2021_90: The evolving jigsaw puzzle: origins, diversity, modifications and development of skull sutures

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The vertebrate skull provides protection for the brain, supports numerous cranial muscles and allows many other critical functions. Such cranial skeleton of any vertebrate is a very complex three-dimensional puzzle of bones and its exact shape and composition reflect the evolutionary history of the species, reveal biomechanical properties and are heavily used for classification and taxonomic identification. Cranial sutures separate the bones of the skull and function as sites of bone growth and stress diffusion. They are essential for proper development of individual skull bones and for their integration with each other and other cranial tissues and organs. Sutures can remain open or close leading to fusion of bordering bones. Suture closure leads to changes in skull composition during evolution and improper suture closure during development can lead to a variety of abnormal conditions in humans. Thus, understanding of how sutures are established, maintained and how they close is critical to addressing many of the long-standing questions on vertebrate skull evolution, development and disease.

To gain new insights into the suture biology, this PhD student will join an active effort to explore a growing database of 3D CT (computer tomography) scans of vertebrate skulls in Abzhanov and Goswami groups. More specifically, this student will continue and complete analysis of suture types using our own comprehensive suture classification system which spans the entire diversity of vertebrates from early extinct placoderm fishes to modern tetrapods. Thus, the 1st aim will be to quantitatively and qualitatively measure diversity of sutures from their origins and document how they changed through the major life history transitions, such as water-to-land transition, from feeding by suction to feeding by biting (reptiles and birds) and chewing (mammals). In particular, suture diversity will be matched with changes in skull composition and changes in skull modularity and integration. The 2nd aim is to compare developing sutures in crocodilian, bird and turtle embryos. These related reptilian lineages show both gross similarity of their skull composition and suture patterns but also demonstrate examples of multiple sutural closures, e.g. premaxillary bones fusing to form a beak bone in birds and turtles, and formation of fused frontal and parietal bones to form a thick brain vault in crocodilians. These sutures will be studied using an arsenal of histological, cell proliferation and gene expression methods to reveal the genetic causes of these transitions. Under the 3rd aim, the discovered candidate genes will be validated by functional experiments on chicken and crocodilian embryos (available from a breeding facility). The data from this project will help to better understand the nature of large-scale skull composition patterns in vertebrates and will provide mechanistic explanation underlying changes in modularity and integration during skull evolution.

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