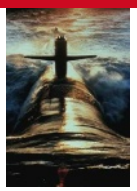

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'Virophage' suggests viruses are alive

The discovery of a giant virus that falls ill through infection by another virus[1] is fuelling the debate about whether viruses are alive.

"There's no doubt this is a living organism," says Jean-Michel Claverie, a virologist at the the CNRS UPR laboratories in Marseilles, part of France's basic-research agency. "The fact that it can get sick makes it more alive."

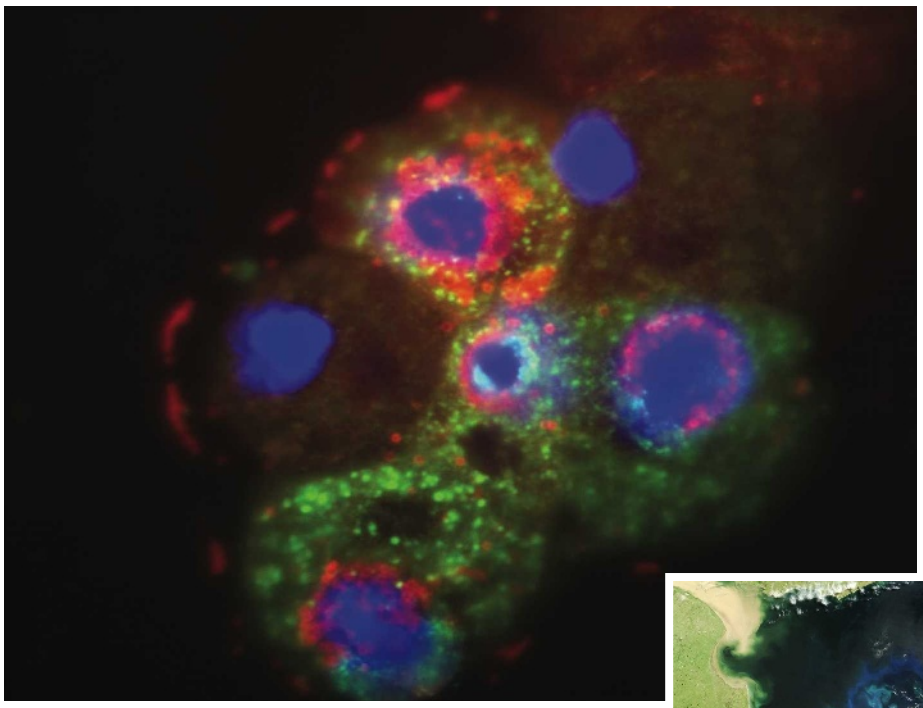
Giant viruses have been captivating virologists since 2003, when a team led by Claverie and Didier Raoult at CNRS UMR, also in Marseilles, reported the discovery of the first monster[2]. The virus had been isolated more than a decade earlier in amoebae from a cooling tower in Bradford, UK, but was initially mistaken for a bacterium because of its size, and was relegated to the freezer.

Closer inspection showed the microbe to be a huge virus with, as later work revealed, a genome harbouring more than 900 protein-coding genes[3] — at least three times more than that of the biggest previously known viruses and bigger than that of some bacteria. It was named *Acanthamoeba polyphaga* mimivirus (for mimicking microbe), and is thought to be part of a much larger family. "It was the cause of great excitement in virology," says Eugene Koonin at the National Center for Biotechnology Information in Bethesda, Maryland. "It crossed the imaginary boundary between viruses and cellular organisms."

Now Raoult, Koonin and their colleagues report the isolation of a new strain of giant virus from a cooling tower in Paris, which they have named mamavirus because it seemed slightly larger than mimivirus. Their electron microscopy studies also revealed a second, small virus closely associated with mamavirus that has earned the name Sputnik, after the first man-made satellite.

With just 21 genes, Sputnik is tiny compared with its mama — but insidious. When the giant mamavirus infects an amoeba, it uses its large array of genes to build a 'viral factory', a hub where new viral particles are made. Sputnik infects this viral factory and seems to hijack its machinery in order to replicate. The team found that cells co-infected with Sputnik produce fewer and often deformed mamavirus particles, making the virus less infective. This suggests that Sputnik is effectively a viral parasite that sickens its host — seemingly the first such example.

The team suggests that Sputnik is a 'virophage', much like the bacteriophage viruses that infect and sicken bacteria. "It infects this factory like a phage infects a bacterium," Koonin says. "It's doing what every parasite can — exploiting its host for its own replication."



REF. 1

J. SCHMALTZ/NASA

Giant mamavirus particles (red) and satellite viruses of mamavirus called Sputnik (green). Virophages may be common in plankton blooms (inset).

Sputnik's genome reveals further insight into its biology. Although 13 of its genes show little similarity to any other known genes, three are closely related to mimivirus and mamavirus genes, perhaps cannibalized by the tiny virus as it packaged up particles sometime in its history. This suggests that the satellite virus could perform horizontal gene transfer between viruses — paralleling the way that bacteriophages ferry genes between bacteria.

"There's no doubt that this is a living organism. The fact that it can get sick makes it more alive."

The findings may have global implications, according to some virologists. A metagenomic study of ocean water[4] has revealed an abundance of genetic sequences closely related to giant viruses, leading to a suspicion that they are a common parasite of plankton. These viruses had been missed for many years, Claverie says, because the filters used to remove bacteria screened out giant viruses as well. Raoult's team also found genes related to Sputnik's in an ocean-sampling data set, so this could be the first of a new, common family of viruses. "It suggests there are other representatives of this viral family out there in the environment," Koonin says.

By regulating the growth and death of plankton, giant viruses — and satellite viruses such as Sputnik — could be having major effects on ocean nutrient cycles and climate. "These viruses could be major players in global systems," says Curtis Suttle, an expert in marine viruses at the University of British Columbia in Vancouver.

"I think ultimately we will find a huge number of novel viruses in the ocean and other places," Suttle says — 70% of viral genes identified in ocean surveys have never been seen before. "It emphasizes how little is known about these organisms — and I use that term deliberately." ■

Helen Pearson

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3. Raoult, D. *et al. Science* **306,** 1344–1350 (2004).
4. Monier, A., Claverie, J.-M. & Ogata, H. *Genome Biol.* **9,** R106 (2008).