Giant virus discovery sparks debate over tree of life

The Klosneuviruses contradict the theory that viruses make up a distinct domain of life, but not everyone is convinced.

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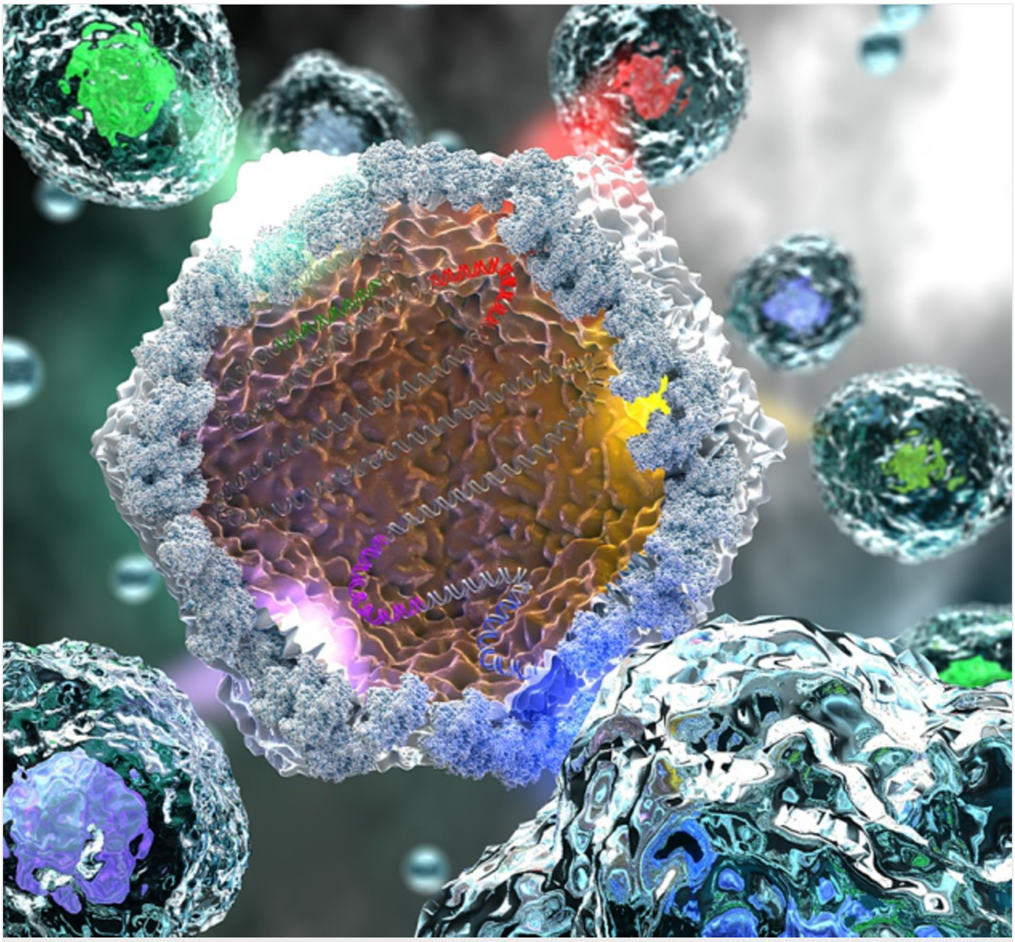

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An illustration of what a Klosneuvirus might look like.

Evolutionary biologists have never known what to make of viruses, arguing over their origins for decades. But a newly discovered group of giant viruses, called Klosneuviruses, could be a 'missing link' that helps to settle the debate — or provoke even more discord.

In 2003, researchers reported that they had found giant viruses, which they named Mimiviruses, with genes that suggested their ancestors could live outside of a host cell[1]. The discovery split researchers into two camps. One group thinks viruses started out as self-sufficient organisms that became trapped inside other cells, eventually becoming parasitic and jettisoning genes they no longer needed. Another group views viruses as particles that snatched genetic material from host organisms over hundreds of millions of years.

A study[2] published on 6 April in *Science* provides evidence for the latter idea, that viruses are made up of a patchwork of stolen parts. But it has already sparked controversy and is unlikely to settle the raucous debate.

After the Mimivirus discovery, some researchers developed a theory that put viruses near the root of the evolutionary tree. They proposed that viruses comprised a 'fourth domain' alongside bacteria, eukaryotes — organisms whose cells contain internal structures such as nuclei — and bacteria-sized organisms called archaea.

Mimiviruses, which at 400 nanometres across are about half the width of an *E. coli* cell and can be seen under a microscope, were unique in that they contain DNA encoding the molecules that translate RNA messages into proteins. Normal viruses make their host cells produce proteins for them.

The team that discovered Mimiviruses thought the virus' ability to make their own proteins suggested that these viral giants descended from ancient free-living cell type that may no longer exist[2]. "They reinitiated the debate about the living nature of viruses, and of their relationship with the 'cellular' world," says evolutionary biologist Jean-Michel Claverie of Aix-Marseille University in France, a co-author of the original Mimivirus paper.

Filling in the gaps

The question could be resolved by comparing genome sequences from viruses with those of their eukaryotic hosts. Mimiviruses contain too few eukaryotic-like genes to perform a statistical analysis that could determine their evolutionary relationships. The difficulty is compounded by the fact that viral genomes mutate very quickly.

Klosneuviruses may fill this gap. Their genomes contain code for dozens of enzymes and other molecular machinery used in making proteins. Some of these parts have never been seen before in any virus, including Mimiviruses. "They're kind of this missing link we haven't had before," says study co-author Tanja Woyke, a microbiologist at the Joint Genome Institute in Walnut Creek, California.

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One hypothesis on the origins of viruses says that they picked up parts of their genomes from eukaryotic cells.

Credit: Carla Schaffer/AAAS

Woyke and her colleagues discovered the Klosneuviruses by accident while studying how bacteria break down sewage at a treatment plant in Austria. They sequenced the genomes in their samples to identify the organisms present, and found four genomes similar to those of

Mimiviruses.

Using sophisticated software to trace the evolutionary history of their mystery genomes, the researchers found that the translation genes seemed to have been picked up one by one over hundreds of millions of years. This evidence supports the idea that viruses stole parts of their genomes, they say. It's possible, however, that Mimiviruses and Klosneuviruses originated in different ways, making both ideas on viral origins possible, says Frederik Schulz, a bioinformatician at the Joint Genome Institute and a co-author on the new study.

Debating domains

It’s unclear which eukaryotic organisms donated their genes to the Klosneuvirus group. And because they haven't identified the host, the researchers can't grow the virus yet. The viruses do not seem to infect the same type of amoeba as Mimivirus and other known giant viruses.

Claverie points out that the majority of the Klosneuviruses’ translation machinery does not match that of any other known organism. And he worries that the computational model used to infer the viruses’ ancestry could pick up leftover pieces of DNA in the sample, potentially contaminating the data. “I am waiting to see a real virus isolated with its host in a tube, before I would believe any of their evolutionary interpretations,” he says.

David Moreira, an evolutionary biologist at the University of Paris South, doesn’t think that’s necessary. He says that plenty of evolutionary work can be done on a genome alone, and he is glad to see more papers coming to the conclusion that viruses are not a fourth domain of life.

Mimivirus co-discover Didier Raoult, a microbiologist at Aix-Marseille University, says this latest discovery won’t settle the debate, but it’s a nice find nevertheless. “We’re finding a part of the world that has been completely ignored and need to be patient.”

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References

1. La Scola, B. *et al*. *Science* **299**, 2033 (2003).
2. Schulz, F. *et al*. *Science* **356**, 82–85 (2017).

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