science graduates plentiful and attracting more students to the field.

Fortunes subsequently reversed. Since 2003, the NIH's budget has contracted by around 25% in real terms, increasing competition for dwindling grant money among the surplus of early-career scientists created during the boom.

Without steady growth in the NIH budget, some have suggested that the solution is to train fewer graduates for careers in biomedical research. But the pipeline of new investigators shows no signs of drying up. In 2013, US universities conferred 8,471 biomedical PhDs. These joined thousands of other researchers eligible that year for the NIH's Early Stage Investigator awards — 785 grants aimed at researchers who had graduated in the past decade. Too many heirs are awaiting too few crowns. ■

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2. Jones, B. F. *Rev. Econ. Stat.* **92,** 1–14 (2010).

MARK MOFFETT/MINDEN/GETTY; RALPH LEE HOPKINS/GETTY

Ground finches (left) tend to have large beaks for cracking seeds, whereas warbler finches spear insects.

EVOLUTIONARY BIOLOGY

Darwin's finches join genome club

Scientists pinpoint genes behind famed beak variations.

BY GEOFF MARSH

Researchers have sequenced the genomes of all 15 species of Darwin's finches, revealing a key gene responsible for the diversity in the birds' beaks. The study, published online in *Nature* this week[1], also redraws the family tree of these iconic birds, whose facial variations helped Charles Darwin to formulate his theory of natural selection.

The finches are endemic to Ecuador's Galapagos archipelago and Costa Rica's Cocos Island. Their beaks are adapted to their preferred food: warbler finches, for example, spear insects with thin, sharp beaks, whereas ground finches crack open seeds with strong, blunter beaks. The birds are a textbook example of adaptive radiation, in which a single ancestor responds to a selective pressure — in this case, food availability — by diversifying into several species.

Darwin was the first to note this, during his groundbreaking 1831–36 voyage aboard the HMS *Beagle*. "One might really fancy," he wrote in his diary, "that from an original paucity of birds in this archipelago, one species had been taken and modified for different ends." Almost two centuries later, his early suspicions have been widely confirmed.

Initially, the finches were classified on the basis of their physical characteristics. More recently, it has incorporated variations in key DNA sequences. But nobody had compared whole-genome data from all 15 species until a team led by Leif Andersson, a geneticist at Uppsala University in Sweden, analysed samples from 120 individual birds. "When we did the whole DNA sequence of all the species, we could redraw that tree," he says.

Overall, the researchers found good agreement with current taxonomy, but also some interesting deviations. For example, they conclude that the ground finch *Geospiza difficilis*, which is spread across six islands, actually comprises three species.

Andersson's team also discovered extensive mixing of genes between species. This is in line with field observations of hybrid birds made by study co-authors Peter and Rosemary Grant, evolutionary biologists at Princeton University in New Jersey who have worked in the Galapagos for decades. The genomic data reveal that the birds have been crossbreeding throughout their evolutionary history.

Darwin famously sketched his initial idea of phylogeny as a branching tree, above which he wrote "I think". Now, says Peter Grant, "he might wish to redraw that tree by making connections between some of the branches, representing the hybridization and gene exchange".

By looking at closely related finches that have different beak shapes, the researchers were able to pinpoint the genes responsible for beak morphology. One of those genes, *ALX1*, is involved in the facial development of vertebrates, including fish and mammals. In humans, for example, loss of *ALX1* leads to severe facial deformities[2].

In the finches, the gene displayed two distinct variants that matched up neatly with beak shape. Individuals from a species with a highly variable beak shape — the medium ground finch (*Geospiza fortis*) — had a mixture of the blunt and pointed gene variants. The finding dovetails nicely with work by the Grants that documents the species' rapid evolution as recently as the 1980s, when a drought affected the bird's food supply and its beak started to become more pointed to accommodate a new diet[3].

Andersson suspects that *ALX1* drove that adaptation, but others say the picture is more complicated. Beaks "differ in many parameters, not just being blunt or pointed", says Ricardo Mallarino, an evolutionary biologist at Harvard University in Cambridge, Massachusetts. Functional studies of *ALX1* should help to reveal exactly what the gene controls, he says. His colleague, evolutionary biologist Arkhat Abzhanov, says that *ALX1* may be especially important for finches with very specialized beaks.

What would Darwin make of the findings? "We would have to give him a crash course in genetics," Grant says. "But then he would be delighted. The results are entirely consistent with his ideas." ■

1. Lamichhaney, S. *et al. Nature* http://dx.doi.org/10.1038/nature14181 (2015).
2. Uz, E. *et al. Am. J. Hum. Genet.* **86,** 789–796 (2010).
3. Grant, P. R. & Grant, B. R. *40 Years of Evolution: Darwin's Finches on Daphne Major Island* (Princeton Univ. Press, 2014).