Changes to Embryo Can Elicit Change in Adult

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In a study illustrating the apparent linkages between the evolutionary development and embryonic development of species, researchers have uncovered the genetic elements that determine the structure and function of a simple biomechanical system, the lower jaw of the cichlid fish. In addition, they've shown that increasing expression of a particular gene in an embryo can lead to physical changes in the adult fish. The results appear in the November 11, 2005 issue of the *Proceedings of the National Academy of Sciences*.

"We're using the jaw to think about the genetic basis of biomechanical systems," said J. Todd Streelman, assistant professor in the School of Biology at the Georgia Institute of Technology. "We want to understand the genes that control this lever system. What we found was that this simple biomechanical system is much more complex than previously thought."

Streelman, along with colleagues from the Forsyth Institute at the Harvard School of Dental Medicine and the Hubbard Center for Genome Studies at the University of New Hampshire, predicted that components of the jaw that were functionally or developmentally related would be controlled by the same set of genes, or genetically integrated.

"We were surprised to see that the genetic basis of components involved in opening the jaw is independent of the jaw-closing system," said Streelman.

Researchers compared two cichlid species that dwell in Africa's Lake Malawi. One species had force modified jaws that are more adept at biting prey; the other had speed modified jaws, which are more accomplished at using suction to feed on plankton. Each jaw system is essentially a lever system made up of one out-lever and two in-levers.

"We found that as the closing in-lever gets longer, the out-lever gets shorter and vice-versa," explained Streelman. "When the in-lever is long, this gives the jaw a high mechanical advantage and the jaw can produce more force for biting. When the out-lever is long, that results in a lower mechanical advantage and a better design for suction-feeding. This negative correlation is produced by genetic integration."

But, when the team mapped the regions of the genome controlling the jaw-opening system, they found that these levers are controlled by different chromosomes.

In another part of the study, researchers showed that the gene bmp4 is a major factor in controlling the jaw-closing system. When the team injected bmp4 protein into the developing embryos of another fish species, the zebrafish, they saw that the mechanical advantage (and thus the biting power)of the jaw increased.

"This experiment fuses the traditional disciplines of developmental genetics and evolutionary biology," said Streelman. "We've demonstrated that important functional differences operating in adult organisms are elicited by changes in early development. Our next goal is to understand the genetic bases underlying the differences between the simple biomechanical system of the lower jaw and complex systems of the anterior jaw in these fish."

Source: Georgia Institute of Technology