Geographic isolation drives the evolution of a hot springs microbe

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Sulfolobus islandicus, a microbe that can live in boiling acid, is offering up its secrets to researchers hardy enough to capture it from the volcanic hot springs where it thrives. In a new study, researchers report that populations of *S. islandicus* are more diverse than previously thought, and that their diversity is driven largely by geographic isolation.

The findings open a new window on microbial evolution, demonstrating for the first time that geography can trump other factors that influence the makeup of genes an organism hosts.

S. islandicus belongs to the archaea, a group of single-celled organisms that live in a variety of habitats including some of the most forbidding environments on the planet. Once lumped together with bacteria, archaea are now classified as a separate domain of life.

"Archaea are really different from bacteria - as different from bacteria as we are," said University of Illinois microbiology professor Rachel Whitaker, who led the study.

Whitaker has spent almost a decade studying the genetic characteristics of *S. islandicus*. The new study, in the Proceedings of the National Academy of Sciences, compares three populations of *S. islandicus*, from hot springs in Yellowstone National Park, Lassen National Park in California and the Mutnovsky Volcano on the Kamchatka Peninsula, in eastern Russia.

The extreme physical needs of *S. islandicus* make it an ideal organism for studying the impact of geographic isolation. It can live only at temperatures that approach the boiling point of water and in an environment that has the pH of battery acid. It breathes oxygen, eats volcanic gases and expels sulfuric acid. It is unlikely that it can survive even a short distance from the hot springs where it is found.

By comparing the genetic characteristics of individuals from each of the three locations, Whitaker and her colleagues were able to see how each of the *S. islandicus* populations had evolved since they were isolated from one another more than 900,000 years ago.

The complete genetic package, or genome, of *S. islandicus* contains a set of core genes that are shared among all members of this group, with some minor differences in the sequence of nucleotides that spell out individual genes. But it also contains a variable genome, with groups of genes that differ - sometimes dramatically - from one subset, or strain, to another.

Whitaker's team found that the variable genome in individual strains of *S. islandicus* is evolving at a rapid rate, with high levels of variation even between two or three individuals in the same location.

"Some people think that these variable genes are the way that microbes are adapting to new environments," Whitaker said. "You land in a new place, you need a new function in that new place, you pick up that set of genes from whoever's there or we don't know who from, and now you can survive there. We have shown that does not occur."

"This tells you that there's a lot more diversity than we thought," Whitaker said. "Each hot spring region has its own genome and its own genome components and is evolving in its own unique way. And if each place is evolving in its own unique way, then each one is different and there's this amazing diversity. I mean, beetles are nothing compared to the diversity of microbes."

Archaea, like bacteria, can transfer genes to one another, but they also obtain new genes from free-floating genetic elements, called plasmids, or from viruses that infect the cells and insert their own genes into the archaeal DNA. What did vary in the genomes of *S. islandicus* could be traced back to plasmids and viruses, Whitaker said. There were also a lot of lost genes, with much variation in the genes lost between the strains.

"Most of the genes that are coming and going, at least on Sulfolobus, seem to be on viruses and plasmids," Whitaker said. The researchers found that about one-third of the variable genes were specific to a geographic location. The viruses and plasmids that had lent their genes to Sulfolobus in one site were different from those found in another. Also, much of the variation was found in genes devoted to the microbe's immune system, indicating that *S. islandicus* is evolving largely in response to the assault of local pathogens such as viruses.

These findings challenge the idea that microbes draw whatever they may need from a near-universal pool of available genetic material, Whitaker said. It appears instead that *S. islandicus*, at least, acquires new genes from a very limited genetic reservoir stored in viruses and other genetic elements that are constrained to each geographic location on Earth.

Source: University of Illinois at Urbana-Champaign (news : web)