Biologists find that red-blooded vertebrates evolved twice, independently

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Sea lamprey.

(PhysOrg.com) -- Nature, in all its glory, is nothing if not thrifty.

Through the process of natural selection, it finds new uses for existing features, often resulting in what is known as convergent evolution -- the development of similar biological traits in different orders of animals, such as powered flight in birds and bats.

Now, research by University of Nebraska-Lincoln biologists has found convergent evolution of a key physiological innovation that traces back through the two deepest branches of the vertebrate family tree.

A team led by Jay Storz (prounounced storts), assistant professor of biological sciences, analyzed the complete genome sequences of multiple vertebrate species and found that jawless fishes (e.g., lampreys and hagfish) and jawed vertebrates (pretty much everything else, including humans) independently invented different mechanisms of blood-oxygen transport to sustain aerobic metabolism.

Specifically, comparative analysis of their gene repertoires revealed that the ancestors of jawed and jawless vertebrates co-opted completely different precursor proteins to serve as oxygen-transport hemoglobins, the respiratory proteins that give blood its red color. The jawed and jawless vertebrates separated about 500 million years ago, late in the Cambrian Period and about 30 million years after the first vertebrate precursors (the chordates) show up in the fossil record.

"What we've discovered is that similar physiological problems called forth similar solutions in different branches of the vertebrate family tree," Storz said. "For example, jawed vertebrates invented one type of hemoglobin as an oxygen transport protein, whereas the other main vertebrate lineage, the jawless fishes, represented today by lampreys and hagfish, came up with their own independent solution for the same physiological problem."

That problem was size, which can matter greatly in natural selection when it comes to staying alive to find and keep a mate and to produce and protect offspring. Many animals, such as insects, get by without any type of oxygen transport protein in their circulation because they're small enough that they can rely exclusively on the passive diffusion of oxygen through what's called the tracheal system. But that process puts an upper limit on body size, which is why insects don't grow to much more than 3 inches long.

The evolution of hemoglobins as oxygen transport proteins a half billion years ago opened up new opportunities for the evolution of aerobic metabolism, and thereby facilitated the evolution of increased body size and internal complexity in animal evolution. The UNL study showed that nature found more than one way to cross that evolutionary threshold.

"The oxygen transport hemoglobins that were independently invented by the jawed and jawless vertebrates are functionally quite similar, but there are numerous structural details that belie their independent origins," Storz said. "These small but telling differences reflect the fact that the proteins evolved their oxygen-transport function from different ancestral starting points.

"The discovery that the hemoglobins of jawed and jawless vertebrates were invented independently provides powerful testimony to the ability of natural selection to cobble together similar design solutions using different starting materials."

The findings were reported in the July 26-30 online edition of the *Proceedings of the National Academy of Sciences.*

Provided by University of Nebraska-Lincoln