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The Evolution of Chordate Neural Segmentation

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Abstract

Amphioxus is the closest relative to vertebrates but lacks key vertebrate characters, like rhombomeres, neural crest cells, and the cartilaginous endoskeleton. This reflects major differences in the developmental patterning of neural and mesodermal structures between basal chordates and vertebrates. Here, we analyse the expression pattern of an amphioxus *FoxB* ortholog and an amphioxus *single-minded* ortholog to gain insight into the evolution of vertebrate neural segmentation. *AmphiFoxB* expression shows cryptic segmentation of the cerebral vesicle and hindbrain, suggesting that neuromeric segmentation of the chordate neural tube arose before the origin of the vertebrates. In the forebrain, *AmphiFoxB* expression combined with *AmphiSim* and other amphioxus gene expression patterns shows that the cerebral vesicle is divided into several distinct domains: we propose homology between these domains and the subdivided diencephalon and midbrain of vertebrates. In the Hox-expressing region of the amphioxus neural tube that is homologous to the vertebrate hindbrain, *AmphiFoxB* shows the presence of repeated blocks of cells along the anterior–posterior axis, each aligned with a somite. This and other data lead us to propose a model for the evolution of vertebrate rhombomeric segmentation, in which rhombomere evolution involved the transfer of mechanisms regulating neural segmentation from vertical induction by underlying segmented mesoderm to horizontal induction by graded retinoic acid signalling. A consequence of this would have been that segmentation of vertebrate head mesoderm would no longer have been required, paving the way for the evolution of the unsegmented head mesoderm seen in living vertebrates.

Keywords

amphioxus; FoxB; SIM; brain evolution; hindbrain; rhombomeres; segmentation

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