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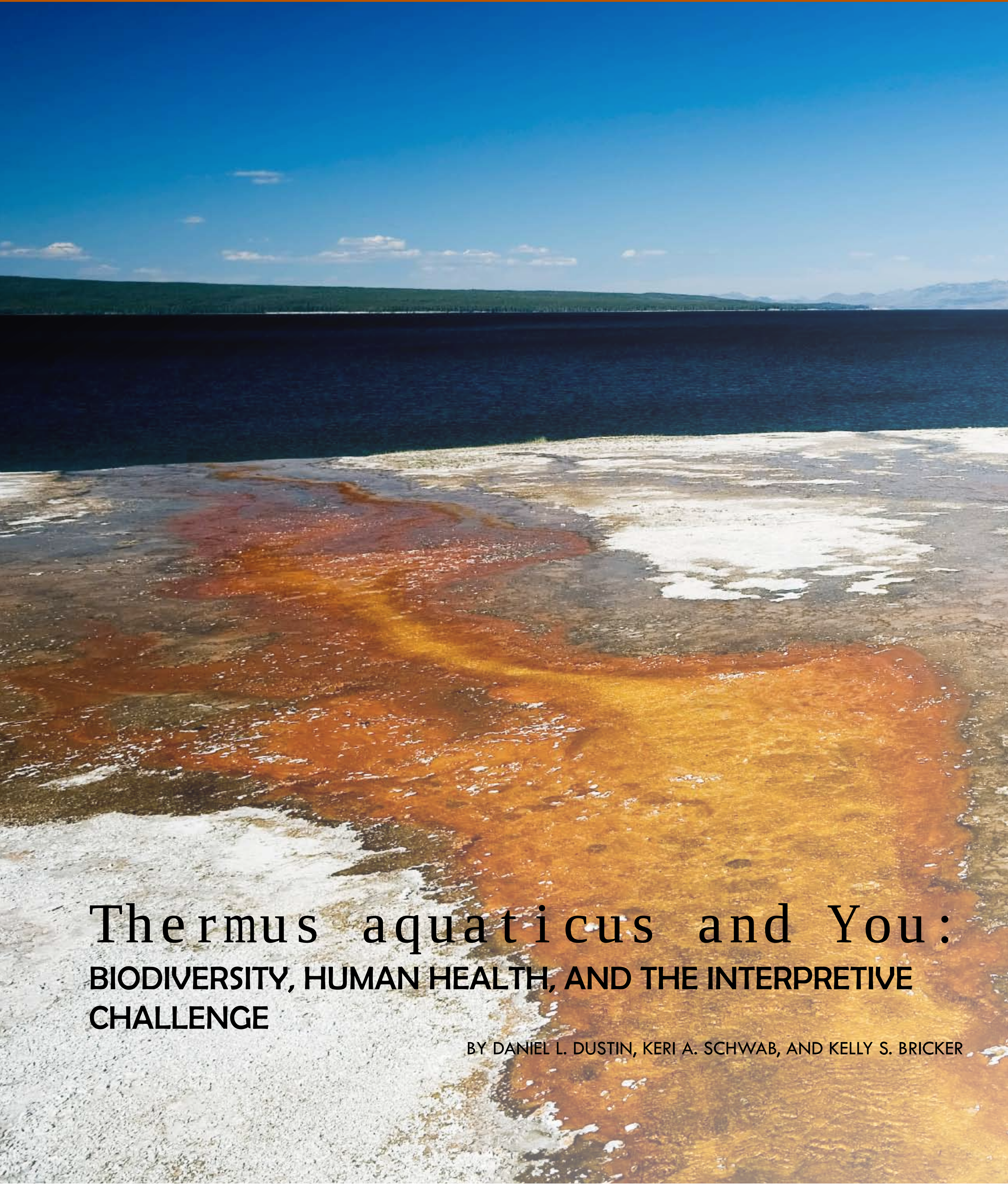

Thermus aquaticus and You:

BIODIVERSITY, HUMAN HEALTH, AND THE INTERPRETIVE CHALLENGE

BY DANIEL L. DUSTIN, KERI A. SCHWAB, AND KELLY S. BRICKER

Imagine being imprisoned for a crime you didn't commit. How would it affect your physical, mental, and emotional health? How would it affect the health of your family and friends? Imagine your sense of helplessness when everyone who should have helped set you free—eyewitnesses, investigators, police, and attorneys—all conspired instead to build a strong case against you. After your trial and sentencing, imagine how you would feel after more than a decade behind bars for something you didn't do.

Such was the case of Christopher Ochoa, who, in 1988, was coerced into confessing to a murder he didn't commit, and whose grandfather died while Ochoa served 12 years in prison. Such was the case of Neil Miller who was incarcerated for nine years after a wrongful rape conviction. Such was the case of Earl Washington who was wrongly imprisoned for 17 years after discrimination, manipulation, and poor legal representation led to his conviction for rape and murder. And such was the case of Gary Dotson who spent eight years in prison on aggravated kidnapping and rape charges, after a victim misidentified him as the perpetrator.

Fortunately, thanks to deoxyribonucleic acid (DNA), these stories have an unexpected happy ending. Since Gary Dotson was first set free by a DNA matching technique in 1989, more than 250 convictions have been reversed in the United States, leading to innocent people being set free. DNA is a spiral molecule found in all organisms. It contains specific genetic information unique to each one of us. For an individual accused of a crime, DNA testing can often help determine beyond a reasonable doubt if that person committed the crime. It is a powerful diagnostic tool for both the prosecution and the defense. But how did DNA testing come to be?

Polymerase Chain Reaction

On a hot dry evening in May of 1983, Kary Mullis, a researcher with the Cetus Corporation, was driving north from Berkeley, California through Mendocino County. He was enjoying the smell of blossoming California buckeyes and thinking about a way to read the sequence of, as he put it, the "King" of molecules, DNA. If he could do that, he felt he could change the world. As he drove on, Dr. Mullis understood that he had to arrange a series of chemical reactions that would represent and display the sequence of a stretch of DNA. He could do this, he thought, by attaching a short synthetic piece of DNA to a long strand of DNA if the sequences matched up somewhere on the longer strand. He then focused on to how to do it. Later on that evening and farther down Highway 128, Dr. Mullis worked out in his mind the rudimentary chemistry for what would come to be known as the polymerase chain reaction (PCR), the key to the DNA matching technique. Ten years later, in 1993, he won the Nobel Prize in Chemistry for that night's conceptual work.

Integral to PCR's utility as an amplification technique for reading DNA is Taq polymerase, a heat resistant enzyme that makes it easier to duplicate specific pieces of DNA. Taq polymerase, in turn, is found in bacteria that thrive at extremely high temperatures. These thermophilic bacteria are considered unusual because they defy what were thought to be the upper temperature limits of life (> 55 degrees Celsius or >131 degrees Fahrenheit). Indeed, the bacterium from which Taq polymerase was isolated thrives in scalding water. And where on earth was that bacterium, that source of Taq polymerase, found?

Thermus aquaticus

In the summer of 1966, Thomas Brock, a microbiologist from Indiana University, was driving cross-country to a summer job in Seattle. He did some climbing in the Grand Tetons and then, against his better judgment, made a detour north to Yellowstone National Park. (Dr. Brock had avoided visiting Yellowstone on several previous occasions, because of his aversion to tourists and crowds.) He stopped briefly at the West Thumb Geyser Basin on the western shore of Yellowstone Lake, and, to his amazement, saw what he described as "algae mats, bright orange, red, and green, spread out along the silica channels under sheets of hot, steaming water" (Brock, 1978, p. 441). Fascinated by what he observed, Dr. Brock spent the next ten years studying microorganisms thriving in Yellowstone's geyser basins. The hot springs proved to be wonderful natural laboratories. The crowning achievement of Dr. Brock's decade of research was the discovery of a new bacterium, Thermus aquaticus, in October of 1966, the bacterium from which the heat resistant enzyme, Taq polymerase, was eventually isolated and adopted for use in the DNA matching process.

Thermus aquaticus and You

The story of Thermus aquaticus's discovery in Yellowstone National Park, and its subsequent role in creating a 1993 Nobel Prize-winning technology that makes it possible to read DNA, is a clear illustration of human health's dependence on biodiversity. Had President Ulysses S. Grant not protected those thermal "laboratories" in the form of a national park in 1872, and had Dr. Brock not made his fateful detour to Yellowstone in the summer of 1966, who knows when, if ever, Kary Mullis and his colleagues would have pieced together the chemical puzzle that resulted in the PCR technique so indispensable to DNA matching. And who knows when Gary Dotson, Earl Washington, Neil Miller, Christopher Ochoa, and those 250 innocent others would, if ever, have been set free.

We often think of Yellowstone as a tourist attraction to be enjoyed for its recreational amenities. Indeed, inscribed on the Roosevelt Arch at the Gardiner entrance to Yellowstone is "For the benefit and enjoyment of the people." While we think of these benefits as being largely recreational, they represent but a fraction of the overall benefits Yellowstone has to offer. Benefits come in many forms, and as the Thermus aquaticus story illustrates, the health benefits have turned out to be enormous. Clearly, the National Park Service's (NPS) custodial responsibility is much larger than we typically give it credit for. By preserving Yellowstone's biodiversity, the NPS has contributed immensely to the health of people everywhere. This is a benefit well beyond the context of recreation. One can only wonder what other potential health benefits lay hidden in the Yellowstone ecosystem awaiting future Dr. Brocks of the world?

The Interpretive Challenge

The Thermus aquaticus story demonstrates the connection between biodiversity and human health vividly. But this kind of connection must be communicated to the general public in a way that resonates with their personal experience if the implications of the connection are to be clearly understood. Because our scientific understanding of the working of things typically outpaces our common understanding, we believe the real challenge is an interpretive one. We must design effective ways to communicate complex ecological interrelationships and interdependencies to everyday people in everyday language if we are to gain widespread public support for biodiversity conservation.

We have told the story of Thermus aquaticus in a way that reflects Freeman Tilden's (1967) principles of interpretation by allowing the story itself to reveal its relevance to you,

Runoff from the West Thumb Geyser Basin, Yellowstone National Park.

thereby provoking you to reconsider the meaning of the story to your own life. Who among us cannot relate to the horror of an innocent person being wrongly imprisoned? Who among us would not welcome a scientific breakthrough that could exonerate us from a false accusation? Who among us would not want to protect the origin of that scientific breakthrough? Who among us, then, does not now feel a little more committed to protecting Yellowstone National Park and the biodiversity it represents?

Reconnecting with Nature

This interpretive challenge is heightened by our society's increasing disengagement from the natural world. The United States of America is now more than 85% urbanized. We are, by and large, city dwellers far removed from the sources of biodiversity that sustain us. The danger in this separation rests in the possibility that we may lose sight of our dependency on nature for our sustenance. We may not miss what we do not know and do not see. And in distancing ourselves from nature, we may behave increasingly in ways that are detrimental to the health of us all.

Getting people back to nature means more than enhancing physical, mental, and emotional health, important as they are. It means reestablishing a basic understanding of humankind's dependence on the natural world. This will be harder and harder to do if the context for most people's life experiences is confined to the city. Helping people really, truly understand that human health is dependent on the health of ecosystems far removed from human populations, and that humans must modify livelihoods and lifestyles to ensure the continued good health of those distant reservoirs of biodiversity, is a daunting educational task. To accomplish it, we must employ creative approaches to interpretation that employ vivid examples that illustrate complex ecological interrelationships and interdependencies, make environment-health connections explicit, and motivate us to get back to nature, learn from nature, and live our lives in harmony with nature. Therein resides the connection between Thermus aquaticus and you.■

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