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Breathing rust - and new life into bug science

By Mary Wiltenburg | *Staff writer of The Christian Science Monitor*

AMHERST, MASS. – Iron lungs may be the answer. To the problem of nuclear pollution, the demand for new energy sources, the mystery of Earth's earliest life, and the search for life in space. A family of tiny iron-breathing critters discovered by Derek Lovley, professor of microbiology at the University of Massachusetts, Amherst, is redefining what scientists have believed possible in all these areas.

"It's a great time to be a microbiologist," says the bright-eyed professor, outdoorsman, and dad. "I've got a team of 50 people working with me; almost every day somebody discovers something that changes the way we think about how things work."

He never planned to be a biologist. But poking around in the muck at the bottom of Maryland waterways for the United States Geological Survey in 1987, Dr. Lovley discovered a new type of bacteria: the iron-breathing *geobacteraceae* (Latin for "earth" and "rod," their habitat and shape). Poisoned by oxygen, these organisms thrive in environments free of it, underground and underwater.

Though scientists have known for a century that microorganisms can breathe sulfates, nitrates, and carbon dioxide, no one had previously tested for life forms that survive on rust. In the Potomac riverbed, Lovley discovered huge numbers of the tiny geobacter - 10,000 to an inch - that were breathing iron in the sediment all around them - and lunching on gas. Leaky gas-station tanks had fouled the river, and

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the geobacter were converting the pollutant to carbon dioxide. Lovley began to wonder what else these small wonderbugs were capable of.

To date, he and his team at UMass have discovered two major uses for the bacteria and their fellow mineral-breathers - plus two main clues to longstanding scientific puzzles. They also recently have sequenced the geobacter genome, and are developing a computer model of the microbe they hope may predict its behavior in other applications.

If the US today were to try to clean all its nuclear sites where uranium now poisons the groundwater, Lovley says, the cost would bankrupt the country. His team has an alternative, successfully tested at a uranium mine in Colorado the past two summers. By pumping a favorite geobacter food - acetate, or vinegar - into the ground, they caused a native population of bacteria to expand. As the microbes ran out of iron to breathe, they latched onto uranium instead.

Breathing the mineral, the bacteria added two electrons to it, changing it to a form that does not dissolve in water. The insoluble uranium fell out of the water supply about 30 feet underground, rendering the toxic, radioactive material inert and basically harmless.

Not to be outdone, a sweet-toothed cousin of the geobacter, *Rhodoferax ferrireducens*, is proving useful in energy production. As reported in this month's issue of Nature Biotechnology, Lovley and his team have developed a fuel cell in which microbes digesting a teaspoon of sugar produce enough energy to power a Christmas tree bulb.

Sealed in a tube of sugar water with a graphite electrode, the bacteria breathe the graphite and scientists harness the current of electrons running off. Though these bug batteries are not yet efficient enough to run more than a calculator, Lovley's team is working to increase their viability as an alternative energy source.

Apart from their practical uses, the geobacter are also a window on the question of the origins of life on Earth. Scientists studying iron-breathers in hot ocean vents now believe the planet's mineral-breathing bacteria preceeded oxygen-lovers by a billion years.

"When organisms learned to make oxygen, that was probably the greatest pollution event in the history of the world," says Lovley. He estimates the gas's advent quickly changed the proportion of nonoxygen-breathing organisms to half the population on Earth - about where it is today. "There is likely a biomass of organisms living under the earth equal to all those that live on its surface," he says.

The most unsettling thing about the geobacter for many scientists and doctors is their immunity from sterilization. Lovley's team has found the bacteria thriving in undersea environments at 250 degrees F. - the gold standard for heating equipment to ensure no microorganisms are living on it.

Though the revelation may not mean changes at your dentist, it will have a bearing on the hunt for life on other planets. Until now, scientists haven't seriously been looking for life on hot, oxygen-free, mineral-rich planets. Lovley's research could redefine their search.

Questions about the distant past and the great beyond don't trouble Lovley. The origins of life, he says, will always be just theories - and as for aliens, "I've got enough to worry about here on Earth."

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