DAILY NEWS

Virus may aid photosynthesis

New study suggests phage genes may also help host bacteria

By Charles Choi

Marine viruses may use their own photosynthesis genes to enhance their fitness by temporarily boosting the energy production of bacteria they infect, scientists report this week in *Nature*. The advantages the viruses transfer to their hosts "may have helped enable these bacteria to become the dominant photosynthetic organisms in their habitats," co-author Debbie Lindell at the Massachusetts Institute of Technology at Cambridge told *The Scientist*. More research into how viruses could temporarily benefit a host's metabolism could shed light on their co-evolution, and what environmental factors most likely impact hosts in their habitats, she added.

Many viruses that infect cyanobacteria carry photosynthesis genes. Lindell and her colleagues at co-author Sallie Chisholm's lab noted that in podovirus P-SSP7, photosynthesis genes have overlapping start and stop codons and are transcribed along with essential phage capsid genes, suggesting they are integral parts of the viral genome. Indeed, when the researchers infected *Prochlorococcus* with the phage and inhibited photosynthesis with darkness or drugs, significantly less viral genome replication took place, demonstrating that the replication process depends on photosynthesis.

Cyanobacteria photosynthesis requires photosystem PSII. Both *Prochlorococcus* and the phage have high-light-inducible genes (*hli*) for proteins that protect photosynthetic machinery from light damage. They also carry the gene *psbA*, encoding the PSII core reaction center protein D1. This protein undergoes rapid turnover due to light-induced damage, and therefore requires continuous synthesis to sustain photosynthesis.

After *Prochlorococcus* was exposed to the virus, host *psbA* transcription dropped to roughly half of maximum levels within hours. Transcription of most of the host *hli* genes also declined significantly -- part of a general reduction in host transcription, as would be expected during an infection, the authors write. Still, background irradiance gradient single-turnover fluorometry showed that host PSII efficiency declined very little during infection, demonstrating photosynthesis was still continuing in the cell.

Reverse transcription polymerase chain reaction (RT-PCR) showed that, after exposure to the virus, phage *psbA* and *hli* mRNA levels steadily increased, making up half of all observed

psbA transcripts after seven to eight hours. Since the maximum level of infection the researchers achieved with this host-phage system is also 50 percent, they suggest that in infected *Prochlorococcus*, host *psbA* and *hli* transcription eventually stopped. And almost all *psbA* and *hli* transcripts detected after exposure to the virus were transcribed from the phage genome to supplement the otherwise weakened host's metabolism.

These are "clear and strong" findings, Luis Villarreal at the University of California at Irvine, who did not participate in this study, told *The Scientist*. He noted the virus the researchers used was a T7-like phage, and a recent report proposed a T7 viral-like DNA polymerase was involved in chloroplast evolution. This suggests viruses could have originated some genes involved in photosynthesis, in addition to carrying bacterial photosynthesis genes around between species, he said.

This "trick" the virus developed to gain "just another 2 to 3 hours of photosynthesis" shows "that survival in the ocean is not an easy task," Oded Beja at the Technion Israel Institute of Technology, also not a co-author, told *The Scientist* in an Email. He is currently researching whether viral genes expressed in cyanobacteria *Synechococcus* and *Synechosystis* can also boost host photosynthesis.

Lindell and her colleagues note organisms could conceivably use phage D1 for non-photosynthetic functions instead, such as obtaining manganese for viral metabolism. She hopes to isolate a *Prochlorococcus* PSII complex, and test directly whether it interacts with phage D1. Lindell also plans to see whether phages bearing deactivated photosynthesis genes fare poorly after infection, to confirm the genes help the virus.

Future research could explore how prevalent the photosynthesis genes are among cyanobacteria phages, and what other host-like genes phages might employ to boost their fitness, she offered. For instance, Lindell suggested phage genes might help hosts acquire phosphate.

Links for this article

D. Lindell et al, "Photosynthesis genes in marine viruses yield proteins during host infection," *Nature*, published online Oct. 12, 2005. http://www.nature.com

Debbie Lindell http://web.mit.edu/chisholm/www/people/debbie.html

CL Bishop, "Prochlorococcus plumbs the depths." *The Scientist*, Aug. 28, 2003. http://www.the-scientist.com/news/20030828/02

Sallie Chisholm http://web.mit.edu/chisholm/www/people/chisholm.html

P. Hunter, "Photosystems I and II in 3-D," *The Scientist*, July 14, 2003. http://www.the-scientist.com/2003/7/14/34/1

P. Hunter, "A new resolution for photosystem II," *The Scientist*, Feb. 16, 2004. http://www.the-scientist.com/2004/2/16/25/1

D. Lindell et al, "Transfer of photosynthesis genes to and from *Prochlorococcus* viruses," *PNAS*, July 27, 2004. [PubMed Abstract]

Luis Villarreal http://darwin.bio.uci.edu/~faculty/villarreal

J.U. Adams, "On the fringes of life," *The Scientist*, April 12, 2004. http://www.the-scientist.com/2004/04/12/25/1

J. Filee, P. Forterre, "Viral proteins functioning in organelles: a cryptic origin?" *Trends in Microbiology*, published online September 12, 2005. http://www.sciencedirect.com/science/journal/0966842X

Oded Beja http://biology.technion.ac.il/beja/index.html