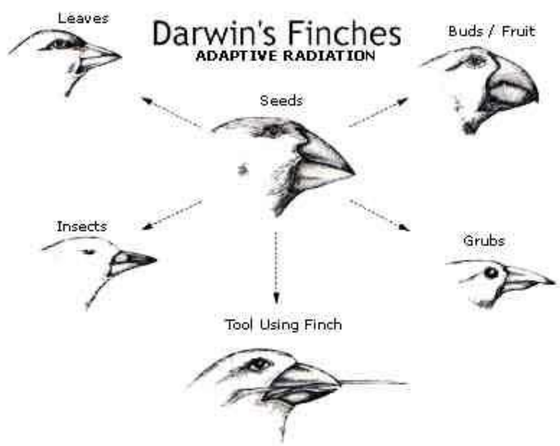
ScienceWatch – Beak Variation in Darwin's Finches: It's in the Genes



Darwin's finches are described in every biology textbook as a classic example of evolution in action. They comprise 14 closely related species that differ in beak shapes and sizes and live on the Galápagos Islands. The group includes ground-dwelling birds (*Geospiza*) that feed on different sized seeds or cactus flowers and tree-dwelling birds (*Camarynchus*) that feed on different sized insects or types of fruit, and each beak is adapted for a specialized feeding task. Cataloging the birds he collected in 1835 helped Darwin formulate his theory of evolution because he realized that all the finch species arose from one ancestral form that had adapted to a variety of feeding conditions. Today the finches are considered a perfect example of *adaptive radiation*, in which one species diversifies into many to exploit a wide range of habitats.

The finches continue to be popular subjects for evolutionary biologists. For example, a team headed by Peter and Rosemary Grant of Princeton University is conducting a decades-long study of the effects of natural selection on the birds. They have discovered that the finches rapidly adapt to sporadic deluges and droughts caused by El Niños and La Niñas. Rainfall, or lack of it, determines whether large or small seeded plants will become abundant, and birds with the right sized beaks rapidly proliferate in response to which seed size predominates.

But how such a variety of beaks arose in the first place has been a mystery until now. Two teams of developmental biologists using the tools of modern molecular biology have published reports in the September 3rd issue of the journal *Science*. They show that a protein, which normally causes skull bone development, also affects beak size and shape in developing bird embryos. One team, headed by Cheng Ming Chuong, at the University of Southern California in Los Angeles, found that beak shape in chicken embryos could be altered by modulating the level of a bone-growing protein in the region responsible for beak growth. The bone morphogenetic protein, *Bmp4*, acts as a signal to stimulate beak growth. The team could artificially raise the level of *Bmp4* by local injection of a virus, which contained the *Bmp4* gene. Using this technique they produced late stage embryos with larger and even misshapen beaks. Furthermore, arresting beak development by removal of the embryonic growth zone was partially reversed by replacing the excised region with *Bmp4*-coated beads.

The second study performed independently by Clifford Tabin of Harvard Medical School in Boston and his colleagues shows that *Bmp4* determines beak size and shape in the six ground-dwelling Darwin's finch species of the genus *Geospiza*. Three species in this group have broad deep beaks of varying sizes to crush seeds, while the other three have long, thin beaks for eating cactus flower nectar or fruit. Tabin's team looked at the location and timing for the production of ten different growth factors during beak development in embryos of the small-beaked birds versus the large-beaked birds. *Bmp4* was the only factor that had a different pattern of expression in the two groups. In general, the *Bmp4* gene was active earlier (and making more *Bmp4* protein) in the finches with larger beaks. However, each species showed a somewhat different expression pattern of *Bmp4*, which resulted in a characteristic beak size and shape.

Tabin *et al*. conclude that regulation of the *Bmp4* protein is the principal way in which beak variation occurs in the finches. The differences were acted upon by natural selection and resulted in the evolution of the finch species, which led Darwin to his theory. *Bmp4*, it seems, is the underlying source for the most important concept in biology.

Saul Scheinbach