PROJECT TITLE: Patterns, processes, rates, and constraints, in the evolution of morphological disparity
DTP Research Theme(s): Living World

Lead Institution: University of Bristol
Main Supervisor: Prof Philip Donoghue FRS, School of Earth Sciences, University of Bristol
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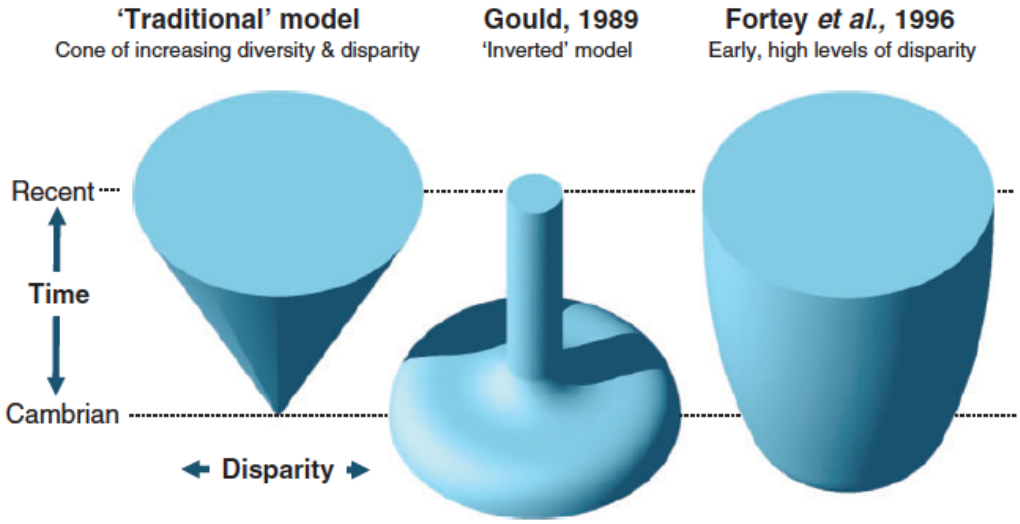

Image Caption: Competing models for the evolution of morphological disparity

Project Background

Biodiversity, living and dead, exhibits discontinuous variation in shape and form between clusters of similar species in what can be considered morphological 'design space' [1]. For example, the animal kingdom is divided into phyla distinguished by their unique bodyplans. The tempo and mode by which these disparate morphologies evolve is hotly disputed, at the heart of debate over the nature of apparently explosive radiations, like those of animals and placental mammals, as well as the nature of the evolutionary process itself.

Why do bodyplans vary irregularly? Do clusters in design space reflect adaptive peaks and are unoccupied regions impossible - or are they unoccupied because of extinction or because insufficient time has elapsed? Is the range of designs (morphological disparity) realised progressively or episodically through time? The answers to these questions have profound implications, particularly for whether the same processes shape macroevolution throughout deep time (uniformitarianism) or whether these forces change over Earth History [2].

Project Aims and Methods

To date, analyses have been based on empirical case studies of (principally) extinct organisms [3] but they are difficult to interpret because they lack a theoretical foundation in which to discriminate the causes of different patterns of morphological disparity and how they vary through time. or empirical foundation. This project will exploit new tools for simulating the evolution of morphological characters [4,5] under the diversity of evolutionary processes that are inferred to have shaped the morphological disparity of real clades. These include intrinsic factors (such as changes in rates of character evolution and the scale of innovation, phylogenetic burden, and lineage duration) as well as extrinsic factors (such

as competition and mass extinction events). You will examine each of these putative drivers and limits, alone and in combination, to determine whether they yield the patterns of design space occupation that are observed in real clades. You will also explore how the structural and phylogenetic relationships among characters contribute to morphospace occupation.

In addition to undertaking simulations, you will work also with real data from living and fossil species, exploring the impact that taxon-loss has on extant disparities, and the impact that character-loss has on the assessment of disparity in extinct groups. While you may sample broadly across organismal diversity and throughout the Phanerozoic, there is also scope to focus on particular groups, depending you're your personal interests.

Ultimately, the results of the simulation studies will identify the relative roles of different evolutionary processes in shaping the occupation of design space, and provide a new theoretical framework within which to evaluate the results of empirical disparity analyses. They will also speak to a seminal controversy in macroevolution, namely the uniformitarian/non-uniformitarian debate.

Candidate

Candidates with a background in Earth Sciences, Palaeontology, Biological Sciences, or Genetics, would well-suited to this project.

Training

In addition to the wealth of general training provided by the GW4+ DTP, we will provide training in the design and execution of simulation-based research, as well as in the application of evolutionary models and disparity analyses, as well as their interpretation. On successful completion of this project, you will have a unique skillset that will provide the foundation for an exciting career in palaeobiology and evolutionary biology, including numerical computational skills that will be readily transferable to careers outside academia.

References / Reading List

1. D. H. Erwin, Disparity: morphologic pattern and developmental context. Palaeontology **50**, 57-73 (2007).
2. D. H. Erwin, Evolutionary uniformitarianism. Developmental biology **357**, 27-34 (2011).
3. Hughes, M., Gerber, S. & Wills, M. A. Clades reach highest morphological disparity early in their evolution. *Proceedings of the National Academy of Sciences, USA* **110**, 13875-13879 (2012).
4. J. E. O'Reilly et al., Bayesian methods outperform parsimony but at the expense of precision in the estimation of phylogeny from discrete morphological data. Biology Letters **12**, 20160081 (2016).
5. Puttick, M. N. *et al.* Uncertain-tree: discriminating among competing approaches to the phylogenetic analysis of phenotype data. *Proceedings of the Royal Society B: Biological Sciences* **284**, (2017).

Links

School webpage - http://www.bristol.ac.uk/earthsciences/courses/postgraduate/

NERC GW4+ DTP Website: http://nercgw4plus.ac.uk/
Bristol NERC GW4+ DTP Prospectus:
http://www.bristol.ac.uk/study/postgraduate/2017/doctoral/phd-great-western-four-dtp/

Application deadline: 23.59 GMT, Sunday 7 January 2018
How to apply to the University of Bristol:
http://www.bristol.ac.uk/study/postgraduate/apply/

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