Evolution of new genes captured

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(Phys.org)—Like job-seekers searching for a new position, living things sometimes have to pick up a new skill if they are going to succeed. Researchers from the University of California, Davis, and Uppsala University, Sweden, have shown for the first time how living organisms do this.

The observation, published Oct. 19 in the journal *Science*, closes an important gap in the theory of natural selection.

Scientists have long wondered how living things evolve new functions from a limited set of genes. One popular explanation is that genes duplicate by accident; the duplicate undergoes mutations and picks up a new function; and, if that new function is useful, the gene spreads.

"It's an old idea and it's clear that this happens," said John Roth, a distinguished professor of microbiology at UC Davis and co-author of the paper.

The problem, Roth said, is that it has been hard to imagine how it occurs. Natural selection is relentlessly efficient in removing mutated genes: Genes that are not positively selected are quickly lost.

How then does a newly duplicated gene stick around long enough to pick up a useful new function that would be a target for positive selection?

Experiments in Roth's laboratory and elsewhere led to a model for the origin of a novel gene by a process of "innovation, amplification and

divergence." This model has now been tested by Joakim Nasvall, Lei Sun and Dan Andersson at Uppsala.

In the new model, the original gene first gains a second, weak function alongside its main activity—just as an auto mechanic, for example, might develop a side interest in computers. If conditions change such that the side activity becomes important, then selection of this side activity favors increasing the expression of the old gene. In the case of the mechanic, a slump in the auto industry or boom in the IT sector might lead her to hone her computer skills and look for an IT position.

The most common way to increase gene expression is by duplicating the gene, perhaps multiple times. Natural selection then works on all copies of the gene. Under selection, the copies accumulate mutations and recombine. Some copies develop an enhanced side function. Other copies retain their original function.

Ultimately, the cell winds up with two distinct genes, one providing each activity—and a new genetic function is born.

Nasvall, Liu and Andersson tested this model using the bacterium Salmonella. The bacteria carried a gene involved in making the amino acid histidine that had a secondary, weak ability to contribute to the synthesis of another amino acid, tryptophan. In their study, they removed the main tryptophan-synthesis gene from the bacteria and watched what happened.

After growing the bacteria for 3,000 generations on a culture medium without tryptophan, they forced the bacteria to evolve a new mechanism for producing the amino acid. What emerged was a tryptophan-synthesizing activity provided by a duplicated copy of the original gene.

"The important improvement offered by our model is that the

whole process occurs under constant selection—there's no time off from selection during which the extra copy could be lost," Roth said.

Provided by UC Davis