Lyme bacteria show that evolvability is evolvable

Natural selection favours those with a greater capacity to generate genetic variation.

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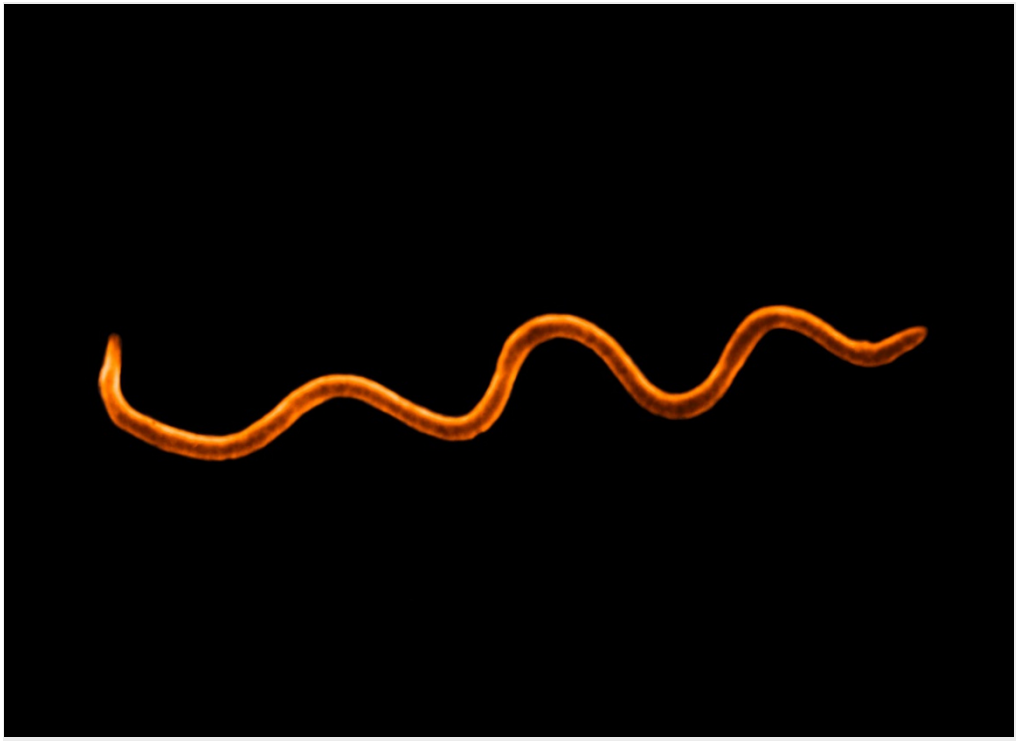

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Borrelia burgdorferi, the bacterium that causes Lyme disease, is skilled at evading the immune responses of its animal hosts.

Some gamblers succeed by spiriting cards up their sleeves, giving them a wider range of hands to play. So do some bacteria, whose great capacity for genetic variability helps them evolve and adapt to rapidly changing environments.

Now research on *Borrelia burgdorferi*, the bacterium that causes Lyme disease, shows that the capacity to evolve can itself be the target of natural selection. The results were published today in *PLoS Pathogens*[1].

“There are other data that suggest that there could be selection on evolvability, but this is the first example where there really aren’t any other confounding answers for the data,” says lead author Dustin Brisson, an evolutionary biologist at the University of Pennsylvania in Philadelphia.

B. burgfdorferi can cause a chronic infection even if its animal host mounts a strong immune response — evading those defences by tweaking the shape and expression of its main surface antigen, VlsE. A series of unexpressed genetic sequences organized into ‘cassettes’ recombine with the VlsE gene, changing the resulting protein such that it escapes detection by the host’s immune system.

“They make a clever case that the variation in these cassettes tells you something about evolvability and the results back up the idea,” says Tim Cooper, an evolutionary biologist at the University of Houston in Texas.

The researchers studied the molecular evolution of the cassettes’ genetic sequences in 12 strains of *B. burgdorferi*. They found that natural selection seemed to favour bacteria with more genetic variability within their cassettes, and hence a greater capacity to generate different versions of the antigen.

“Greater diversity among the cassettes in itself shouldn’t be a selective advantage considering they aren’t expressed and don’t do anything else,” says Brisson. “But we did find evidence of selection, so the question is what else could it be for besides evolvability?”

Brisson also examined samples of *B. burgdorferi* frozen in the 1990s by his co-author, Brian Stevenson, a Lyme disease researcher at the University of Kentucky in Lexington. Stevenson had collected the samples after experimentally infecting mice with once strain of the bacterium and re-isolating the organisms a year later to see how they evolved. When he and Brisson re-examined the samples, they found that changes to the genetic sequences of the silent cassettes were more common than changes in other parts of the genome.

“It makes a lot of sense that organisms should be predisposed to dealing with future environments, but when you get down to thinking about how this might come about, it’s not so obvious,” says Paul Rainey, an evolutionary geneticist at the New Zealand Institute for Advanced Study in Auckland and the Max Planck Institute for Evolutionary Biology in Plön, Germany. “These guys show quite clearly that natural selection can lead to the evolution of types that have a greater capacity to respond to future environments.”

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References

1. Graves, C. J., Ros, V. I. D., Stevenson, B., Sniegowski, P. D. & Brisson, D. *PLoS Pathog.* http://dx.doi.org/10.1371/journal.ppat.1003766 (2013).