Assessing fossils, fossilization and phylogeny to reconstruct the origin and evolution of arthropods

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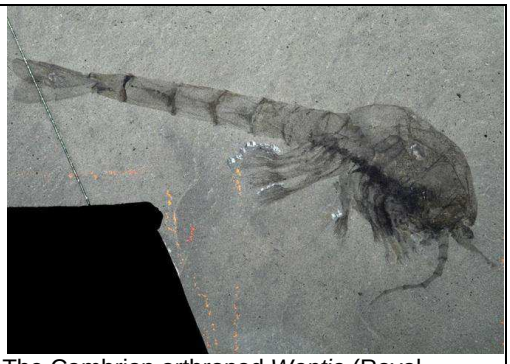
Introduction:

Can the fossil record be reliably used to reconstruct the relationships of extinct organisms? Do the losses of morphology that occur during decay and fossilization cause biases in our interpretations of fossils? How is our understanding of evolutionary processes changed when we take fossilization filters and biases into account? This project aims to address these questions by focusing on the origin and early evolution of arthropods - one of the most important evolutionary episodes in the history of life on earth. A combination of phylogenetic simulations, modeling and laboratory experiments investigating anatomical decomposition will be undertaken to assess fossilization biases and their effect on interpretations of arthropod fossils and phylogeny. The data generated from theoretical and empirical studies will serve as a powerful and unique tool with which to re-visit the palaeontological data and the evolutionary inferences drawn from them.



The Cambrian arthropod *Waptia* (Royal Ontario Museum)

Project Summary

The use of fossils in evolutionary contexts is largely predicated on our ability to recognize their morphology and affinity in relation to other taxa. The fossil record, however, is notoriously and inescapably incomplete. The form of missing data particular to fossils has been found cause serious problems when reconstructing phylogenies (Sansom and Wills 2013). Furthermore, experimental work has demonstrated that systematic loss of anatomy during post-mortem decay can cause chordates to appear more primitive than when alive (Sansom et al 2010). As such, the decay processes that are fundamental to fossilization can undermine our ability to use and interpret the fossil record. It is currently not known whether this phenomenon of “stem-ward slippage” is widespread, or how our understanding of various evolutionary events is affected in when we revisit fossil data in light of decay. For example, recent work has described early arthropod fossils with neural and vascular tissues (Tanaka et al 2013) yet the feasibility preservation of tissues of these kinds is untested.

This projects aims to 1) assess the broader nature of fossilization filters and the ubiquity of “stem-ward slippage” and 2) see how our understanding of evolutionary processes is changed when we take these processes into account. To do this, the project student will 1) use simulations and theoretical studies to investigate the role of fossilization process (taphonomy) in building evolutionary trees (phylogeny), 2) conduct laboratory experiments to identify patterns of anatomical loss during decay and decomposition in a range of suitable modern organisms and 3) use the combined data from theoretical and experimental work to test for decay biases and revise evolutionary hypotheses based on palaeontological data. The focus will be on arthropods – the most diverse group of animals both in terms of numbers, species and body plans. Their fossil record has shed much light on the origin and early evolution of this important group but has, in many cases, been equivocal (Budd and Telford 2009). Only by using the powerful combination of theoretical and empirical approaches will it be possible to ascertain if we can have

confidence in the fossil record as it stands, and more broadly, to refine and inform our understanding of evolutionary events and processes.

Training will be provided for phylogenetic methods, software, and scripting (PAUP, TNT), experimental taphonomy, which will be conducted in the dedicated laboratory, and fossil analysis (taxonomy, SEM). The balance between the theoretical, experimental and palaeontological aspects of the project will depend on the needs and experiences of the student. A background in palaeontology or zoology is essential, some prior knowledge of, or experience with, systematics and/or arthropods is desirable.

References

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