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How Did These Indestructible Pond Critters Get Their Genes?

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posted December 21, 2015 at 4:12 pm

The original Z151 lived in a pond in Lancashire, England. She spent her days the way most microscopic animals of her species do, munching on the pond's algae and using her eight translucent legs to shamble from one clump of pond scum to another, until November 13, 1987, when a fellow named Bob McNuff scooped her up as part of a water sample.

McNuff, the founder of a one-man biology supply company called Sciento, gave the original Z151 a new home, one full of algae to eat. Z151 became one of the first tardigrade specimens—also known as "water bears" or "moss piglets"—to thrive in a laboratory environment, and her descendants have survived every gauntlet scientists have thrown at them, from extreme cold to extreme heat. Their cousins have even survived the vacuum of space for ten days before being brought back to Earth.

In November a paper in the *Proceedings of the National Academy of Sciences* (PNAS) announced that McNuff's Z151 tardigrade strain, representing the species *Hypsibius dujardini*, has become the first tardigrade to have its genome sequenced. The University of North Carolina team behind the *PNAS* paper concluded that seventeen percent of the *H. dujardini* genome came from non-tardigrade sources, including hundreds of species of bacteria, which challenges the longstanding notion that animals only exchange genes within their own species. But then, just nine days later, a competing team from the University of Edinburgh, posted a preliminary paper on the preprint server BioRXiv discounting the find. They had also sequenced Z151 tardigrades and found a few bacterial genes but nowhere near the number UNC's paper describes. The Edinburgh concluded that many of the UNC team's bacterial genes came from contamination.

A cells keeps DNA wrapped up tight in its nucleus, so isolating the DNA for sequencing requires adding chemicals that break down the cell, sparing only short fragments of DNA. Those chemicals also break down the cells of any bacteria that happen to be around, and a lot of times, DNA pieces from the bacteria get mixed in with the animal's DNA.

When the UNC team first saw the bacterial genes, that was what they thought had happened. "Every genome project ends up sequencing more organisms than they really mean to because as you're sequencing an animal, you also catch the microbes that are on the surface and the microbes that are in the gut," said the lab's senior investigator Bob Goldstein. "So when we saw all these foreign genes, our first instinct was to throw them all out."

Instead, they inspected the data more closely. The UNC team's bacterial genes appeared to be spread throughout the tardigrade genome. Furthermore, some of the genes looked slightly different from the bacterial versions, suggesting that those genes had evolved to work well in animal cells.

Thomas Boothby, the paper's lead author and a post-doc at UNC, hypothesized that picking up bacterial genes may be a side effect of being indestructible. Tardigrades' famous resilience stems from their ability to shrivel themselves into tiny, dried-out kernels. Each can remain dormant in this form—called a "tun"—long enough to evade extreme temperatures and outlast fatal radiation. When they dry out their cells, their DNA becomes breakable, Boothby argues.

When conditions improve, the tardigrades open up the pores in their cell membranes extra-wide to let water back in. Sometimes loose fragments of DNA from bacteria and other organisms might fall in through the pores, Boothby says. Every once in a blue moon, a helpful bacterial gene might get stitched into a tardigrade chromosome and stay there for millions of years, the *PNAS* paper speculates.

However, the Edinburgh team and others who study invertebrate genomes think the UNC team may not have done enough to make sure that all of the bacterial genes are, in fact, integral parts of tardigrade chromosomes. A handful of the bacterial genes the UNC team found also turned up in the Edinburgh reconstruction of the tardigrade genome, but overall, the Edinburgh analysis showed that Z151 doesn't have any more bacterial genes than any other animal. "It is the extent that is at question," genomicist Julie Dunning Hottopp wrote in a blog post. "Reality may lie in the vast expanse between the two estimates."

Tardigrades' super-powers may have nothing to do with where their genes came from. Both teams concede that more work needs to be done to reach a definite conclusion, but the current consensus is that tardigrades probably aren't the inadvertent gene scavengers the *PNAS* paper describes. The UNC team's paper has 380 pages of supplementary details about methods and data; however, its critics think that wishful thinking may have skewed the UNC's interpretation of their data.

"That's not unusual in genome projects," said Jonathan Eisen, an evolutionary biologist who helped debunk a claim about bacterial gene transfer into the human genome in 2001. "People are working on an animal that they already think is cool, and they're putting a lot of time, energy, and effort into this genome."

"This isn't about killing someone's hypothesis," Eisen said. "This is how science is supposed to work…And tardigrades are cool whether they have bacterial genes or not!"