# Conquest of land began in shark genome

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When the first four-legged animals sprouted fingers and toes, they took an ancient genetic recipe and simply extended the cooking time, say University of Florida scientists writing in Wednesday's issue of the journal PLoS ONE.

Even sharks — which have existed for more than half a billion years— have the recipe for fingers in their genetic cookbook — not to eat them, but to grow them.

While studying the mechanisms of development in shark embryos, UF scientists identified a spurt of genetic activity that is required for digit development in limbed animals.

Previous work suggested that the transition from fins to limbs involved the addition of a late phase of gene activity during embryonic development, something thought to be absent during the development of fish fins.

The finding shows what was thought to be a relatively recent evolutionary innovation existed eons earlier than previously believed, shedding light on how life on Earth developed and potentially providing insight for scientists seeking ways to cure human birth defects, which affect about 150,000 infants annually in the United States.

"We've uncovered a surprising degree of genetic complexity in place at an early point in the evolution of appendages," said developmental biologist Martin Cohn, Ph.D., an associate professor with the UF departments of zoology and anatomy and cell biology and a member of the UF Genetics Institute. “Genetic processes were not simple in early aquatic vertebrates only to become more complex as the animals adapted to terrestrial living. They were complex from the outset. Some major evolutionary innovations, like digits at the end of limbs, may have been achieved by prolonging the activity of a genetic program that existed in a common ancestor of sharks and bony fishes.”

Researchers say the same genes that produced ancient fins likely enlarged their role about 365 million years ago in amphibians struggling to adapt to swamps and terrestrial living, creating a distinct burst of development and more versatile appendages.

Using molecular markers to study the formation of skeletal cartilage in embryos of the spotted catshark, UF scientists isolated and tracked the activity of Hox genes, a group of genes that control how and where body parts develop in all animals, including people.

They discovered a phase of gene expression in sharks that was thought until recently to occur only when digits began to form in limbed animals.

Why, then, don’t sharks have fingers?

Renata Freitas and GuangJun Zhang, co-authors of the paper and graduate students in the zoology department of the College of Liberal Arts and Sciences, speculate that sharks and many other types of fish do not form more dramatic appendages during this late phase of Hox gene expression because it occurs briefly and only in a narrow band of cells, compared with the more extended time frame and larger anatomical area needed to prefigure the hand and foot in limbed animals.

“We know when this particular Hox gene is mutated in humans, it results in malformations of fingers and toes,” Cohn said. “Until now it was thought these mutations were affecting a relatively recent innovation in the genetic process of limb development. Our results show that this phase of Hox expression is much more ancient and suggest that if the origin of digits involved a prolonged activity of Hox genes, a truncated period could result in defective digits."

In a parallel study, researchers at the University of Chicago found this second phase of gene expression in paddlefish, a primitive living descendant of early fish with the first bony skeletons.

Finding the second phase in sharks, which have skeletons consisting not of bone but of cartilage, means the genetic processes necessary to muster fingers and toes existed more than 500 million years ago in the common ancestor of fish with cartilaginous skeletons and bony fish — more than 135 million years before digits debuted in the earliest limbed animals.

"The leap from aquatic life to terrestrial life is an extremely dramatic, important point in evolution that has captured the interest of many," said Marie Kmita, Ph.D., director of the Genetics and Development Research Unit at the Institut de Recherches Cliniques de Montréal who was not involved in the research. "Understanding how changes in gene regulation modify the body architecture is of extreme interest to scientists who are trying to find ways to improve human health by learning from developmental processes. This work shows a late phase of gene regulation seems fated to the emergence of digits."

Source: University of Florida