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Songbirds may hold key for vocal learning

UH biologist contributes to collaborative study in Nature magazine

HOUSTON – Whether you're a songbird or a human, there's a lot we can learn from our elders when learning vocalization. A University of Houston researcher was part of a team that uncovered the genome of the zebra finch, which may one day help people who suffer from speech impairments, learning disabilities and problems with forming social connections.

IMAGE: Preethi Gunaratne, a University of Houston professor, and Ashley Benham, one of her graduate students in biochemistry, used state-of-the art sequencing technology in their songbird research that allows rapid sequencing...

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Preethi Gunaratne, an assistant professor of biology and biochemistry at UH, played a lead role in microRNA discovery and analysis in relation to changes in the auditory forebrain of zebra finches in response to song. This research eventually will be used to study vocal learning in humans. Wesley Warren from the Genome Sequencing Center at Washington University in St. Louis and David Clayton from the University of Illinois at Urbana-Champaign led the team of scientists.

Their findings are described in a paper titled "The Genome of the Zebra Finch: Special Insights into Vocal Learning and Communication," appearing April 1 in *Nature,* the weekly scientific journal for biological and physical sciences research.

Songbirds – and, in this case, the zebra finch (*Taeniopygia guttata*) – are the only animal model for studying the evolution of speech and language in humans. They have been studied as a paradigm to understand how vocal communication can be used to tell apart individuals when selecting partners during courtship and forming social boundaries.

IMAGE: Preethi Gunaratne, an assistant professor of biology and biochemistry at the University of Houston, was part of a team that uncovered the genome of the zebra finch.

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"Interestingly, although both males and females are able to differentiate between different song types, the ability to learn and copy a particular song type that is specific to the family lineage is passed down only through the males," Gunaratne said. "Young males learn and copy the song that is vocalized by their father, and this song learning must be accomplished during early infancy. After learning the song of their father, the sons are able to vocalize the specific song of their father very accurately. Therefore, the songbird has much to offer in relation to our efforts to understand the role of learning and memory in acquired human speech."

Among the key findings of this paper is that although the overall structure of the zebra finch genome is similar to that of chickens, which do not learn or vocalize songs and are the only birds to have been sequenced until now, the genes expressed in the brain that have to do with neurological functions have evolved more rapidly in songbirds. In addition, Gunaratne was surprised to find that this ability to learn and vocalize engages a large number of RNAs (molecules involved in the transmission of genetic information) that do not code for proteins and were previously considered to be junk. In the last decade, she says, there has been a paradigm shift where small non-coding RNAs, called microRNAs, have emerged as important regulatory molecules that can diminish the levels of hundreds of genes that cooperate to form a network that supports a specific biological process. Each individual small RNA acts as a magnet to capture a specific set of gene transcripts.

Gunaratne, who is also an assistant professor in the pathology department at the Human Genome Sequencing Center at the Baylor College of Medicine, is a pioneer in the field of microRNAs in Houston.

In collaboration with Clayton, who is a pioneer in the application of molecular genetics and genomics to songbird research, the team determined the complete set of microRNAs expressed in the auditory forebrain – the part of the brain that is involved in vocal learning – of male and female zebra finches exposed to song versus silent conditions. The auditory forebrain is of central importance in controlling the neural circuits needed for learning and vocalization of song in these birds.

The researchers found the set of microRNAs that are expressed in the auditory forebrain when a songbird is listening to a song is very different from the set of microRNAs that are expressed when the song is discontinued. A number of microRNAs that can potentially manipulate hundreds of genes that originally cooperated to support a specific function like song learning are induced in the absence of song. This allows the brain to clear out gene transcripts that are needed for song learning when they are no longer needed under the silent conditions.

"Similarly, when the young bird hears the father's song a second time, a new set of microRNAs that can potentially support song learning are expressed and now act to potentially clear gene transcripts that cooperate to support the brain function under silent conditions," Gunaratne said. "Basically, because a single microRNA can concurrently diminish the levels of hundreds of genes, they allow major shifts in gene networks to happen when we go from one situation to another."

Two of Gunaratne's graduate students, Ashley Benham and Jayantha Tennakoon, along with Jong Kim, an undergraduate student from her lab, and Ya-chi Lin, a graduate student from the Clayton lab, played important roles in this project. Their contributions on the details of the role of microRNAs in song learning in zebra finches is in preparation for yet another publication, demonstrating the type of student success essential to Tier-One status.

Gunaratne says this work would not have been possible without the Illumina Next Generation Sequencing instrument housed in the Institute for Molecular Design at UH. In 2008, UH became one of the first academic institutions to acquire state-of-the art sequencing technology that allows rapid sequencing of entire genomes within weeks. This investment has transformed the research of not only UH faculty, but also of a large number of faculty in the Texas Medical Center, as well as other national and international universities and institutions through collaborations with researchers at UH.

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NOTE TO JOURNALISTS: A high-resolution photo of Preethi Gunaratne working with the gene sequencing instrument is available to media by contacting Lisa Merkl.

About the University of Houston

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About the College of Natural Sciences and Mathematics

The UH College of Natural Sciences and Mathematics, with 170 ranked faculty and approximately 4,500 students, offers bachelor's, master's and doctoral degrees in the natural sciences, computational sciences and mathematics. Faculty members in the departments of biology and biochemistry, chemistry, computer science, earth and atmospheric sciences, mathematics and physics conduct internationally recognized research in collaboration with industry, Texas Medical Center institutions, NASA and others worldwide.

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