DESCRIPTION

The bodies of threespine stickleback fish in certain populations evolved as they adapted from living in the ocean to a life exclusively in freshwater environments. One adaptation was the loss of pelvic spines, which are homologous to the hind limbs of four-legged animals. Scientists have determined that changes to the stickleback pelvis are largely due to changes in a particular gene regulatory switch, a stretch of noncoding DNA sequence that functions to turn genes on or off. Mutations in gene switches that control developmental genes are an important evolutionary mechanism responsible for the diversity of animal forms.

KEY CONCEPTS

- Dramatic changes in traits can occur through mutations in a small number of genes, or even a single gene.
- Different environments can provide different selective pressures on an organism’s morphology. In the stickleback, pelvic spines provide a selective advantage in environments with large predatory fish, but are a liability in environments with dragonfly larvae.
- All the cells of the body contain the same genes, but only a subset of those genes is active in any particular cell type. For example, liver cells express a different set of genes than muscle cells.
- The expression of genes that control development—the process by which a fertilized egg divides, grows, and develops into an adult—is regulated by genetic elements called switches. Switches determine at which times during development and in which cells or tissues a particular gene is turned on or off.
- Mutations that alter the function of a genetic switch can affect when and where a gene is expressed without affecting that gene’s protein product. Thus, a mutation in a genetic switch that regulates the expression of the Pitx1 gene in the pelvis will not affect the gene’s expression and protein product in other parts of the body.
- Evolutionary change can occur rapidly from a geological perspective—typically measured in millions of years—if the environment strongly favors or disfavors a particular trait. In the case of freshwater stickleback populations in North America, the loss or reduction of pelvic spines evolved within the past 10,000 years.
- Similar evolutionary adaptations can occur independently in different populations that have similar selective pressures, and in some cases may result from the same genetic mechanism. For example, pelvic reduction occurred in separate freshwater stickleback populations due to mutations in the same genetic switch.
- The evolution of anatomical traits can be studied by carefully measuring and comparing related populations living in different habitats, by comparing the DNA of individuals with similar and different traits, and by analyzing the same trait in related species found in the fossil record. It is possible to use all three approaches to study the evolution of pelvic reduction in the stickleback.

CURRICULUM AND TEXTBOOK CONNECTIONS

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SUGGESTED AUDIENCE

This film is appropriate for middle school and high school biology students to teach concepts in evolution and the genetic changes responsible for evolutionary change. For advanced biology students, this film can be used as a starting point to teach molecular biology concepts and techniques.

KEY REFERENCES