



Contribution ID: 41

Type: **Talk**

Tomographic insight into the evolutionary assembly of the vertebrate head

Thursday, 15 September 2011 11:30 (45 minutes)

Most living vertebrates are jawed vertebrates (gnathostomes), and the living jawless vertebrates (cyclostomes) provide scarce information about the profound reorganization of the vertebrate head during the evolutionary origin of jaws. The extinct bony jawless vertebrates (ostracoderms) are regarded as precursors of jawed vertebrates, providing insight into this formative episode in vertebrate evolution. Using synchrotron radiation X-ray tomography, we describe the cranial anatomy of galeaspids, a 435–370 Ma 'ostracoderm' group from China and Vietnam. The paired nasal sacs of galeaspids are located anterolaterally in the braincase, and the hypophyseal duct opens anteriorly towards the oral cavity. These structures were thus already independent of each other, like in gnathostomes and unlike in cyclostomes and osteostracans and, therefore, have the condition that current developmental models regard as prerequisites for the development of jaws. Thus, reorganization of vertebrate head was not driven deterministically by the evolutionary origin of jaws but occurred stepwise, ultimately allowing the rostral growth of ectomesenchyme that now characterizes gnathostome head development.

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Session Classification: Plenary session

Track Classification: Plenary session