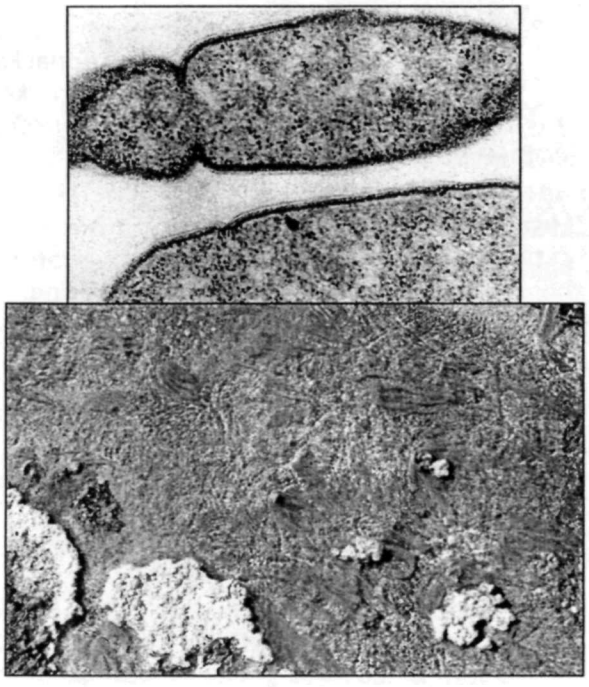
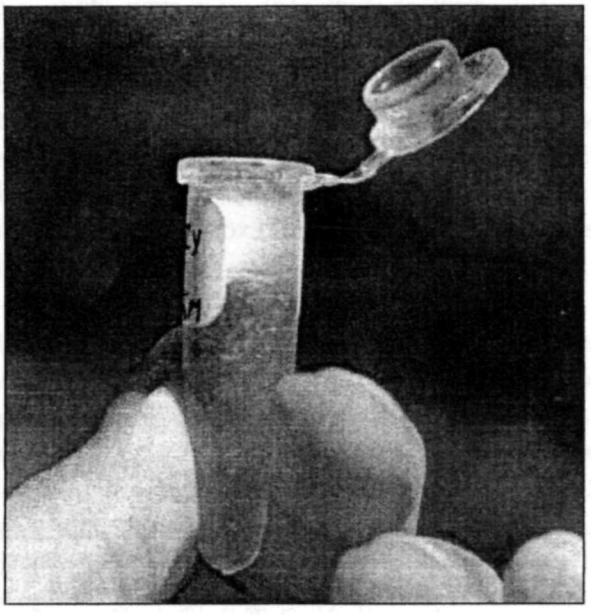
Bioprospecting and Benefits-Sharing

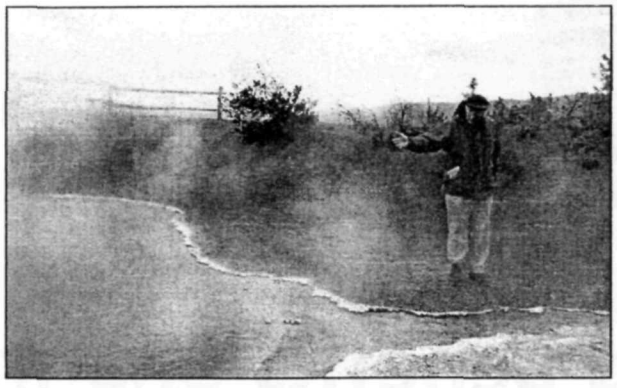


Thermus aquaticus, *a hydrothermal microbe.*
Above: *magnified.*



A microbial sample.

YELLOWSTONE'S HYDROTHERMAL MICROBES have been the subject of scientific research and discovery for more than 100 years. One of these discoveries—of the uses for *Thermus aquaticus*—has led to scientific and economic benefits far beyond what anyone could have imagined. Today, several dozen scientific research projects—sponsored by universities, NASA, and corporations—are underway in the park to investigate the extremophiles. In recent years, some of their discoveries have been used for commercial purposes.



Dr. Thomas Brock in Yellowstone.

History

Careful scientific study of these curious life forms began in earnest in 1966, when Dr. Thomas Brock discovered a way to grow one of the microorganisms living in the extraordinary hot waters (more than 70°C) of Mushroom Pool in Yellowstone National Park. This bacterium, *T. aquaticus,* proved essential to one of the most exciting discoveries in the twentieth century.

Two decades ago, the study of DNA was barely possible. Things we take for granted today, such as DNA fingerprinting to identify criminals, DNA medical diagnoses, DNA-based studies of nature, and genetic engineering were unimaginable. But in 1985, the polymerase chain reaction (PCR) was invented. PCR is an artificial way to do something that living things do every day—replicate DNA. PCR is the rocket ship of replication, because it allows scientists to make billions of copies of a piece of DNA in a few hours. Without PCR, scientists could not make enough copies of DNA quickly enough to perform their analyses. An enzyme discovered in *T. aquaticus*—called Taq polymerase—made PCR practical. Because it came from a thermophile (heat-loving organism), Taq polymerase can withstand the heat of the PCR process without breaking down like ordinary polymerase enzymes. A synthetic version of this enzyme is now used and has allowed DNA studies to be practical and affordable.

Many other species of microbes have been found in parks since 1966. Each one produces thousands of proteins, some useful to scientists. Researchers estimate more than 99% of the species actually present in nature have yet to be identified.

The Issue

Should the potential scientific and economic benefits resulting from collaboration with scientists who use their research results for commercial purposes be used to support and strengthen the National Park Service's primary mission of resource preservation?

Definitions

Bioprospecting is the search for useful scientific information from genetic or biochemical resources. Bioprospecting does not require the sort of grand-scale resource consumption typical of extractive industries associated with the term "prospecting," such as timber harvesting and mining.

Benefits-sharing is an agreement between researchers, their institutions, and the National Park Service that returns benefits to the parks when results of research have potential for commercial development.

History

1966: The microorganism *Thermus aquaticus* was discovered in a Yellowstone hot spring.

1985: An enzyme from *T. aquaticus,* which is synthetically reproduced, contributed to the DNA fingerprinting process that has earned hundreds of millions of dollars for the patent holder.

1997: Yellowstone signed a benefits-sharing agreement with Diversa Corporation, which ensures a portion of their future profits from research in Yellowstone National Park will go toward park resource preservation.

1999: A legal challenge put on hold implementation of this agreement until an environmental analysis is completed.

Current Status

- NPS is conducting an environmental impact statement (EIS) to decide whether benefits-sharing should be a part of NPS policy for parks nationwide. Through a public process, the EIS will examine the potential impacts of implementing and not implementing benefits-sharing agreements.
- Each year, more than 50 research permits are granted to scientists to study microbes in NPS units. Research permits are only granted for projects that meet stringent park protection standards.
- Research microbiologists continue to find microorganisms in parks that provide insights into evolution, aid in the search for life on other planets, and reveal how elements are cycled through ecosystems.

Science

Because much of modern biotechnology is based on the use of enzyme catalysts for biochemical reactions—including genetic engineering, fermentation, and bioproduction of antibiotics—newly discovered enzymes are becoming increasingly important in the advancement of science, medicine, and industry.

National parks offer unique opportunities to study natural systems and living things. To a large extent, the biodiversity of the U.S. is exemplified by the National Park System's nearly 400 park units totaling approximately 84.4 million acres. NPS conserves and manages examples of nearly all the variety of life found in the United States today. It is increasingly obvious to park managers, scientists, and others that the more that is learned about the organisms existing in parks, the more it is confirmed that national parks are important places of special and complex biological diversity.

Ongoing Research

More than 50 research studies are being done on microorganisms from NPS areas. For example, NASA is studying thermophile-influenced mineral deposits that might help determine if life exists on Mars. Other microbes have been found that are useful in producing ethanol, treating agricultural food waste, bioremediating chlorinated hydrocarbons, recovering oil, biobleaching paper pulp, improving animal feed, increasing juice yield from fruits, improving detergents, and a host of other processes.

Controversy

Along with this exciting new dimension in park resources and research, some questions have been raised about whether or not bioprospecting of microbes should be allowed. Long-standing laws, regulations, and policies instruct parks to allow scientific research as long as it does not harm park resources or values. Park managers do not allow the commercial use or sale of park specimens or "harvesting" microbes beyond the tiny samples required for scientific analysis. Thus, only information and insight gained from research on park specimens may be commercialized—not the specimens collected from the park. In addition, bioprospectors are not the only ones who may get ideas from their research that can be applied to commercial uses. Any scientist may accidentally learn something that leads to a commercial success. Nonetheless, some people question the appropriateness of allowing scientists to perform research in a national park if they are avowed bioprospectors, even if their research may reduce greenhouse gas emissions or cure cancer.

Scientists at work.

Benefits-Sharing

The issue of benefits-sharing came to the forefront when Yellowstone recognized that the development of the polymerase chain reaction (PCR) had resulted in a multi-million dollar business. Federal legislation authorizes the NPS to negotiate agreements that would provide parks a reasonable share of profits when park-based research yields something of commercial value.

Hoffman-La Roche, a Swiss pharmaceutical company, purchased the U.S. patents for the PCR process and Taq polymerase from Cetus Corporation in 1991 for a reported $300 million. Since then, PCR has become one of the cornerstones of modern medical diagnostics, and annual sales of Taq polymerase have grown to an estimated $100 million. Yellowstone National Park and the United States public have received no direct benefits although this commercial product was developed using an enzyme derived from a Yellowstone microbe. Hoffman-La Roche

and the researchers acted lawfully throughout the development and sales of Taq polymerase. At issue is whether the NPS should insist that research institutions and companies share the benefits they may acquire from the results of research using a park research specimen or whether the NPS should relinquish any claim to a portion of such benefits.

Benefits-Sharing Agreements

In 1997, Yellowstone National Park became the first U.S. national park to enter into a benefits-sharing agreement called a Cooperative Research and Development Agreement (CRADA). Other federal agencies, including the National Institutes of Health and the Department of Energy, routinely use CRADAs to conduct collaborative research and development with private researchers. These agreements could allow parks to collaborate with researchers and receive equitable benefits, such as equipment, training, or funding for conservation projects, when research on biological material from the park leads to commercially successful inventions. Similar benefits-sharing agreements are increasingly used in other countries to protect biodiversity by allowing the host nation to benefit from commercial discoveries that depended on its national parks and other protected areas.

Under this particular CRADA, Diversa Corporation would pay Yellowstone $100,000 over five years and royalty payments if sufficient profits result from research on Yellowstone microbes. The agreement did not allow additional specimen collection nor did it enable Diversa to do anything that was not already allowed under the NPS research permit system.

Diversa, which has research sites in Costa Rica, Iceland, Antarctica, and at the bottom of the Pacific and Atlantic oceans, collects DNA from hydrothermal habitats and screens the genes for the ability to produce useful compounds. In its labs, scientists splice the most useful genes into microbial "livestock," and these microbes then produce the compound or enzyme. As with all NPS research specimens, the Yellowstone microbes themselves remain in federal ownership. None of Yellowstone's natural resources are ever sold. Specimens used by all bioprospectors remain federal property.

Into Court

Four entities, including two organizations opposed to biotechnology and an environmental group, sued the National Park Service in 1998, alleging the Yellowstone-Diversa CRADA was a commercialization of public resources without public input.

In April 2000 the judge ruled in favor of the National Park Service but let stand a previous order requiring NPS to complete an environmental analysis of the impacts of the agreement according to National Environmental Policy Act procedures. The CRADA between Diversa and Yellowstone is suspended until such an analysis has been completed.

As global biodiversity declines, national parks and other preserves become increasingly important as sources of genetic diversity for scientific study as well as products that may benefit humanity. More than half of the pharmaceuticals in use in the United States contained at least one major active compound derived from or patterned after natural compounds.

For more information on bioprospecting and benefits-sharing in the NPS, please see:
www.nature.nps.gov/benefitssharing

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