrangement like this one with Diversa Corporation, Yellowstone has not shared in these revenues.

The abundant concentration of thermophilic microbial life at Yellowstone provides an important opportunity to explore new ways to support valuable scientific microbial research at the park as well as to improve public understanding about these little-known resources. Heightened scientific interest in Yellowstone's rich microbial diversity also offers an important opportunity to enhance the prestige of the role of national parks and microbes in American life.

Indeed, the extreme environments found in Yellowstone's 10,000 hot springs, geysers, fumaroles, boiling mud pots and other thermal features provide habitat for a great diversity of microorganisms that have evolved with characteristics that offer many potentially useful applications in science and industry. Yellowstone's protected areas represent the greatest concentration of thermal habitats on the earth's surface.

Yellowstone Thermophiles Conservation Project

As part of an initiative involving Yellowstone National Park, WFED, the Yellowstone Park Foundation, and the National Park Foundation, a formal effort will be made to encourage cooperative scientific exploration of the park's thermal resources in ways that will capture benefits for Yellowstone while maintaining its unique habitats. This Yellowstone Thermophiles Conservation Project designates three core areas of activity: (i) microbial biodiversity conservation, (ii) scientific research and data management, and (iii) Public outreach and education.

Project activities will be designed to strengthen local thermal habitat conservation efforts as well as microbial culture collection development and maintenance. Another aim of the project is to encourage expanded study of thermal habitats, particularly including microbial forms and biochemical compounds found in such settings. The project also will foster the development of an integrated database that will include habitat, geographical, biological, and other key scientific information.

Finally, an important component of the project involves improving public awareness and appreciation of the value of national parks and the biodiversity they protect. To implement this part of the program, a series of pamphlets, films and videos, presentations and media education, and in-the-field workshops and excursions is being planned.

Newly discovered microbial life forms, preserved in the park, are finding their way into society's mainstream. How many other forms of life remain undiscovered in unexpected places? We will never know unless such wild places are preserved. As in the 19th century, Yellowstone continues as a time-honored wilderness where an invigorating sense of wonder and brilliant discoveries can combine to shed light on humanity's place in the universe.

Important Information about Bioprospecting Agreements

- Authorization to collect microorganisms and to do research at parks such as Yellowstone must be obtained. National Park Service regulations prohibit the collection of biological samples or other natural resources without a research specimen collection permit, which provides a mechanism for governing research-focused bioprospecting at the park. Although such permits are routinely issued, they formerly did not include provisions that allow the park to share in the benefits that can result from research activities involving park resources.
- Such a permit authorizes a researcher to collect and use samples obtained from the park for scientific research purposes consistent with the terms and conditions specified in the permit. The permit does not grant any exclusive or property rights to the researcher. For example, in the case of microorganisms, researchers are authorized to collect only small amounts of representative samples from hot springs and other thermal features in Yellowstone Park. Researchers, who are required to submit reports to Yellowstone that describe the samples collected, may be accompanied in the field by Yellowstone staff, who monitor procedures and provide assistance and information relevant to the specific research project.
- Yellowstone evaluated use of the Department of the Interior's established guidelines for negotiation of cooperative research and development agreements (CRADA) to address the benefit-sharing issue. The Department of the Interior's CRADA policy is outlined in the Department handbook, "Technology Transfer, Marketing Our Products and Technologies," published in May 1996. While research specimen collection permits govern access to Yellowstone's biological resources for research purposes, CRADA's provide the framework for the park to negotiate benefits-sharing arrangements.
- Sales of natural products collected at national parks are prohibited. National Park Service research specimen collection permits operate similarly to biological transfer licenses issued by the National Institutes of Health (NIH) that grant licensees the right to use the biological materials in accordance with the terms and conditions specified in the license. Neither the National Park Service research specimen collection permit nor the NIH biological materials transfer agreement involves a sale because a change in ownership does not occur.
- The Yellowstone-Diversa CRADA, in distinguishing between the "resource use" and "research results," helps to assure that Yellowstone shares in profits and scientific information generated from valuable research results. The CRADA grants no exclusive or private rights with respect to any biological specimens collected from Yellowstone.

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[World Foundation for Environment and Development](http://www.wfed.org/resources/reports/article4.htm)