Collaborative Research: Lower Actinopterygians, the Interrelationships of the Basal Forms of the Largest Vertebrate Group

PROJECT SUMMARY

Actinopterygii, or ray-finned fishes, includes over half of all living vertebrates yet the early evolution of this group remains poorly understood. With this AToL project, we propose to resolve the phylogenetic relationships of lower actinopterygians, defined here as all non-eusteleostean fishes. Extant lower actinopterygians are represented by relatively few species when compared to their fossil relatives, and some have great economical value and/or are critically endangered. The relationships among lower actinopterygians are critical for understanding the early diversification of teleosts, widely held as the most "successful" vertebrate group, with over 27,000 living species. The phylogenetic history of fossil and living lower actinopterygians remains problematic in part because there has not yet been a coordinated, large-scale effort to explore their relationships. We will investigate the phylogenetic relationships of these fishes using an integrated approach, with a large number of taxa and robust morphological and molecular data sets. We have assembled a group of worldwide experts in paleontology, morphology, molecular biology, and phylogenetics. Through this project, we will explore the relationships of actinopterygians to other osteichthyans, study the interrelationships of the different groups of lower actinopterygians, and study the basal relationships of the teleosts to better understand this key branch of the vertebrate Tree of Life.

Intellectual Merit. We will develop phylogenetic hypotheses based on molecular and morphological characters for 560 extant species and 550 fossil taxa. New morphological and molecular data will be collected, including nuclear gene data, developmental data and anatomical data derived from new technologies (e.g., CT scans). This will allow us to critically test hypotheses of molecular and morphological evolution. We will assemble distributional data and phylogenetic hypotheses to provide a base for broad scale biogeographic studies. Specific research questions include: 1) Are extant non-teleostean actinopterygians deeply rooted in the phylogeny of ray-finned fishes, or do they form a monophyletic group closely related to teleosts? 2) Do morphological constraints generate convergent characters that inaccurately reflect phylogenetic relationships? 3) Do synapomorphies of certain groups of extant lower actinopterygians (bichirs, sturgeons) characterize larger groups of actinopterygians? 4) Is 'Holostei' (= gars + bowfins) monophyletic? 5) Which fossil and extant lower actinopterygian taxa are most closely related to teleosts? 6) What are the basal relationships among extant teleosts?

Broader Impacts. Resolving the basal relationships of actinopterygians is essential for understanding a major branch of the Tree of Life, and is critical for outgroup analysis for early evolutionary studies of sarcopterygians - the other half of vertebrates. Our study will contribute to the systematics and biogeography of economically important groups of fishes (e.g., anchovies) and to better inform to conservation efforts (e.g., sturgeons). Study of this diverse, ubiquitous group of animals is also important for understanding the ecological evolution of aquatic environments generally. Postdoctoral scholars, graduate and undergraduate students will be trained in an integrative environment. We will stimulate international collaborations, and produce many publications and symposia at national and international meetings. Resulting databases will be posted on appropriate Web sites (e.g., DeepFin, Tree of Life, Morphbank, FMNH) to maximize their dissemination. Our Web Portal will communicate our results, and information on the history, evolution, biology, distribution, and economic value of lower actinopterygians to the scientific community and the general public. We will develop internet presentations and films to educate the public about life in the past and how scientists work to understand the evolution of biodiversity through studies of fossil and living species.