How a fish can fry: Scientists uncover evolutionary clues behind electric fish

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Take a muscle cell, modify it over millions of years, and you end up with an exciting and literally shocking evolutionary result: the electric fish. Electric fish have evolved several times in varying levels of complexity. Two groups of electric fish, one in Africa (Mormyroids) and one in South America (Gymnotiforms), have independently evolved sophisticated communication systems using these cells. By emitting and sensing weak electrical signals, the fish have bypassed the usual means of communication, such as with sounds and visual signals, and go directly to electrical signals. This allows them to quietly "talk" to each other in the dark so that most predators can't eavesdrop. Both groups of fish are incredibly diverse; one species, the famous electric eel of South America, even evolved such strong and intense electric signals that it can electrocute its prey.

A gene that is particularly important for electric cells is the voltage-gated sodium channel. During an ancestral gene duplication event, the voltage-gated sodium channel of muscle, Scn4a, duplicated to Scn4aa and Scn4ab. This caused sodium ion channel genes to diversify and in parallel the same duplicate gene, Scn4aa, specialized for electric cells in Africa and South America while the other, Scn4ab, remained specialized for muscles. The regulated currents flow through the ion channels and generate electrical signals. In the advanced online publication of *Molecular Biology and Evolution*, authors Ammon Thompson et al., showed that the Scn4aa sodium channel gene may have an evolutionary bias over its twin to take part in novel cell types derived from muscle cells.

Evidence for their hypothesis was provided by RT-qPCR data of Scn4aa and Scn4ab from electric fish, which were compared with non-electric fish. They speculate that the down-regulation of the Scn4aa gene leads to quicker evolution and adaptation. Also, in an exciting discovery, they found this same Scn4aa gene expression pattern in a species of fish that uses sound to communicate, showing another extraordinary evolutionary adaption from the ancient gene duplication. The results provide a compelling hypothesis that gene duplications and gene 'expression drift' may be a more common evolutionary phenomenon in the development of new organ systems.

By peering into the evolutionary history of these genes we're starting to understand why the same gene plays a role in the repeated evolution of these unusual organs," said researcher Ammon Thompson.

Provided by Oxford University Press

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