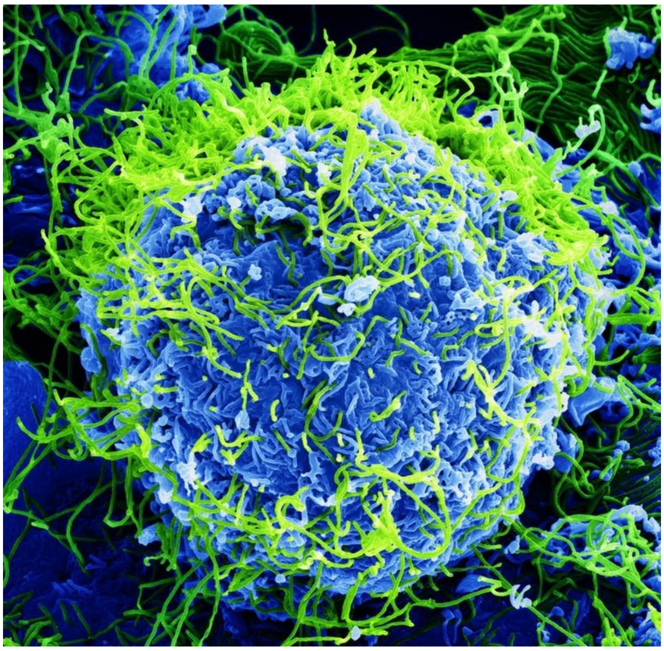
Viruses can cause global pandemics, but where did the first virus come from?

29 May 2018, by Arinjay Banerjee, Karen Mossman And Vikram Misra



A colourized scanning electron micrograph magnified 20,000 times of Ebola virus particles (green) from a chronically infected African Green Monkey kidney cell (blue). Credit: BernbaumJG/Wikimedia Commons

Viruses such as Ebola, influenza and Zika make headlines. They grab our attention with their potential to cause widespread disease and death.

But where did these viruses first come from?

Unlike bacteria, viruses aren't living organisms —they can't reproduce on their own. Instead, they hijack cells to multiply, spread and cause disease.

But what if it wasn't always this way?

Scientists studying a so-called giant virus called a Tupanvirus (named for the South American Guarani God of Thunder) found that it, unlike the viruses we encounter today, had an almost complete machinery to take care of itself.

This recent discovery has refuelled the debate over the origin of viruses.

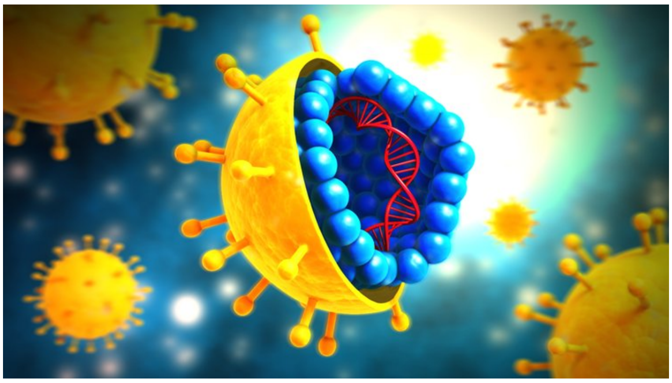
Frozen viruses

There is no physical fossil record of viruses like there is for the dinosaurs.

One way scientists detect viruses, and study their origins, is to look for their genetic material —molecules of DNA or RNA —in animal tissues and soil.

Even though the movies might have you believe otherwise, viral genetic material has never been detected in fossilized plant leaves or in insects trapped in amber.

However, some ancient viruses have been detected in permafrost in Siberia, and there are hopes of discovering more as global warming continues to thaw ground that has been frozen for thousands of years. Until then, we remain limited in our ability to precisely reconstruct the origin of viruses.



An illustration of the hepatitis C virus. Credit: U.S. Centers for Disease Control and Prevention

Virus evolution

Viruses are microscopic organisms that require a living cell, often called a host, to multiply. They largely consist of genetic material (either DNA or RNA) wrapped in a protein coat.

These DNA and RNA sequences may change over time, accumulating modifications to the genetic code that favour the survival of the virus. Scientists can look at these genetic sequences to estimate how different viruses are related and how they may have evolved.

These studies have shown us that viruses do not have a single origin; that is, they did not all arise from one single virus that changed and evolved into all the viruses we know today. Viruses probably have a number of independent origins, almost certainly at different times.

One assumption scientists make when considering the origin of viruses is that each co-evolved with its host. For example, the herpes virus that infects humans evolves over time, adapting so that it will continue to retain the ability to infect human cells.

If we consider that all life forms on Earth began in the ocean, then it's reasonable to believe that viruses evolved with their hosts in the seas. As these creatures moved onto land and evolved, viruses also evolved and gained the ability to infect terrestrial organisms.

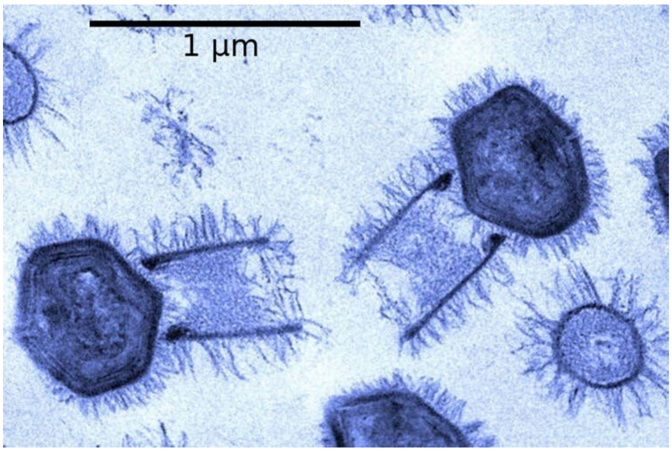
Earlier this year, scientists discovered evidence that some viruses may be millions of years old and have been in existence since the first vertebrates existed. But this doesn't explain the origin of viruses per se.

Origin stories

One theory hypothesizes that viruses arose from circular DNA (also called a plasmid) that can replicate independently and move between cells, transferring genetic information from one organism to another. For example, some plasmids carry the genes responsible for antibiotic drug resistance.

According to this theory, the plasmid escaped from cells and evolved in a way that allowed it to enter another cell to produce viruses.

Another theory suggests that viruses could have evolved from more complex free-living organisms, such as bacteria, or cells. A recent study showed that a protein called ARC that is important for memory in humans can form virus-like particles and transfer RNA between cells. Perhaps similar ancient proteins evolved to move from one organism to another.



The Tupanvirus is a giant virus that can infect protists and amoebas, but are no threat to humans.

And then there was that recent discovery of the giant Tupanvirus in a Brazilian soda lake. Lakes like this are very salty and have a high pH. They may mimic the conditions of aquatic environments on Earth billions of years ago.

Tupanvirus has a more complete set of protein-making machinery than any other known virus. Unlike other viruses, it's probably not as dependent on the cell it infects to replicate. This discovery has reignited interest in the theory that viruses arose from complex, free-living cells.

Which came first?

Both the theories above assume that cells existed before viruses, and that viruses potentially evolved in the presence of cells.

But there is yet another hypothesis that proposes that viruses existed first, even before cells. In a prehistoric world, viruses might have existed as self-sustaining entities, a sort of ancient machine that could probably reproduce its genetic material. Over time, these prehistoric viruses may have formed complex, organized structures that eventually evolved into cell-like entities.

For the time being, these are only theories. The technology and resources we have today cannot confidently test these theories and identify the most plausible explanation for the origin of viruses.

An alternative —yet seemingly impossible —strategy would be to isolate or identify viruses in their primitive forms on other planets such as Mars. Staying on Earth seems like a more plausible approach.

The ongoing discovery of new viruses, like Tupanvirus or a 30,000-year-old relative of giant DNA viruses (Pithovirus), may allow us to piece together the puzzle of their origins.

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