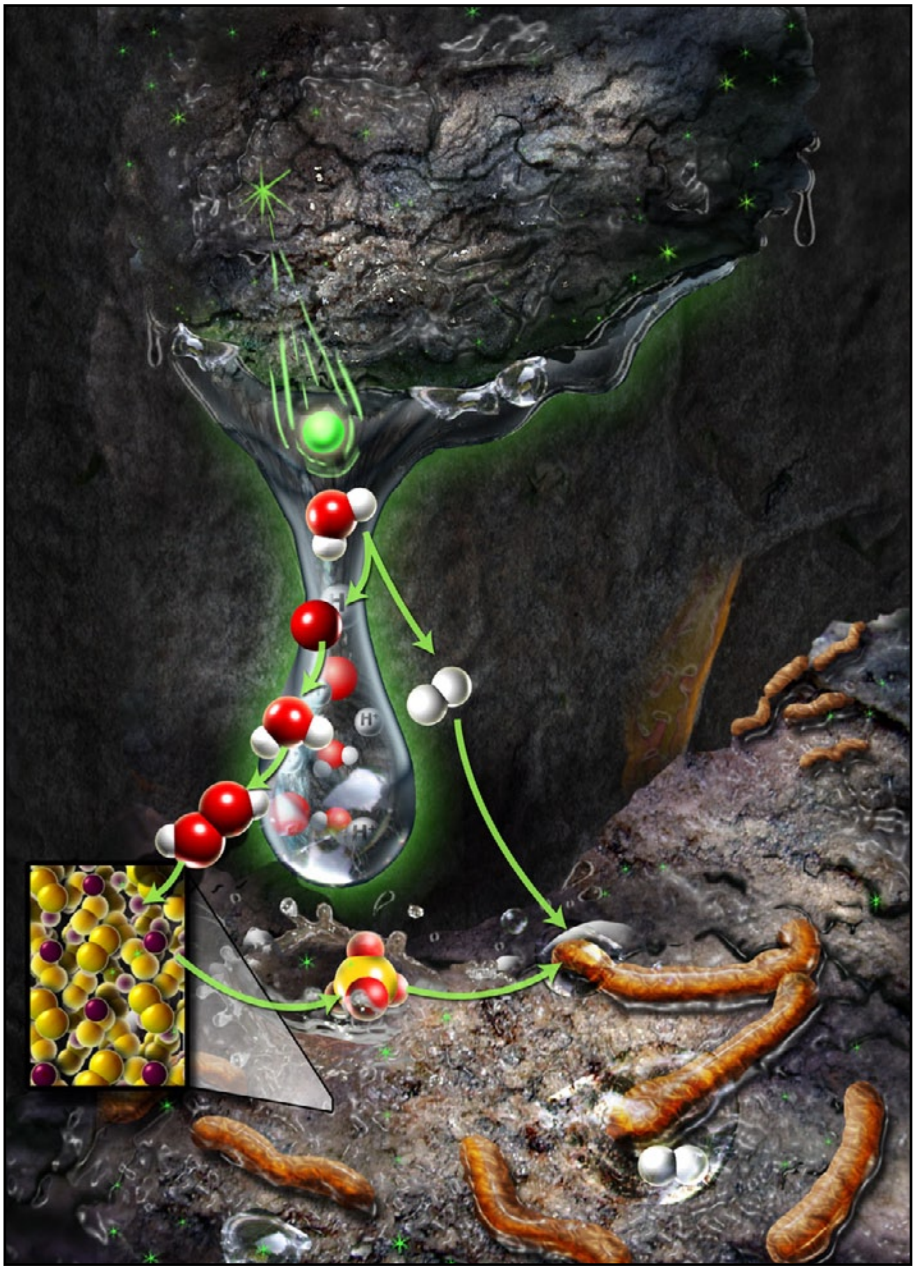
X-treme Microbes: Eating Radioactivity



◀ The newly discovered microbes were found nearly two miles deep in ancient water seeping through a fracture in a 2.7-million-year-old rock formation. The rock contains radioactive uranium, thorium and potassium, as well as an iron-sulfur compound called pyrite, or fool's gold, among other constituents.

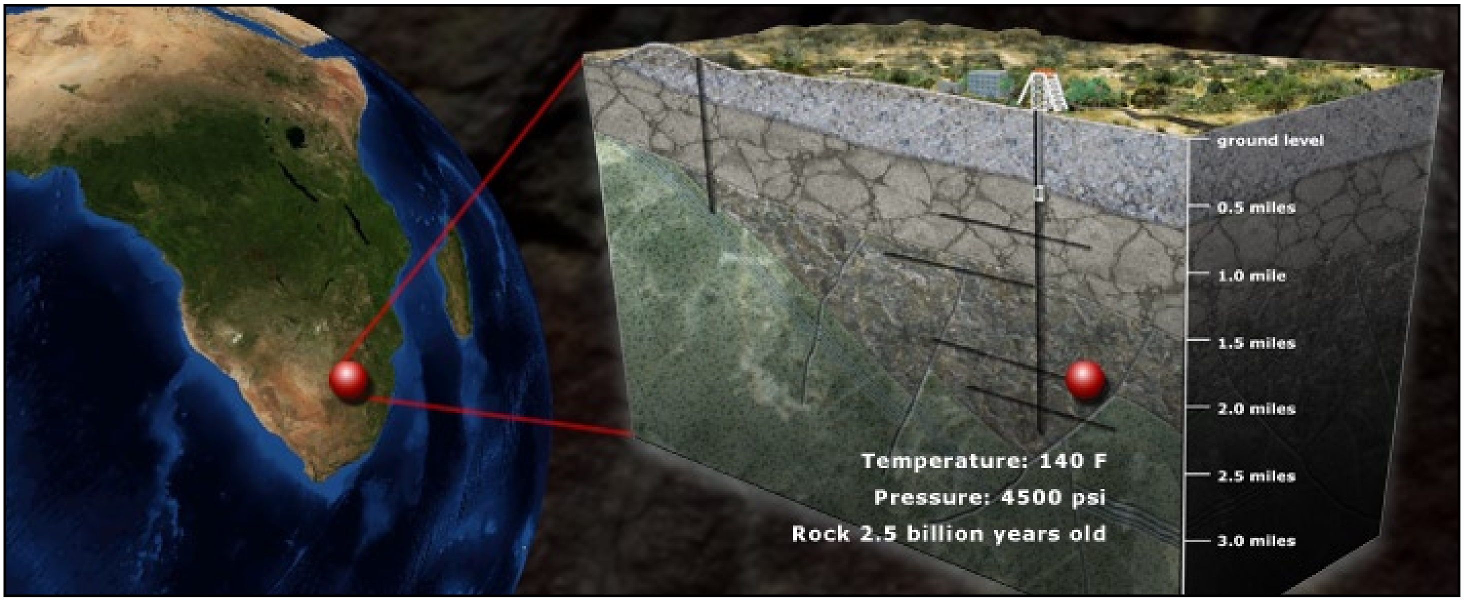
A cascade of reactions supplies the microbes with their remarkable if meager diet. First, radioactivity cracks water molecules (H_2O) into their components: hydrogen (H_2) and oxygen (O).

The detached oxygen atoms combine with adjacent water molecules to make hydrogen peroxide (H_2O_2). The peroxide then reacts with an iron-sulfur compound called pyrite (FeS_2), producing sulfate ions (SO_4^{2-}) that the microbes can "eat." Each sulfate ion is lacking two electrons, which are supplied—inside the organisms—by the conveniently available leftover hydrogen gas (H_2). The microbes use that reaction to store energy.

Credit: Nicolle Rager Fuller, National Science Foundation

Not so long ago, everyone believed that the primary source of energy for all life was sunlight. Even for carnivores: After all, they eat herbivores that eat vegetation produced by photosynthesis. Ditto for bacteria stuck in the perpetual dark of the human gut, or for lightless ocean-bottom ecosystems that utilize oxygen dissolved in seawater—oxygen created by sunshine in plants and algae above. Ultimately, it seemed, everything depended on the Sun.

But in the 1960s, scientists began discovering exotic organisms that play by astonishingly different rules. Now, a team searching deep in a South African gold mine has



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Scientists discovered the microbes at the bottom of one of the world's deepest gold mines in South Africa. Miners were drilling exploratory holes in preparation for a new tunnel, and the U.S. researchers took advantage of the situation when the drilling struck a high-pressure water-bearing fracture. They took water samples for 54 days, and found that the samples were dominated by one type of microbe that resembles an extremophile seen elsewhere. Further study may reveal how it is related to others.

found one that redefines the very limits of life: Bacteria that subsist in rock at huge pressure for thousands of years by "eating" by-products of radioactivity, completely isolated from any organic matter or effects of photosynthesis.

Tullis Onstott of Princeton University, Lisa Pratt of Indiana University and colleagues think the microbes may have first trickled down there between three and 25 million years ago, and were forced to survive on the leftovers that result when radioactivity from uranium, thorium and potassium in the native rock breaks down molecules of water, prompting a sequence of chemical reactions that produces hydrogen peroxide, breaks down pyrite, and forms sulfates.

They developed a way of taking metabolic advantage of these reactions that is very different from the processes used by their conventional topside cousins.

These rock-dwellers may be some of above-ground life's oldest relatives. Pratt and Onstott suspect that they're probably not much different now than when they were separated from the surface, because they grow very slowly to conserve scarce nutrients.

In fact, "very slowly" is an understatement: Whereas E. coli, like those found in the intestines of mammals, divide every day or so, the subsurface microbes reproduce once a year at most, and possibly only every 300 years … or more!

So far, researchers haven't been able to grow them in the lab under the microbes' natural conditions. But they are working on genomic sequencing to evaluate how closely related the newly discovered bacteria are to other extremophiles and surface organisms.

In the future, those studies may change the way instruments look for life on Mars. And they may even begin to answer the question: Did life on Earth begin underground?