# Mass Extinctions, Ancient Viruses May Hold Clues to Life's Origins

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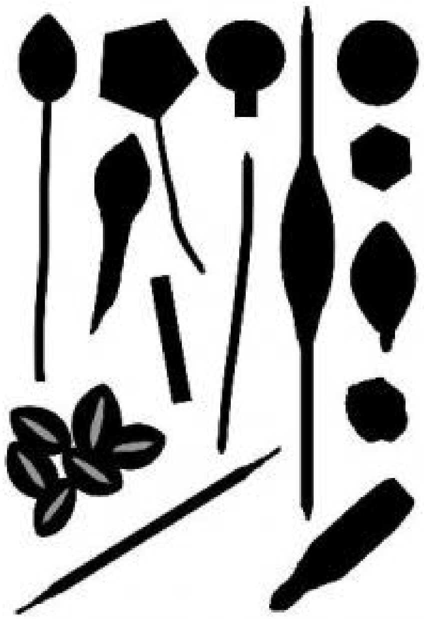

Crenarchaeal viruses come in diverse morphologies, as shown by these silhouettes. According to a new model, because these viruses live in hot, acidic environments, they may have been immune to the mass extinctions throughout Earth's history, which explains why they have almost nothing in common with today's more modern organisms. Image credit: Jalasvuori and Bamford.

(PhysOrg.com) -- Mass extinctions occur repeatedly, though irregularly, throughout Earth's history, and occasionally these extinctions have been devastating to life on our planet - or have they? Extinction events have sometimes accelerated the evolution of life on earth by eliminating old dominating species and making room for new ones. A new study takes this idea a step further, showing that life may have never achieved the complexity necessary for the development of advanced multi-cellular organisms without recurring extinction events.

In their study, Matti Jalasvuori and Jaana K.H. Bamford of the University of Jyväskylä in Jyväskylä, Finland, have developed a model that helps to explain how life evolved from its origins to the complex cellular systems we see today. Their model is based on a type of virus in the archaeal kingdom called Crenarchaeota, which thrives in extremely hot, acidic environments like those found on the bottom of the ocean, where the viruses infiltrate hosts called acidophilic hyperthermophiles. Because crenarchaeal viruses share almost no similarities with other viruses or organisms, they likely originated very early in Earth's history.

"On a personal note, I find it exciting to think that very early life on Earth might have had a wide variety of peculiar viruses," Jalasvuori told *PhysOrg.com*. "We may ask whether their presence is a natural consequence of the processes that led to the origin of the first cells."

In addition to having few similarities with other organisms, crenarchaeal viruses are unexpectedly diverse among themselves, as well. Their diverse morphologies include spheres, light bulbs, bottles, tulips, polyhedrons with tails, and more. In an attempt to explain the origins of these differences, Jalasvuori and Bamford propose that mass extinctions caused by meteorites and volcanoes might have wiped out many cellular organisms, but the hyperthermophiles at the bottom of the ocean would have survived, along with their parasitic viruses.

As the scientists explain, both meteorite impacts and volcanic eruptions can warm the Earth. Meteorites boil the oceans and heat the atmosphere, as well as vaporize sulfoxides in rocks upon impact, leading to poisonous acidic rain. Similarly, volcanism in the form of flood basalts increases carbon dioxide levels, causing atmospheric warming and acid rain. While meteorites and volcanoes are considered the two main causes of extinctions, the "snowball Earth" scenario, in which Earth is covered in ice, may have been another extinction mechanism.

While these events may have led to the extinction of the majority of bacterial and archaeal cells living in cool and neutral-pH environments, the naturally acidic and geothermally heated environments of the crenarchaeal viruses and their hosts would not have been greatly affected. The hyperthermophiles are already used to hot acidic conditions, and geothermal heat would protect them from snowball Earth conditions. The scientists propose, then, that crenarchaeal viruses have simply maintained their originally diverse morphologies, whereas viruses of non-hyperthermophile hosts (including other crenarchaeal viruses) have not. In this view, crenarchaeal viruses in geothermally heated areas would have formed from the primordial gene pool.

As previous research has shown, the battle between viruses and the cells they try to infect is thought to be a major force in driving evolution. Under pressure from viruses, cells continually develop mutations to avoid infections, but these mutations usually aren't useful in other ways (except coincidentally).

However, as the new model shows, when an extinction event occurs that kills off many of the cells in an environment, the number of viruses also decreases for lack of hosts. The viruses' main weapon is having a variety of host recognition proteins (HRPs) that know which cells to attack. But fewer viruses means fewer HRPs, so that surviving cells that are immune to the few remaining viruses now have a chance to evolve in an environment free of virus interference. Under virus-free conditions, cells can inherit mutations that are likely to be more useful in the long run, rather than simply defensive strategies. In this way, extinction events speed up the development of new biological functions that might otherwise be unlikely to emerge. Without extinction events, viruses might control all of Earth's evolution.

"I find the idea that viruses face extinctions along with their hosts important," said Jalasvuori. "It is widely believed that viruses, in a sense, control the evolution of their hosts and kill the evolutionary winners. Therefore, right after extinction level events, such as massive meteorite impacts, there would be very few viruses to bring the success-story of the winner to an end. Some of the novel evolutionary innovations observed today might have emerged for the first time in the genomes of these winners."

Nevertheless, the hot, acidic environments in which ancient species live is not necessarily a hindrance to evolution, and may in fact be essential to life's origins. Without such regions, emerging life might not have survived meteorite bombardments and volcanic eruptions that repeatedly wipe out species "farther from the nest." Yet, as Jalasvuori and Bamford note, their proposal is only a model, and more research is required to see how well the model fits with data and laboratory studies. Overall, the study shows that the diversity of crenarchaeal viruses in geothermally heated areas requires further attention, since the details could help scientists better understand the origins of life.

"We have experiments taking place within laboratory microcosmoses, in which we attempt to determine the impact of viruses on the evolution of different aspects of their hosts," said Jalasvuori. "These cosmoses give us the control over the factors that could have an effect on the evolution of the hosts and thus we should be able to see more precisely the adaptive traits that are caused by viruses and those that are not."

More information: Jalasvuori, Matti and Bamford, Jaana K.H. "Did the Ancient Crenarchael Viruses from the Dawn of Life Survive Exceptionally Well the Eons of Meteorite Bombardment?" *Astrobiology*, Volume 9, Number 1, 2009. © Mary Ann Liebert, Inc. DOI: 10.1089/ast.2007.0189.