X-treme Microbes: Amazing Survivors

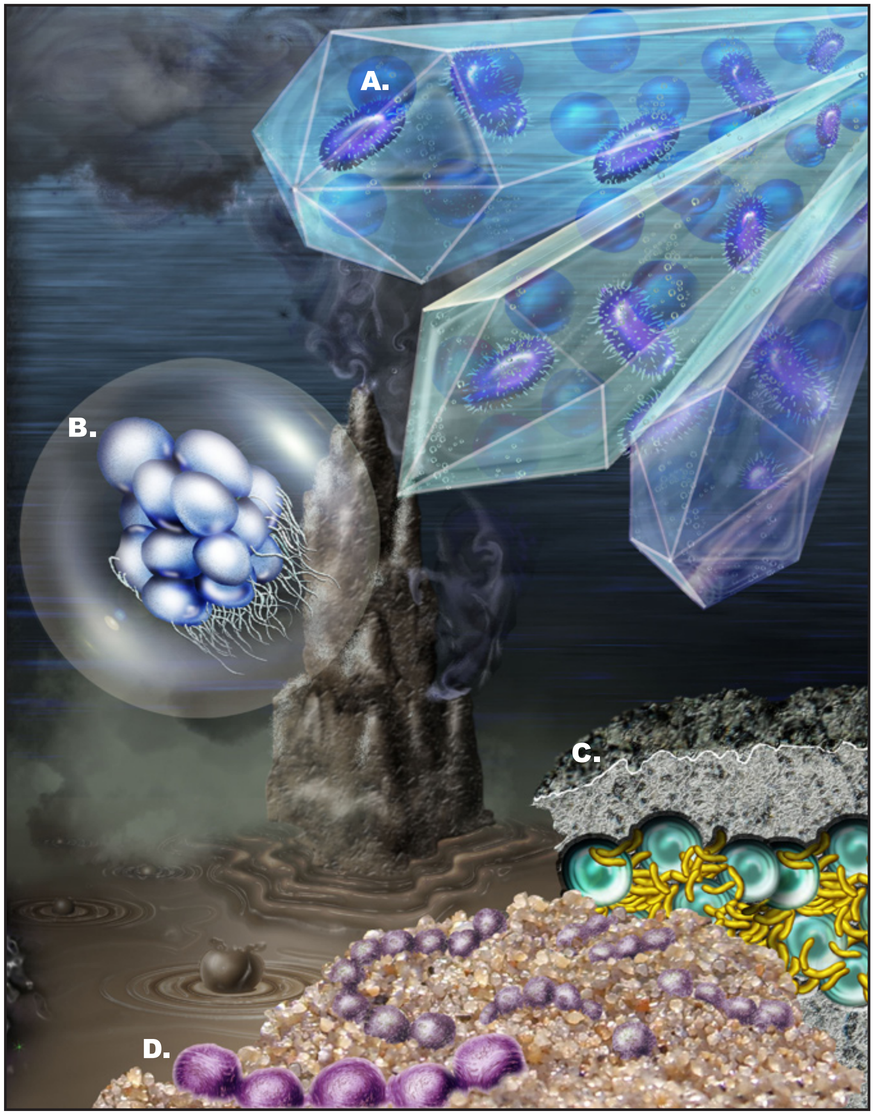
Extremophiles are organisms capable of living in conditions that would kill other life-forms, including intense cold, heat, pressure, dehydration, acidity/alkalinity and other chemical and physical extremes. A few animals, such as frogs that freeze solid in winter, can qualify. But in large part, the world's endurance champs are microbes: bacteria and an ancient lineage of single-celled creatures called archaea.

Many of them, apparently, have retained traits necessary eons ago when the young Earth was a violently inhospitable place. Nowadays, they're relegated to the most forbidding pockets of the planet, where scientists are studying their survival mechanisms—and probing the outermost boundaries of life.

Dry Life

Life can't exist without any water. But research is showing how shockingly little is necessary. Even in the planet's driest places—such as the Atacama high desert in Chile or the Dry Valleys in Antarctica—scientists have found that microbes can set up shop a few inches below the surface. In such circumstances, certain extremophiles have evolved novel biochemistry with functions that compensate in some respects for lack of water. Investigators are studying the DNA of these survivors to determine which genes contribute to the cells' abilities.

Other organisms found in Atacama and elsewhere can enter a seemingly lifeless, freeze-dried state, reviving only if and when some water appears. In the ultra-arid Dry Valleys, for example, researchers recently discovered that a mat of cells that had been dormant for two decades began photosynthesis within a day of exposure to liquid water. And a few marvelous microbes, tested in experiments on the space shuttle, have even survived the vacuum and radiation bombardment of empty space.



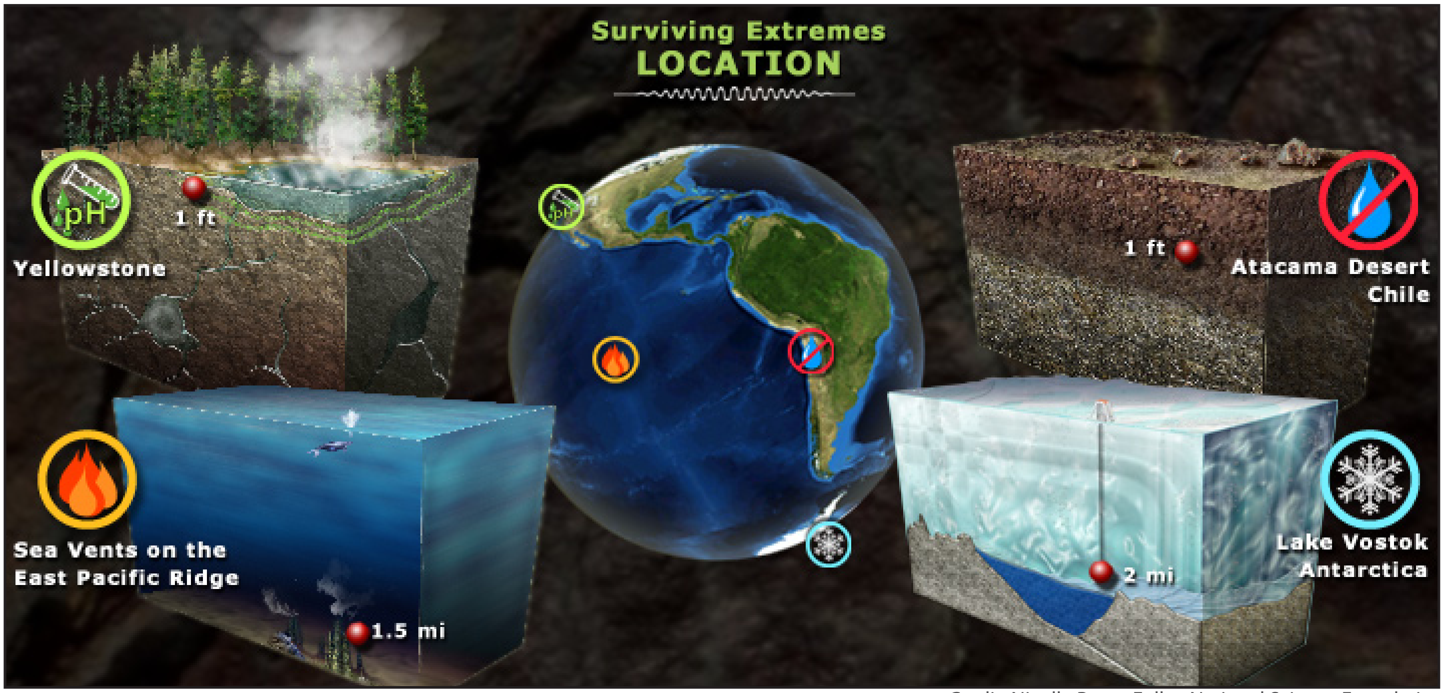
Credit: Nicolle Rager Fuller, National Science Foundation

A. Numerous kinds of extreme life forms can live in ice, and some can even subsist in the year-round ice layer that covers lakes in Antarctica. B. At hydrothermal vents in the sea floor, outflowing minerals often form "chimneys" in which hardy extremophiles thrive. C. Microbes have been seen to infiltrate pores in the rock at highly acid hot springs in Yellowstone Park. D. Even the driest deserts on Earth contain some organisms, leading many scientists to wonder about life on Mars.

Cold Life

Lots of creatures can live in the cold. But it takes special talents for cells to survive at the South Pole, where temperatures often drop below -100 F. Yet that's where scientists found a certain kind of bacteria that can get through the polar winter and have active metabolisms in surroundings as cold as 1.4 F.

That's just one of many creatures specially adapted to extremely frigid venues. Researchers uncovered microbes in an ice core extracted from just above Lake Vostok, an ancient



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Scientists studying the geological extremes of Yellowstone National Park—where the enzyme that powers DNA fingerprinting was first found—keep discovering novel organisms. Sea vents, too, are a continual source of new information about extremophile life. The desiccated, ultraviolet-blasted terrain of the Atacama high desert in Chile is home to dry-adapted microbes called xerophiles. And in Antarctica, Lake Vostok—a huge body of million-year-old liquid water buried under two miles of ice—may hold enormous surprises.

body of water buried thousands of feet below the Antarctic ice surface. At the other end of the Earth, extreme-tolerant organisms have shown up in the permafrost of northern Alaska.

Laboratory studies have shown that many cold-surviving life-forms (collectively known as psychrophiles) have remarkable cellular ingredients that prevent the formation of ice crystals. Others have evolved a talent for huddling together into mats called biofilms. Many can't live at all above 50 F. It's just too hot.

Vent Life

Miles below the ocean surface on the lightless seafloor, giant cracks in the Earth's crust create sites where mineral-dense water—heated to 600 F—spews forth in roiling clouds. It's as forbidding an environment as one could imagine. Yet scientists have found hosts of organisms that have learned to thrive there.

In those circumstances, of course, photosynthesis simply isn't possible. But certain kinds of single-celled archaea have developed a unique alternative called chemosynthesis: a means of converting inorganic hydrogen sulfide dissolved from rocks into food. Archaea living on or under the seafloor make up vast microbial mats and other configurations that provide the foundation for a bizarre and abundant community of towering tube worms, gigantic clams and mussels, and strange fish and crabs that can withstand the titanic pressure and utter dark.

Acid Life

When it comes to acidity versus alkalinity, most mammals are wimps. On the pH scale, 7 is neutral. The lower the number, the more acidic; the higher, the more alkaline. Human blood has to stay between 6.8 and 7.8 to support life. But nature is replete with creatures that thrive on the extreme ends of the pH scale.

In Yellowstone National Park, for example, researchers took water samples and found organisms fully adapted to extremely hot acidic conditions. In California, other scientists studying the contents of mine drainage revealed incredibly tiny microbes living comfortably at a pH level as low as 0.5—the equivalent of battery acid.

On the double-digit side of the scale, soda lakes in Africa with a pH around 10 (about the same as drain unclogger) support dozens of microbial species with specially evolved chemistry that keeps the pH inside the cells neutral.

Lab studies of both acidophiles and alkalophiles continue to show the remarkable—and often unexpected—range of conditions to which life can adapt.