Genetic, developmental and anatomical basis of natural selection for sensory structures

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The glowing structures are bones that house the inner ear. The rounded, coiled structure is the cochlea, for hearing. The arch is one of three semicircular canals on each side. These contain balance-related structures that sense roll, pitch and yaw. Elizabeth Dumont at UMass Amherst and colleagues have launched a large study of the genetic, molecular and anatomical bases of how bats sense their environment and other bats to ensure survival and reproduction. Credit: UMass Amherst

Hoping to understand how the tremendous diversity of life on Earth evolved even as irreversible species and habitat loss rapidly proceeds, a research group of bat experts including biologist Elizabeth Dumont of the University of Massachusetts Amherst has received a five-year, $1.91 million grant from the National Science Foundation to study how bats sense their environment and other individuals, including potential mates, to ensure survival and reproduction.

Through NSF's "Dimensions of Biodiversity" program, Dumont and her two co-principal investigators, Liliana M. Dávalos at Stony Brook University and Karen Sears at the University of Illinois at Urbana-Champaign, along with Stephen Rossiter at Queen Mary University of London, will study three biological dimensions in 130 species of New World leaf-nosed bats: The gene repertoires associated with sensory systems, the molecular and cellular processes that generate special sensory structures in embryos, and the way space is allocated to different sensory structures in the head.

Dumont, whose lab will focus on three-dimensional imaging of bat heads and evaluating variation in the size, shape and spatial distribution of sensory structures, says, "This project integrates multiple disciplines to answer questions that evolutionary biologists have been posing for decades. It combines science at the frontier of molecular biology and imaging techniques with basic knowledge of natural history to shed light on the most intricate mechanisms that generate evolutionary novelties and open up new niches."

Specifically, Dumont and a graduate student will stain bat heads with an iodine solution and use CT scans to image where muscles are attached, how big the eyeballs are and structures of the inner ear, for example. "We'll look at the size and shape of structures associated with smell, hearing and taste. This will give us a new view of anatomy, and for many bat species these have never been imaged before," she says.

"If you think of the head, it's a small space where there is competition in the evolution of the eyes, ears and sense of smell. You don't see animals with specialized structures for all three senses. There is tremendous diversity, especially in these bats. We'll explore the anatomy of which organs takes up more space, how that is related to genetics and to embryonic development and the ecological niche the animal thrives in. We'll ask what natural selection is working on to produce so much diversity, and what are the gene changes that go along with the development of a particular nose, for example," Dumont adds.

"At the end of five years we hope to be able to show the genetic, developmental and anatomical basis of the evolution of sensory structures in a group of mammals. This has never been done before."

Her colleague Sears comments, "The tools necessary to conduct these types of studies are only now becoming standard for organisms that are not typically maintained in laboratories. This new toolkit will allow us to not only track the development of sensory organs, but also to test the action of key genes in the lab. The potential to discover mechanisms relevant to many other species and not just bats is unprecedented."

Provided by University of Massachusetts Amherst