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News

Virus-like particles speed bacterial evolution

The exchange of genetic information among ocean bacteria has been greatly underestimated.

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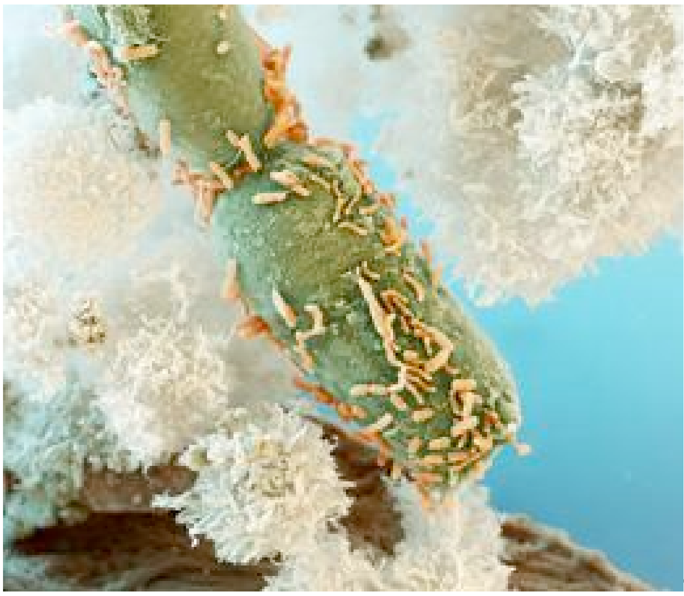


Genes are shuttled between ocean bacteria many times faster than was previously thought.EYE OF SCIENCE / SCIENCE PHOTO LIBRARY

In the ocean, genes can hop between bacteria with unexpected ease, thanks to strange virus-like particles that shuttle genes from one species to another[1]. These particles, called gene-transfer agents (GTAs), insert DNA into bacterial genomes so frequently that gene transfer in the ocean may occur 1,000 to 100 million times more often than previously thought. This suggests that GTAs have had a powerful role in evolution.

"We know there's a lot of gene shuffling going on in bacteria, but nobody had come up with a good mechanism by which it happens," says John Paul, a marine microbiologist at the University of South Florida College of Marine Science in St Petersburg, and an author on the study that finally succeeded in uncovering a mechanism.

GTAs, which harbour bits of their host's genome inside a protein coat, reside in bacterial genomes. When they exit, they take some of their host's genes with them. For 30 years, they have remained obscure objects of occasional study in the lab.

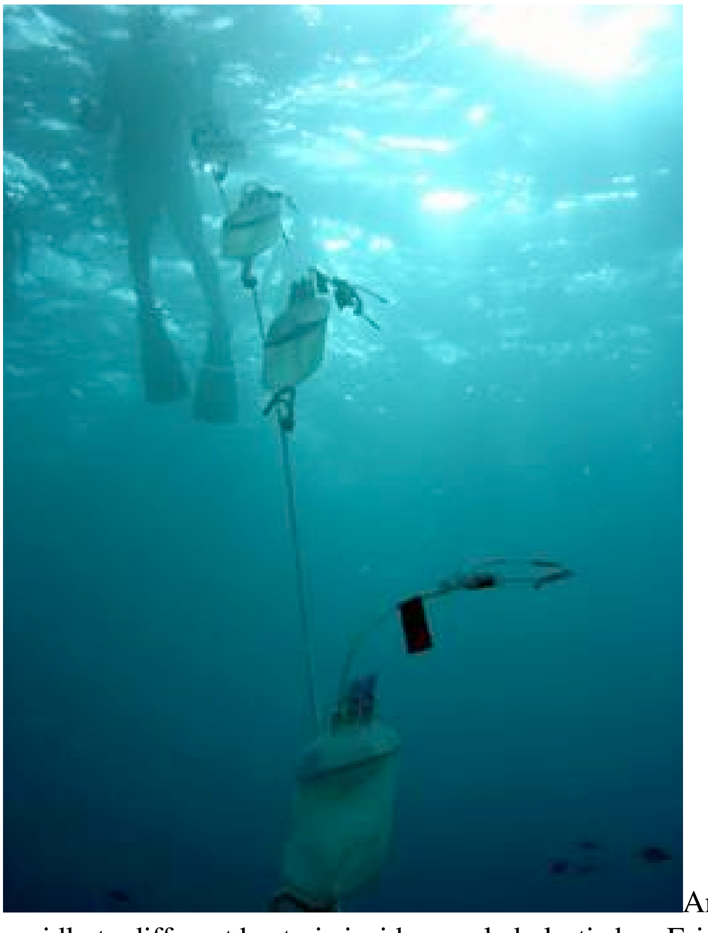
“They're promiscuous little bastards.”

Paul's team engineered GTAs to contain a gene conferring antibiotic resistance. The researchers sealed these GTAs in bags filled with seawater collected from different coastal environments, and floated the bags in the ocean to mimic natural conditions as closely as possible. After incubation overnight, up to 47% of the bacteria living in the seawater-filled bags had incorporated the particles and their genetic contents into their genomes. The work is published today in Science[1].

"They're promiscuous little bastards," says Paul, pointing out that that the GTAs infected many different strains of ocean bacteria.

Ocean oddballs

"GTAs are very peculiar," says Eugene Koonin, an evolutionary biologist at the National Institutes of Health in Bethesda, Maryland. "Their only function seems to be transferring genes."



An antibiotic-resistance gene spread rapidly to different bacteria inside a sealed plastic bag.Erich Bartels

Last year, Koonin and his colleagues examined genomic analyses of marine viruses and predicted GTAs to be major contributors to gene transfer in the ocean[2]. He says that the current paper confirms his prediction by finding frequent GTA-mediated gene-transfer events in a marine microbial community.

Horizontal gene transfer — whereby genes are shuffled between organisms rather than passed down from parent to offspring — helps to explain how bacteria adapt rapidly to changing environments and can quickly acquire resistance to antibiotics. If one bacterium has a beneficial gene, that gene can spread horizontally to other bacteria in the population, increasing its frequency by improving the survival of those that carry it.

Horizontal gene transfer can also occur through direct cell–cell contact or by means of mobile genetic elements called plasmids, or by bacterial viruses — which often destroy the host upon departure. GTAs are virus-like, but they don't seem to take a toll on their host and, what's more, seem to efficiently shuttle genes between unrelated bacteria.

The team found exact copies of the antibiotic-resistance gene that the GTAs carried — a very unlikely finding had horizontal gene transfer occurred by another means. "We were absolutely amazed to see exact matches for the genes we put into the donor strain in different genera that are common in the marine environment," says co-author Lauren McDaniel, also at the University of South Florida College of Marine Science.

The authors chose to insert genes for resistance to the commonly-used lab antibiotic kanamycin for pragmatic reasons — its resistance can be easily detected by treating bacteria with the drug and seeing which ones survive — but Paul says there's no reason why GTAs wouldn't play a part in spreading clinically relevant types of antibiotic resistance.

Meanwhile, evolutionary biologist Jeffrey Townsend at Yale University in New Haven, Connecticut, says that this work stands out from other studies on this topic because the team measured the frequency of gene transfer in nature rather than inferring it through genetic analyses.

"People have had trouble tracking this down before, so this is a very important observation," he says. "In order to understand antibiotic resistance, pathogenicity, or the beneficial things that bacteria do for us, we need to understand how they evolve through horizontal gene transfer — knowing about this process can help us live in a world full of microbes."

- ## References

1. McDaniel, L. D. *et al*. Science 330, 50 (2010). | Article | OpenURL | | ChemPort |
2. Kristensen, D. M., Mushegian, A. R., Dolja, V. V. & Koonin, E. V. Trends Microbiol. 18, 11-19 (2010).