Evolutionary innovations and convergence in Mesozoic marine reptiles: locomotory adaptations to ocean ecosystems

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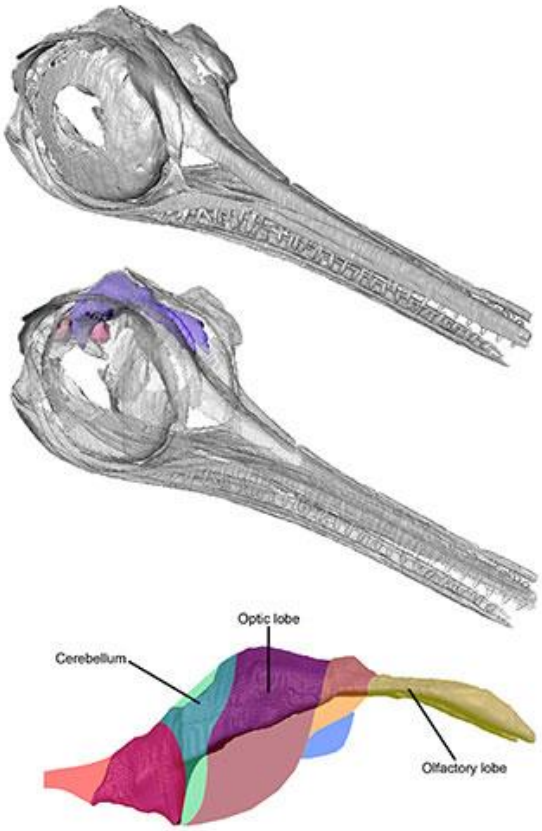
Project description



Understanding the pattern and process of evolutionary convergence is a key objective for palaeontologists and evolutionary biologists alike. Shared environmental and ecological pressures are expected to give rise to the same adaptive traits. Mesozoic marine reptiles, including the diverse ichthyosaurs, mosasaurs, sauropterygians and thalattosuchians, represent an ideal model for testing hypotheses regarding the prevalence and impact of convergent evolution. Visual comparisons highlight many shared morphological features across marine reptiles, and these are often cited as exemplary cases of convergent evolution.

There is evidence that marine reptiles became increasingly adapted to an aquatic environment through time. Basal members of most groups used axial undulation during locomotion, while derived members are thought to have become more energetically efficient cruisers. These shifts are associated with wholesale changes to their bauplans, including altering body proportions and the development of short trunks and specialized limbs. In particular, there is a transition from plesiopedal limbs to hydrofoil-like flippers. However, the affect of these morphological changes on hydrodynamic efficiency has never been rigorously assessed across Mesozoic marine reptiles. Moreover, the extent to which marine reptiles converge on shared forms has not been evaluated quantitatively.

For this project, the student will produce three-dimensional, whole-body computer models (software Blender) for a variety of marine reptiles, representing locomotory grades from all major Mesozoic groups. These models will be used in comparative hydrodynamic analyses (software COMSOL) to explore trends of locomotory performance within and across clades. The student will validate the computer models using modern analogues (sharks and crocodilians). They will also collect morphological and functional characters from the post-cranial skeleton of a wide array of taxa during museum visits. This dataset will be used to create empirical morphospaces that will be mapped onto phylogenies, to quantitatively examine evolutionary rates, directionality and convergence. Together, these data and analyses will allow the student to address a number of fundamental questions. For example, do marine reptiles become increasingly aquatically adapted (improve hydrodynamic efficiency) through geological time? Is morphological and functional convergence abundant across the more derived members of each clade?

The project will provide broad training in in vertebrate palaeontology, comparative anatomy and numerical palaeobiology, in addition to specialist training in comparative phylogenetics and computational fluid dynamics. The student will have the opportunity to visit museums in Europe, China and the United States.

References

Lindgren, J., Caldwell, M. W., Konishi, T. and Chiappe, L. 2010. Convergent evolution in aquatic tetrapods: insights from an exceptional fossil mosasaur. PLoS ONE, 5(8): e11998

Kelley NP, Pyenson ND. 2015. Evolutionary innovation and ecology in marine tetrapods from the Triassic to the Anthropocene. Science 348:aaa371