ABSTRACT for NSF-FRES Award

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Collaborative Research: Testing Evolutionary Pseudocongruence Along the Baja California Peninsula Through Integration of Geologic and Genomic Data

A primary goal of research in earth and biological sciences is to understand how diverse processes such as tectonic activity, rainfall gradients, and glacially driven climate cycles shape evolution and biodiversity over time. The central Baja California peninsula, Mexico, hosts a previously documented pattern of genetic divergence between northern and southern populations that is observed in dozens of species, but the underlying controls on this divergence pattern are presently unknown. This project aims to test three processes that may control biodiversity along the 1000-km long peninsula, through an integrative study of geological, ecological and genomic datasets. One societal benefit of this work will be to leverage ‘big data’ and quantitatively integrate new types datasets for scientific discovery. Among other benefits, the PIs will mentor and train postdoctoral researchers, graduate students, and undergraduate students in best practices of transdisciplinary research that are necessary to keep the U.S. globally competitive in innovation. This work will include collaboration with Mexican scientists and will be coordinated with two other studies in central Baja California that are currently funded by NSF. The team will create a series of short training videos to demonstrate common fieldwork techniques, and a set of animations to summarize the geological and biological history of Baja California with the goal of communicating interdisciplinary geo-biological concepts to non-specialists. The PIs will host a community workshop to advance Earth-Life research, and implement an art-science collaborative course between Arizona State University and the University of Arizona.

This study will test three hypotheses to explain a previously documented pattern of north-south genetic divergence across the central Baja California peninsula: (1) populations were isolated by a physical barrier (marine seaway) in the mid-Peninsular region during Pliocene time; (2) Pleistocene glaciations isolated populations in refugia; and (3) monsoon-driven differences in rainfall timing isolated species through asynchronous reproduction and/or differential adaptation to precipitation regimes. The team will map and date structural, stratigraphic, and volcanic features in the mid-Peninsular region where the divergence occurs; use modern geochronologic methods to constrain the timing of deposition, volcanism, deformation and uplift; evaluate low-coverage genomes of angiosperms, reptiles, and mammals to assess population genomic signatures, loci under local adaptation, and spatial patterns of allelic variation; assess seasonal gene expression; develop niche models for modern and glacial climates; and test for present-day niche divergence. This study will embrace geological and climatic complexity to understand extrinsic factors that control genome evolution and diversification, and explore how biological evolution can be driven by multiple co-occurring processes through time (pseudocongruence). Our approach uses cutting-edge geological, biological and statistical methods within an evolutionary framework to integrate organismal genomic evolution with co-occurring changes in the physical environment. These findings will advance our understanding of geobiology at meso-organizational scales (i.e., intermediate between microbial and global), and will generate new strategies to test for diverse factors that drive evolution. Results of this research will provide foundational steps toward developing new predictive models of Earth-Life evolution that can be applied to deeper timescales and other geobiological systems.