Underground life has a carbon mass hundreds of times larger than humans'

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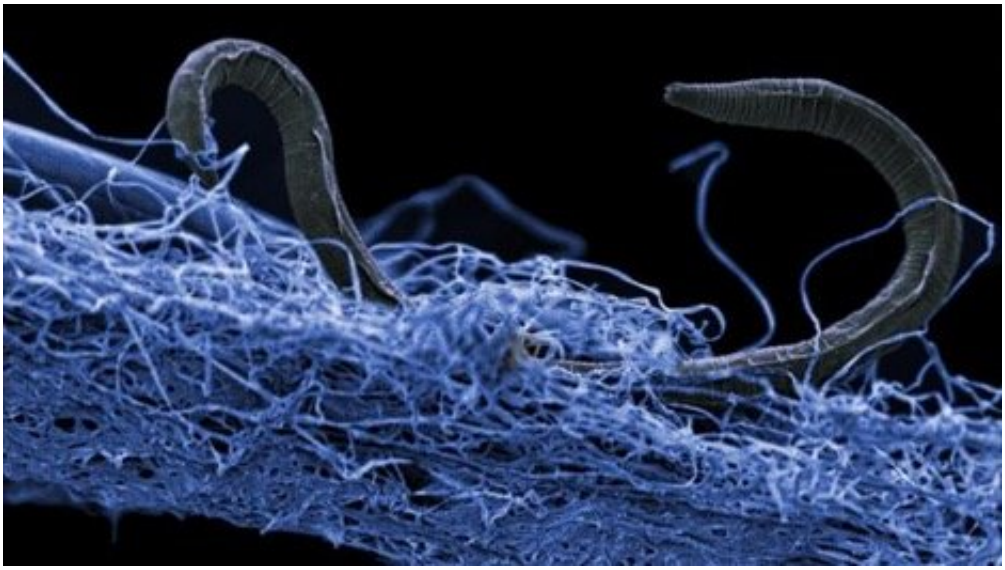


A nematode (eukaryote) in a biofilm of microorganisms. This unidentified nematode (*Poikilolaimus sp.*) from Kopanang gold mine in South Africa, lives 1.4 km below the surface. Credit: Gaetan Borgonie (Extreme Life Isyensya, Belgium).

Microorganisms living underneath the surface of the earth have a total carbon mass of 15 to 23 billion tons, hundreds of times more than that of humans, according to findings announced by the Deep Carbon Observatory and coauthored by UT Professor of Microbiology Karen Lloyd.

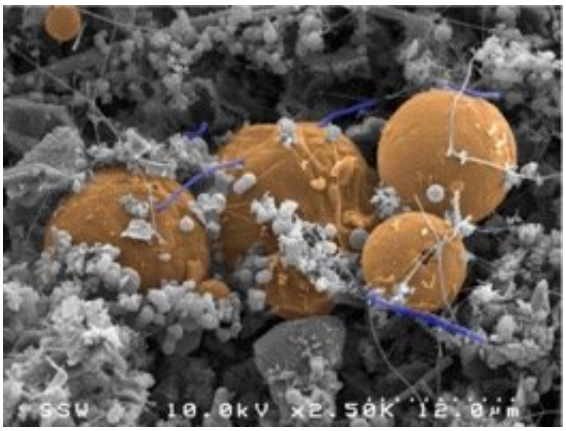
Carbon is the most prevalent element in living beings because it is part of almost all the molecules that are key for biological processes, including proteins, fats, and even DNA. Ninety percent of the earth's carbon is in the subsurface.

"Knowing about how carbon is distributed and how living things use it is crucial for understanding not only life cycles but also our environment," said Lloyd.

The report, which took an international multidisciplinary team 10 years to complete, also sheds light on other aspects of the incredible world of microbial dark matter.

For the research, scientists at hundreds of sites around the world drilled to a depth of 2.5 kilometers into the sea floor. They also took samples from continental mines and boreholes more than 5 kilometers deep into the earth.

In the samples from this deep biosphere, researchers identified members of all three domains of life: bacteria, archaea (microbes without a membrane nucleus), and eukarya (multicellular organisms that contain a nucleus—for example, humans).



Candidatus Desulforudis audaxviator (the purplish, blue rod-shaped cells straddling orange carbon spheres) is a species of bacteria that survives on H2 from radiolysis of water and sulfate derived from oxidation of pyrite by radolytically produced O2 and H2O2, and fixes CO2 and N2. Scientists originally found Ca. Desulforudis living within a fluid and gas-filled fracture 2.8 km beneath Earth's surface at Mponeng Gold Mine near Johannesburg, South Africa. Surprisingly, scientists found no other organisms in their samples, making this deep ecosystem the first found on Earth with only one species. The genus name Desulforudis comes from the Latin for "from sulfur" and "rod," noting its shape and its ability to get energy from sulfates. And audaxviator? From Jules Verne's Journey to the Center of the Earth, and a message in Latin deciphered by Verne's protagonist, Professor Lidenbrock, which read in part: "descend, bold traveler, and attain the center of the Earth." Credit: Greg Wanger (California Institute of Technology, USA) and Gordon Southam (The University of Queensland, Australia)

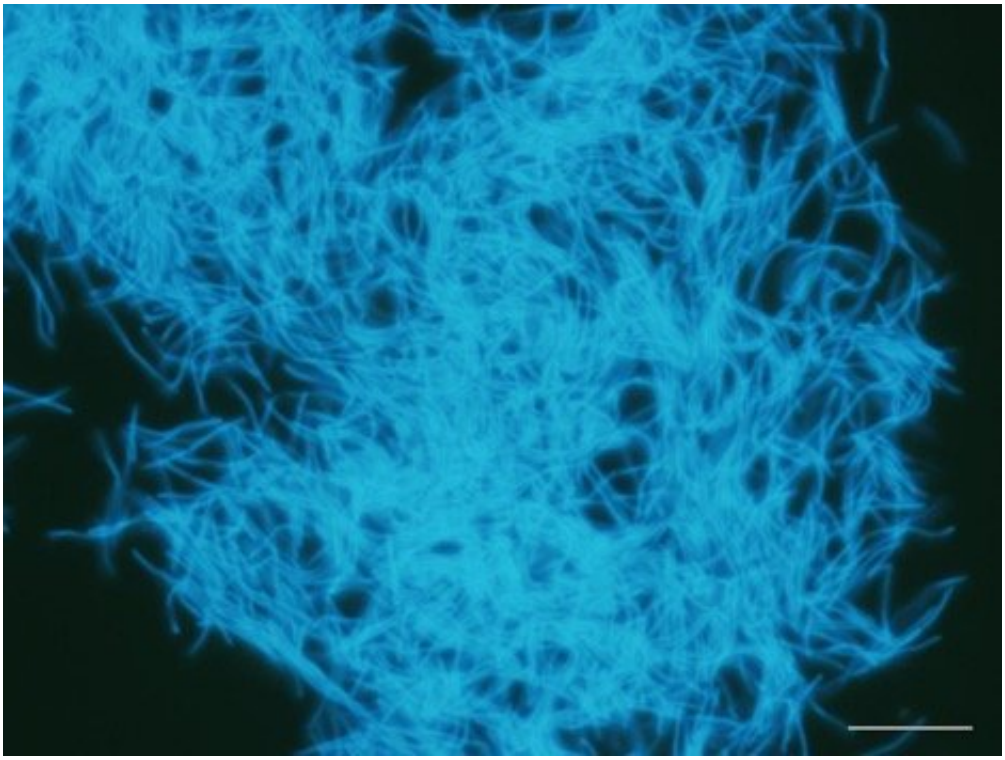
"Ten years ago, we knew far less about the physiologies of the bacteria and microbes that dominate the subsurface biosphere," said Lloyd. "Today we know that, in many places, they invest most of their energy into simply maintaining their existence and little into growth, which is a fascinating way to live."

The report includes several other striking findings:

- 70 percent of all earth's bacteria live underground. This realization dramatically expands the visualization of the tree of life, a biological analogy first proposed in Charles Darwin's On the Origin of Species to explain the relationship between living and extinct organisms.
- The deep biosphere—the zone of life underneath earth's surface—has a volume of between 2 and 2.3 billion cubic kilometers. This is almost as twice the volume of all oceans.

Since climate change is linked to carbon emissions, understanding how these microorganisms interact with carbon could help scientists produce mitigation strategies against climate change with additional time and research, Lloyd said.

"Some of these underground organisms emit carbon and some others sequester it and turn it into rock, for example. But we don't know any of that yet. We have a lot to discover," said Lloyd.



This is a species of Methanobacterium, which produces methane. Found in samples from a buried coal bed 2 km below the Pacific Ocean floor off the coast of Japan, this specimen was retrieved during an Integrated Ocean Drilling Program (now the International Ocean Discovery Program) expedition in 2012 aboard the Drilling Vessel Chikyu. Bar represents 10 μm. Credit: Hiroyuki Imachi (Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Japan).