Cicada study discovers two genomes that function as one

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A cicada. Credit: Juan Emilio Cucumides Carreño

Two is company, three is a crowd. But in the case of the cicada, that's a good thing.

Until a recent discovery by a University of Montana research lab, it was thought that cicadas had a symbiotic relationship with two important bacteria that live within the cells of its body. Since the insect eats a simple diet consisting solely of plant sap, it relies on these bacteria to produce the nutrients it needs for survival.

In exchange, those two bacteria, *Hodgkinia* and *Sulcia*, live comfortably inside the cicada. Since all three divvy up the nutritional roles, each member of the symbiosis is completely dependent on the others for survival.

So, where does this third-wheel bacterium come into play? That is exactly what UM microbiologist John McCutcheon and his team of colleagues stumbled upon once they started delving deeper into the genome sequence of the essential bacteria. Instead of two bacterial symbionts, they actually identified three. *Sulcia* was predictably still there, but they found two different kinds of *Hodgkinia*. What previously was thought to be a tripartite, or a three-way symbiosis, is now proven to actually be a four-way symbiosis.

Their work was published in the Aug. 28 issue of *Cell*, a prestigious scientific journal in an article titled "Sympatric speciation in a bacterial endosymbiont results in two genomes with the functionality of one."

The researchers discovered that *Hodgkinia* had subtly become more complex in what McCutcheon explained as a speciation event, in which the original lineage split to produce two separate but interdependent species of *Hodgkinia*.

"We just didn't expect it," McCutcheon said of this discovery. "I had thought my student made a mistake, but he proved me wrong."

It took a keen eye to identify what were actually two separate versions of the bacteria that were acting as one.

"When we looked at the genes, they were clearly closely related to each other," McCutcheon said. "If there was a broken gene in one version of *Hodgkinia*, it would be complete and functional on the other and visa-versa. So, the functional genes in each, when working together, seem to operate as one."

Because they only are complete when they operate as a team, they are reliant on each other just as the *Sulcia*, and ultimately the cicada, is reliant on their contributions to the symbiotic ecosystem.

"This is an obligate symbiosis – all of the organisms in there need each other," McCutcheon said. "We've shown that what was once a three-way symbiosis is now a four-way symbiosis."

This unexpected discovery piqued the interest of McCutcheon, who theorizes that this evolutionary development is a result of "slop and chance." However, this accidental evolution may answer some questions about how other organisms have evolved and become more sophisticated over time.

Hodgkinia's development closely parallels that of a path of some organelles. Essentially, organelles are to cells what an organ is to the human body. Mitochondria of our own cells are organelles, and like *Hodgkinia*, are derived from symbiotic bacteria.

In the case of the cicada, *Hodgkinia*'s speciation event added a new member to the symbiotic team but it did not add any new functionality to the symbiosis. McCutcheon writes in the paper that, "this process parallels what is observed in some organelles, where massive genome expansions result in little if any observable increase in function."

Understanding the development of organelles is fundamental to understanding the development of life. Because organelles arose such a long time ago, it's impossible to trace back to the specific events that allowed the organelle to become what it is today. By examining *Hodgkinia*'s evolution, researchers in McCutcheon's lab are hoping to gain insight into the storied pasts of organelles whose history has since been erased.

Provided by University of Montana