

## Positive selection, not negative selection, in the pseudogenization of *rcsA* in *Yersinia pestis*

There are two types of natural selection in biological evolution: Positive (Darwinian) selection promotes the spread of beneficial alleles, and negative (or purifying) selection hinders the spread of deleterious alleles (1). Pseudogenization is normally detrimental and prevented by negative selection. However, changes in genetic background or environment may render a formerly useful gene worthless, leading to the relaxation of the negative selection. Consequently, mutations disrupting the gene are fixed by genetic drift, and the gene becomes a pseudogene. This is the common type of pseudogenization by neutral evolution. Sometimes, however, a previously useful gene may become harmful to an organism. In this case, mutations destroying the gene would be beneficial and would be fixed by positive selection. Thus, pseudogenization can be adaptive (2). Recently, Sun *et al.* (3) reported an excellent example of adaptive pseudogenization, convincingly demonstrating that gene loss can also serve as an “engine” of evolution (4). Nevertheless, instead of calling it “positive selec-

tion,” they mistakenly used “negative selection.” The case involves *Yersinia pestis*, the agent of bubonic plague that is frequently transmitted by fleas. The authors found that the *rcsA* gene of *Y. pestis* became a pseudogene in the last 20,000 years (3). Replacing the *rcsA* pseudogene with its functional version represses the formation of biofilms in fleas (3), which would reduce the transmission rate of the bacteria. That is, the pseudogenization of *rcsA* allowed the formation of *Y. pestis* biofilms, which enhances the transmission of the bacteria, and hence was likely driven by positive selection.

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1. Page R, Holmes E (1998) *Molecular Evolution: A Phylogenetic Approach* (Blackwell Science, Oxford).
2. Wang X, Grus WE, Zhang J (2006) Gene losses during human origins. *PLoS Biol* 4:e52.
3. Sun Y-C, Hinnebusch BJ, Darby C (2008) Experimental evidence for negative selection in the evolution of a *Yersinia pestis* pseudogene. *Proc Natl Acad Sci USA* 105:8097–8101.
4. Olson MV (1999) When less is more: Gene loss as an engine of evolutionary change. *Am J Hum Genet* 64:18–23.

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