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Large-scale Genomic Study Reveals New Insights Into Insect Diversity and 500 Million Years of Arthropod Genome Evolution

The evolutionary innovations of insects and other arthropods – the most diverse group of animals on Earth – are as numerous as they are fascinating, from fangs, silk and stingers to exquisitely colored wings and ingenious feats of engineering. Some insects contribute vital ecosystem services, including pollination and decomposition, while others are pests of agriculture or spread diseases.

DNA sequencing allows us to study the genomic blueprints underlying this extraordinary diversity. An international team of scientists, including researchers from the McKenna Lab at the University of Memphis, report in the journal Genome Biology the results from a project designed to kickstart the sequencing of genomes from thousands of arthropod species (the Insect 5,000 Genomes Project; i5k).

Adding the 28 genomes they sequenced to previously sequenced ones enabled a uniquely large-scale comparative analysis involving genomes from 76 arthropod species, including flies, butterflies, moths, beetles, bees, ants, wasps, true bugs, thrips, lice, cockroaches, termites, mayflies, dragonflies, damselflies, bristletails, crustaceans, centipedes, spiders, ticks, mites and scorpions. Their results have wide-ranging implications for our understanding of the evolution and genomic basis of arthropod biology, including insect form and function. Moreover, they support a diversity of new research at the interface between insects and humans, and involving the roles and management of insects in agriculture, forestry and natural ecosystems.

The gene families found to be most dynamically changing in arthropod genomes encode proteins linked to digestion, chemical defence and the building and remodelling of chitin - the major constituent of the arthropod exoskeleton. Adaptability of digestive processes and mechanisms to neutralize harmful chemicals undoubtedly served arthropods well as they conquered a wide variety of ecological niches.

Perhaps even more importantly, the flexibility afforded by a segmented body plan with a dynamically remodellable exoskeleton allowed them to thrive by physically adapting to new ecosystems. Newly evolved gene families also reflect functions known to be important in different arthropod groups, such as visual learning and behavior, pheromone and odorant detection, neuronal activity and wing development.

These may enhance food location abilities or fine-tune species self-recognition and communication. Several detailed genomic studies of individual species from the i5k pilot project focused on their fascinating biological traits, such as horizontal gene transfer from bacteria and fungi enabling digestion of woody plant material by the Asian long-horned beetle, led by Dr. Duane McKenna at the University of Memphis.

i5K researchers are now involved in new ambitious initiatives that will sequence the genomes of additional arthropods, most notably, the global network of communities coordinated by the Earth BioGenome Project (EBP) that aims to sequence all of Earth's eukaryotic biodiversity. The goals include benefitting human welfare, where the roles of arthropods are clear and the hidden benefits likely substantial, as well as protecting biodiversity and understanding ecosystems, where alarming reports of declining species numbers make arthropods a priority.

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