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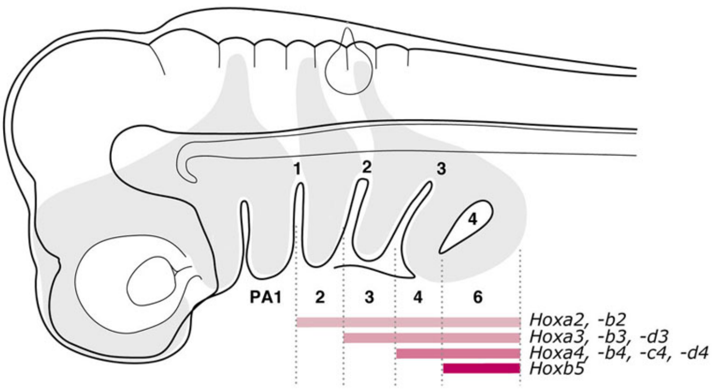
So, Why *Does* the Lamprey Have No Jaw?

May 20, 2004 – The *Hox* code characterizes a family of master control genes that function to establish regional identities in the body segments of animals ranging from worm to human. First identified in studies of fruit fly mutants, *Hox* genes are now known to specify body regions along the anterior-posterior (head-to-tail) axis in both invertebrate and vertebrate species. Recent findings from the RIKEN Center for Developmental Biology (CDB) Laboratory for Evolutionary Morphology (Shigeru Kuratani, Team Leader), published in the May 20 issue of *Nature*, have shed new light on the question of a specific role for *Hox* genes in the evolution of the jaw.

In jawed vertebrates, a group collectively known as "gnathostomes," the embryonic region from which the jaws arise does not express *Hox* genes. This region, called the first pharyngeal arch (PA1), is also found in the embryo of the lamprey, a jawless vertebrate (agnathan). A previous study by another group reported the detection of the expression of a *Hox* gene in the lamprey PA1, and suggested that the retreat of *Hox* gene expression from this region might have set the evolutionary stage for the emergence of gnathostomes, on the premise that *Hox* genes have an inhibitory effect on jaw development. Other experiments, in which either a *Hox* gene was artificially expressed in the normally *Hox*-free gnathostome PA1 and found to suppress jaw development, or, conversely, in which a *Hox* gene was inactivated in the normally *Hox*-expressing PA2, causing it to give rise to jaw-like structures, tended to support the contention of an evolutionary role for *Hox* expression in the innovation of the jaw.



Cartoon showing *Hox* gene expression in pharyngeal arches of the gnathostome. Note that *Hox* expression is absent in the first pharyngeal arch (PA1), from which the jaw develops.

The study by Kuratani and colleagues looked for *Hox* gene expression in the first pharyngeal arch of *Lethenteron japonica*, a different species of lamprey than the one used in the previous study (*Lampetra fluviatilis*) and found none; a discrepancy that might be attributable to inter-species differences. The real significance of this finding is that it strongly counters the hypothesis that a shift in *Hox* gene expression can explain the appearance of the gnathostome jaw.

The expression of *Hox* genes is collinear; that is, the order of their expression down the body axis corresponds to their appearance on the chromosome. One of the most striking findings reported in the previous work suggesting that the loss of *Hox* expression in PA1 might have facilitated the branching off of the gnathostome lineage was that jawless chordates (such as lampreys and lancelets) broke the supposedly universal law of Hox collinearity. Testing this surprising assertion, Kuratani et al. isolated 11 *Hox* cDNAs in *L. japonicum* and checked their expression patterns in developing embryos. They failed to detect *Hox* activity in PA1, or any evidence of a disruption of collinearity, suggesting that this general principle is conserved in agnathans, as in all other known taxa. They propose that the lack of *Hox* expression in PA1 in both jawed and jawless vertebrates might instead simply reflect the fact that this structure gives rise to specialized structures distinct from those that originate in more posterior pharyngeal arches in both groups.