The Black Queen Hypothesis: A new evolutionary theory

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WASHINGTON, DC -- March 27, 2012 -- Microorganisms can sometimes lose the ability to perform a function that appears to be necessary for their survival, and yet they still somehow manage to endure and multiply. How can this be? The authors of an opinion piece appearing in *mBio*®, the online open-access journal of the American Society for Microbiology, on March 27 explain their ideas about the matter. They say microbes that shed necessary functions are getting others to do the hard work for them, an adaptation that can encourage microorganisms to live in cooperative communities.

The Black Queen Hypothesis, as they call it, puts forth the idea that some of the needs of microorganisms can be met by other organisms, enabling microbes that rely on one another to live more efficiently by paring down the genes they have to carry around. In these cases, it would make evolutionary sense for a microbe to lose a burdensome gene for a function it doesn't have to perform for itself. The authors, Richard Lenski and J. Jeffrey Morris of Michigan State University, and Erik Zinser of the University of Tennessee, named the hypothesis for the queen of spades in the game Hearts, in which the usual strategy is to avoid taking this card.

"It's a sweeping hypothesis for how free-living microorganisms evolve to become dependent on each other," says Richard Losick of Harvard University, who edited the paper. "The heart of the hypothesis is that many genetic functions provide products that leak in and out of cells and hence become public goods," he says.

As an illustration of the hypothesis, the authors apply it to one particular microbial system that has been a source of some confusion: one of the most common plankton species in the open ocean, *Prochlorococcus*, which has a much smaller genome than you might expect. Scientists have wondered how *Prochlorococcus* has managed to be extremely successful while shedding important genes, including the gene for catalase-peroxidase, which allows it to neutralize hydrogen peroxide, a compound that can damage or even kill cells. *Prochlorococcus* relies on the other microorganisms around it to remove hydrogen peroxide from the environment, say the authors, allowing it to fob off its responsibilities on the unlucky card holders around it. This is an instance of how one species can profit from paring down while relying on other members of the community to help out.

Losick says the Black Queen Hypothesis offers a new way of looking at complicated, inter-dependent communities of microorganisms. "I have a special interest in how bacteria form biofilms, complex natural communities that often consist of many different kinds of bacteria. The Black Queen Hypothesis provides a valuable new way to think about how the members of these biofilm communities coevolved."

The article can be found online at http://mbio.asm.org/content/3/2/e00036-12

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