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# 'Dead' DNA feeds deep sea life


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Ten years of data collected by Italian researchers suggest that approximately 65% of DNA present in the world's oceans is found in deep-sea sediments, and 90% of that DNA is extracellular. This suggests the deep, extracellular organic material provides a major contribution to the cycling of phosphorus, the authors report in last week's*Science.*

The researchers propose that the main source of DNA originates from dead cells in the surface layers of the oceans, and pelagic-benthic coupling processes control the extracellular DNA distribution in world ocean sediments. In other words, phytoplankton, cyanobacteria, and other dead organisms, free or attached to aggregates -- the so-called marine snow -- travel through the water column to the deep-sea bed, where their DNA is deposited.

"Our study shows that the concentration of DNA in deep-sea sediments worldwide is extremely high," study co-author Roberto Danovaro of the Marine Science Institute of the University of Ancona in Italy told *The Scientist*. "This makes DNA a key molecule once it is dead, as well." Danovaro suggested that researchers consider DNA as a "multifunctional molecule," acting as a reservoir of prokaryotic carbon, nitrogen and phosphorus, all vital to other organisms. The P cycle takes place on the bottom of the oceans, where new nucleic acids are generated from degraded DNA.

Although DNA is a phosphate-rich molecule, it's been unclear what role genetic material plays in the P cycle. For decades, scientists measured living biomass, and detected more DNA than expected in all ecosystems. In order to look closer at the deep-sea environment, Danovaro and his colleague Antonio Dell'Anno spent 10 years collecting samples from the abyss in all oceans and seas, confirming that extracellular DNA is always a major ingredient.

To make sure the DNA was truly extracellular, the researchers measured the difference between the total DNA and the DNA within living microorganisms. They confirmed the results by testing samples with an enzyme that degrades only extracellular DNA, and found that approximately 65% of the material was digested.

Moreover, the researchers found that this extracellular DNA may contribute to P cycling, by sustaining 50% of the microbial life in the abyss. The DNA is selectively mineralized within the organic P pool and rapidly degraded. "The abyss, hosting about $10^{29}$ bacteria (more than the stars in our universe) constitutes the biggest biomass in the planet. And the abyss microbial community, in turn, ensures the stable functioning of ecosystems," Danovaro said.

Jack Middelburg, at the Centre for Estuarine and Marine Ecology in Yerseke, The Netherlands, told *The Scientist* that this is a "novel finding," and no research has "systematically" addressed the role of DNA in P-cycling. "Our understanding of oceanic P-cycling is very limited and the authors have elucidated an important, and so far unrecognized, part of the puzzle."

"The paper by Danovaro is extremely interesting and exciting," Carol Turley at Plymouth Marine Laboratory, in Plymouth, UK, told *The Scientist.* However she raises doubts about the proposed source of the extracellular DNA. The DNA could also originate from lysed organisms that live in the deep sea, she suggested, noting that, when food resources are low, dying cells could release their DNA, which fuels the growth of other bacteria. "This would be a very efficient way of living in a food-limited environment," she noted. Alternatively, the DNA could stem from cells attached to aggregates that have travelled through the water column to the deep sea, and the high pressure and low temperature could cause them to die, "releasing their DNA to supply the P for the growth of their sister bacteria on the sea bed," Turley added.

"There is certainly also another fraction of dead DNA "produced" by deep-sea organisms, but is likely much less relevant" Danovaro added. "We also suspect that a large fraction of this DNA (possibly most of it) is eukaryotic, i.e., not originated by bacteria or cyanobacteria." If the hypothesis is confirmed in future studies, there will be a new "loop of life" determined by the cooperation between prokaryotes and eukaryotes, Danovaro noted. "Prokaryotes are known to decompose organic matter and regenerate nutrients available for phytoplankton – eukaryote – growth, and in turn the dead eukaryotic DNA feed the deep-ocean microbial life."

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