Development, function and evolution of the mammalian jaw joint and middle ear

Supervisory team:
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Project description:

The aim of this PhD is to study the development, function and evolution of the mammalian jaw and middle ear. Mammals are unique among vertebrates in that they have a single bone in their lower jaw and possess three sound-detecting bones in their middle ear. The fossil record documents how the ancestors of mammals reduced the size and number of 'postdentary' bones in the jaw, linked to formation of a unique mammalian jaw joint, and how the bones that once formed the ancestral jaw joint were incorporated into the middle ear. At one point in mammalian evolution, animals existed with an ancestral and a mammalian jaw joint side-by-side, serving dual feeding and auditory functions (Luo 2007, 2011; Tucker 2017). Recent developmental studies reveal that while the eutherian jaw joint forms in the embryo, marsupials and monotremes are born without a fully formed mammalian jaw joint. One of the middle ear ossicles forms a temporary jaw hinge and monotreme juveniles retain a dual jaw joint, similar to that found in fossils closely related to mammals (Anthwal et al. 2020).

This developmental data combined with fossils from the ancestors of mammals represent a unique dataset to understand the function and evolution of the mammalian jaw and middle ear. The aim of the project is to use 3D imaging and computational biomechanics to characterise and compare the mechanics of the developing and fossil mammalian jaw. The student will test if reorganisation of the musculoskeletal system and a change in the mechanics of the jaw was key to jaw and ear evolution at the origin of mammals (Lautenschlager et al. 2018). This will be achieved by creating 3D digital models via imaging of unique developmental and fossil datasets and using finite element modelling to map forces in the jaw. The student will also use mutant mouse models that retain the connection between the ear and jaw, to directly test the influence of these structures on jaw function.

The project is a novel, interdisciplinary mix of evolutionary developmental biology, palaeontology and biomechanics. Collectively the supervisory team are leaders in understanding the functional evolution of the mammalian skull and the developmental biology of the mammalian jaw and ear. As such the student will gain a broad and competitive skill set, working in laboratories specialising in evolutionary developmental biology and computational palaeobiology.