NSF Press Release

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Note to editors and news directors: Also available are the following:
- A feature on Strain 121 (similar but longer, about 1,100 words)
- An accompanying sidebar describing the retrieval of its "black smoker" hydrothermal vent (about 600 words)
- Images and web-quality video (see panel at right)
- Expert sources and background resources

Microbe from Depths Takes Life to Hottest Known Limit

Researchers find iron-reducing archaeon 'Strain 121' respires to greatness

ARLINGTON, Va.—It may be small, its habitat harsh, but a newly discovered single-celled microbe leads the hottest existence known to science.

Its discoverers have preliminarily named the roughly micron-wide speck "Strain 121" for the top temperature at which it survives: 121 degrees Celsius, or about 250 degrees Fahrenheit.

Announcing Strain 121's record-breaking ability to take the heat in the August 15 issue of the journal *Science*, researchers Derek Lovley and Kazem Kashefi write, "The upper temperature limit for life is a key parameter for delimiting when and where life might have evolved on a hot, early Earth; the depth to which life exists in the Earth's subsurface; and the potential for life in hot, extraterrestrial environments."

Previously, the upper known temperature limit for life had been 113 C (235 F), a record held by another hyperthermophilic—or extreme-heat-liking—microbe called *Pyrolobus fumarii*.

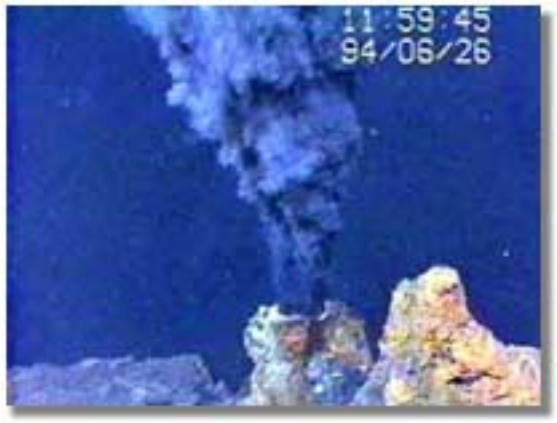
The work by Lovley and Kashefi, researchers at the University of Massachusetts, Amherst, was supported by the National Science Foundation's Life in Extreme Environments program. Their NSF project may also yield clues to the formation of important ore deposits, the remediation of toxic contaminants, and more efficient recovery from petroleum reserves.

On a standard stovetop, water boils at 100 C, or 212 F.

Strain 121, however, comes from water at the ocean bottom, from a surreal deep-sea realm of hydrothermal vents. Heated to extremes by the earth's magma, water there spouts forth through leaks in the ocean floor. The pressure of the immense depths prevents such hot water from turning to steam—even as it sometimes emerges at temperatures near 400 C (750 F).

The sample cultured by Lovley and Kashefi was collected about 200 miles offshore from Puget Sound and nearly a mile and a half deep in the Pacific Ocean by a University of Washington team led by biological oceanographer John Baross.

Baross's crew, also supported by NSF, used a remotely operated submarine to retrieve it from the Pacific Ocean's Juan de Fuca Ridge, a lightless seascape where vents called "black smokers" rise up like three- and four-story chimneys and



Download video
http://nsfvideo.nomex.net/strain121/scsmoker2.mpg (small screen). *Use "Back" to return to press release.*

http://nsfvideo.nomex.net/strain121/scsmoker2lg.mpg (large screen). *Use "Back" to return to press release.*

Note: The videos above require the free QuickTime player which is available at quicktime.com .

View streaming video
pr0384_video1.htm

A "black smoker" vents atop a 10-meter-high chimney, with an internal temperature of 342° C. Considered a "real chugger" by the National Oceanic and Atmospheric Administration's Pacific Marine Environmental Laboratory Vents Program, this vent is about 250 miles south of Finn, the vent that yielded the strain 121 sample.
For additional footage, see: http://www.pmel.noaa.gov/vents/geology/video_other.html
Video courtesy of Pacific Marine Environmental Laboratory, NOAA.

contacts:
http://www.pmel.noaa.gov/vents/contacts.html

Download video
http://nsfvideo.nomex.net/strain121/

continuously spew a blackening brew laced with iron and sulfur compounds. The neighborhood is called Faulty Towers.

While suffocating, crushing, scalding, toxic and downright abysmal by most living standards, the arrangement is not so bad for Strain 121 and its ilk. They are archaea, single-celled microbes similar to, but not quite, bacteria. They often live amid extreme heat, cold, pressure, salinity, alkalinity, and/or acidity.

Archaea literally means "ancient," and Lovley and other biologists tend to call them "deep branchers" because their evolutionary branch splits off trunk of the "tree of life" close to the roots.

According to Lovley, Strain 121—it will be given a species name after his lab finalizes the microbe's description—uses iron the way aerobic animals use oxygen.

"It's a novel form of respiration," Lovley says, explaining how Strain 121 uses iron to accept electrons. (Many archaea also use sulfur.) As oxygen does in humans, the iron allows the microbe to burn its food for energy. Chemically, the respiration process reduces ferric iron to ferrous iron and forms the mineral magnetite.

The presence of vast deposits of magnetite deep in the ocean, its presence as a respiratory byproduct of some archaea, and the abundance of iron on Earth before life began all led Lovley and Kashefi to write that "electron transport to ferrous iron may have been the first form of microbial respiration as life evolved on a hot, early Earth."

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http://nsfvideo.nomex.net/strain121/ hh_fish.mov (large screen). *Use "Back" to return to press release.*

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pr0384_video2.htm

These steep-sided pinnacles rise 22 meters above the sea floor on the east face of the Faulty Towers complex in the Mothra Hydrothermal Field, along the Juan de Fuca Ridge about 2,270 meters below the surface of the Pacific Ocean, about 200 miles off the coast of Puget Sound. The structures support a vent releasing a stew at 300 C, communities of small tubeworm "bushes" (dotting the foreground) and occasional piscine passersby.
Video courtesy of Neptune oceanographic observatory, University of Washington.

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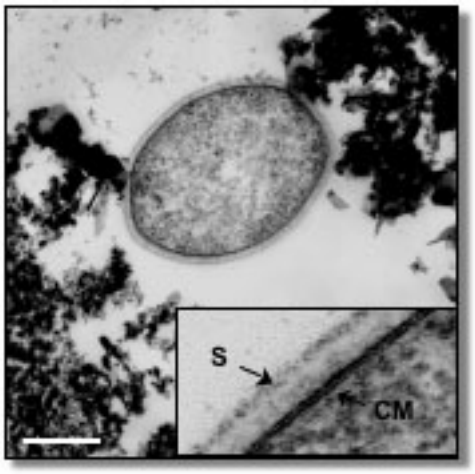


A thin section of Strain 121 illustrates its single-layer cell envelope (S) and cytoplasmic membrane (CM). (The white bar equals one micron.)
Photo courtesy of Derek Lovley, University of Massachusetts, Amherst.
Select image for larger version
(Size: 12KB) , or download a high-resolution TIFF version of image (49KB)

The researchers tested the process with Strain 121 cultures kept at 100 C in oxygen-free test tubes.

"It really isn't technically difficult. You just need some ovens to get it hot enough—and remember not to pick it up with your bare hands," Lovley says, speaking from experience.

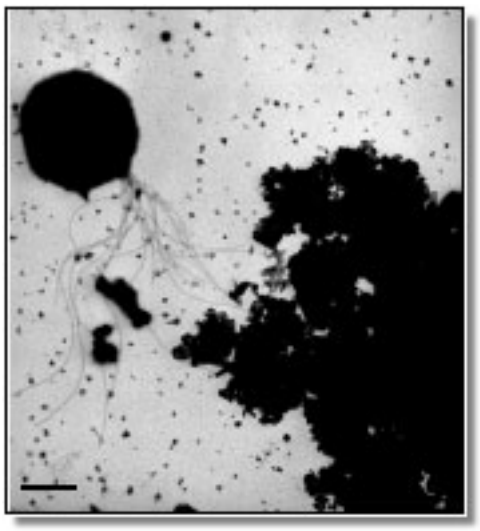
They discovered that Strain 121 grew at temperatures from 85-121 C (185-250 F). (Meanwhile, *Pyrolobus fumarii*, the former top-temperature record-holder, wilted. After an hour at 121 C, only 1 percent of its cells were intact and none appeared viable.)

"Growth at 121 C is remarkable," report Lovley and Kashefi, "because sterilization at 121 C, typically in pressurized autoclaves to maintain water in a liquid state, is a standard procedure, shown to kill all previously described microorganisms and heat-resistant spores."

Not only did Strain 121 survive such autoclaving, its population doubled in 24 hours at such heat and pressure. While they could not detect growth at higher temperatures, the researchers found that cultures that spent two hours at 130 C (266 F) still grew when transferred to a fresh medium at 103 C (217 F), with each new single-celled member appearing like a tiny tennis ball filled with cytoplasm and covered with about a dozen whip-like flagella.

-NSF-

Principal Investigator: Derek Lovley, professor and head, Department of Microbiology, University of Massachusetts, Amherst; (415) 545-9651, dlovley@microbio.umass.edu.



Looking like a freed balloon, the sphere in the upper left is a Strain 121 specimen, with its roughly dozen flagella dangling. The scale bar at lower left is one micron.
Photo courtesy of Derek Lovley, University of Massachusetts, Amherst.
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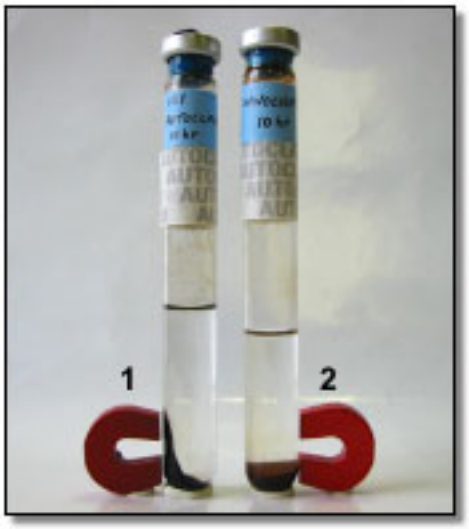
(Size: 11KB) , or download a high-resolution TIFF version of image (45KB)



Magnetite (attracted to the magnet), the byproduct of Strain 121's respiration of iron oxide, offers a tell-tale sign of life in the left tube, compared to the uninoculated tube on the right.
Photo courtesy of Derek Lovley, University of Massachusetts, Amherst.
Select image for larger version
(Size: 8KB) , or download a high-resolution TIFF version of image (95KB)

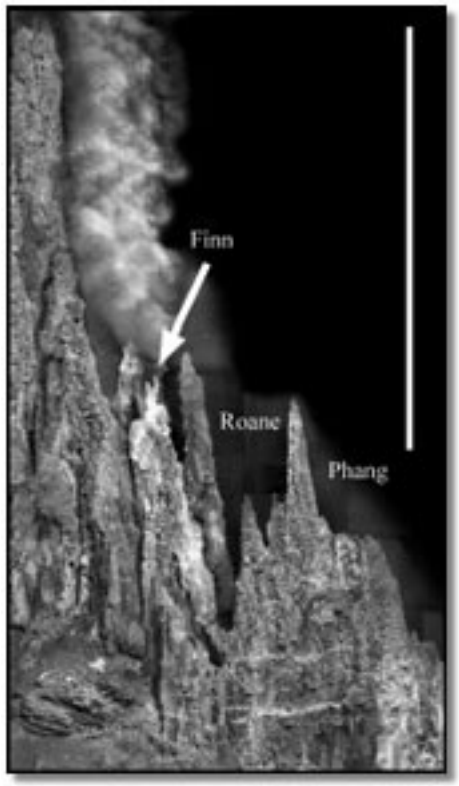
www.geobacter.org

Additional expert: John Baross; professor, Department of Oceanography; (206) 543-0833, jbaross@u.washington.edu

Background Resources, Related News Available on the Web

NSF's Life in Extreme Environments Program: The LExEn research program will explore the relationships between organisms and the environments within which they exist, with a strong emphasis upon those life-supporting environments that exist near the extremes of planetary conditions (includes program announcement, workshop report and lists of research awards). http://www.nsf.gov/home/crssprgm/lexen/start.htm

University of Massachusetts at Amherst news release
http://www.umass.edu/newsoffice/archive/2003/ 081403microbe.html



A photomosaic of the Faulty Towers complex shows three of the structures recovered by the Edifice Rex Sulfide Recovery Project, including the Finn “black smoker,” home of the Strain 121 microbe. (The scale bar represents 13 meters.)
Image courtesy of John Delaney and Deborah Kelley, University of Washington
Select image for larger version
(Size: 804KB)

Larger versions (Total Size: 56KB) of all images from this document

Note About Images

Related previous NSF news releases:

"Hydrothermal Vent Systems Could Have Persisted for Millions of Years, Incubated Early Life" - July 24, 2003: The staying power of sea-floor hydrothermal vent systems like the bizarre Lost City vent field is one reason they also may have been incubators of Earth's earliest life, scientists report in a paper published in the July 25 issue of Science.... http://www.nsf.gov/od/lpa/news/03/pr0376.htm

"Researchers Uncover Extreme Lake -- and 3000-Year-Old Microbes -- in Mars-Like Antarctic Environment" - December 16, 2002: NSF-supported researchers drilling into Lake Vida, an Antarctic "ice-block" lake, have found the lake isn't really an ice block at all.... Because of the arid, chilled environment in which it resides, scientists believe the lake may be an important template for the search for evidence of ancient microbial life on Mars and other icy worlds.... http://www.nsf.gov/od/lpa/news/02/

pr02100.htm

"Scientists Find Underground Environment on Earth That Supports Ancient Life Forms" – January 22, 2002 (news tip):
Deep below the surface of the Beaverhead Mountains of Idaho, a research team led by microbiologists Derek Lovley of the University of Massachusetts at Amherst and Francis Chappelle of the U.S. Geological Survey has found an unusual community of microorganisms that may hold the key to understanding how life could survive on Mars.... http://www.nsf.gov/od/lpa/news/02/tip020122.htm#fourth

"NSF-Funded Researchers Discover Evidence of Microscopic Life at the South Pole" - July 6, 2000:
In a finding that may extend the known limits of life on Earth, researchers supported by the National Science Foundation (NSF) have discovered evidence that microbes may be able to survive the heavy doses of ultraviolet radiation and the extreme cold and darkness of the South Pole.... http://www.nsf.gov/od/lpa/news/press/00/pr0048.htm

"Limits of Life on Earth: Are They the Key to Life on Other Planets? New NSF Grants to Foster Answers" – October 10, 1997:
From scalding hot places that rival Dante's Inferno to frigid locations colder than the dark side of the moon, scientists taking part in a $6 million National Science Foundation (NSF) research initiative are searching for life forms on Earth that may provide insight about possible life on other planets. The first NSF awards in this initiative -- which is titled Life in Extreme Environments (LExEn) -- involve more than 20 research projects and some 40 scientists who will look at life in Earth's most extreme habitats....
http://www.nsf.gov/od/lpa/news/press/pr9761.htm

Non-NSF Links:

"Introduction to the Archaea - Life's extremists" (University of California Museum of Paleontology, a recipient of NSF funding).
http://www.ucmp.berkeley.edu/archaea/archaea.html

NOVA's "Into the Abyss" (PBS Online): A mile and a half beneath the sea off the Pacific Northwest coast, a volcanic ridge has given birth to towering structures that spew toxic, superheated water. The structures, known as black smoker chimneys, are home to bizarre life forms that thrive far beyond the reach of the sun's light. Follow the daring attempt of an ambitious expedition to retrieve several of these black smokers from the seafloor.
http://www.pbs.org/wgbh/nova/abyss/

Pacific Marine Environmental Laboratory's Vents Program (National Oceanic and Atmospheric Administration): Researching the effects of underwater hydrothermal venting systems.
http://www.pmel.noaa.gov/vents/

Black Smoker Expedition (American Museum of Natural History):
This site chronicles the adventures of the Museum's scientists, engineers, and educators as they collected a black smoker sulfide chimney from the ocean floor.
http://www.amnh.org/nationalcenter/expeditions/blacksmokers/index.html

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