The search for beak genes in Darwin’s finches

Educator guide

PAPER DETAILS

Original title: A beak size locus in Darwin’s finches facilitated character displacement during a drought

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DISCUSSION QUESTIONS

	LEARNING STANDARDS
1. When a particular genotype is at a disadvantage, what happens to the genes in that gene pool? What happens at the individual level? What happens to the population as a whole?	**SEP6** **LS3.B** **SP5** **EK1.A.1** **EK1.A.2**
2. Why was it important for the researchers to not only construct a phylogenetic tree based on the entire genome sequences (see Figure 1C), but also based on the *HMGA2* region (see Figure 1D)?	**SEP6** **SP6** **EK1.B.2** **VC1** **NS4**
3. What do the two phylogenetic trees (see Figures 1C and 1D) reveal about the differing sizes of finches?	**SEP6** **Patterns** **LS4.C** **EK1.B.2**
4. How do the findings of this research show how scientific research builds upon previous research? Provide an example.	**Cause and effect** **RST.9-10.9** **VC1** **NS1** **NS5**
5. Do the findings of this study provide enough justification for further studies that would attempt to understand the functions of *HMGA2*? Why or why not?	**Patterns** **EK1.C.3** **NS5**

ACTIVITIES FOR INTERACTIVE ENGAGEMENT

	LEARNING STANDARDS
Writing an abstract Students write a new abstract for the article at a grade-appropriate reading level.	**RST.9-10.2** **RST.11-12.2** **VC1**
Locating this study in the larger field Students use the annotated list of references to explain how this research builds on the published work of at least one other independent group of scientists. Students will evaluate whether data from this research supports or contradicts previous conclusions and reflect on the statement that scientific knowledge is a "community effort."	**RST.9-10.8** **RST.11-12.8** **NS5**
Science in the news Students explore news stories in the Related Resources tab and evaluate the stories for tone, accuracy, missing information, etc. They may then write their own news stories on the article.	**RST.9-10.5** **RST.11-12.5** **RST.9-10.6** **RST.11-12.6** **RST.9-10.8** **RST.11-12.8**
The beak of the finch Students watch the HHMI BioInteractive short film, "The Beak of the Finch." There are a variety of activities that can be used either in conjunction with this film or as separate classroom supplements. HHMI BioInteractive's "Evolution in Action: Data Analysis" offers a classroom-ready lesson for students to get access to some of the scientists' original data. https://www.biointeractive.org/classroom-resources/origin-species-beak-finch https://www.biointeractive.org/classroom-resources/evolution-action-data-analysis	**SEP5** **LS3.B** **LS4.C** **SP5** **EK1.A.2** **EK1.C.3**
Results and conclusions Students diagram each of the experiments presented in the study (divided up by figure, if appropriate). They then consider the results depicted in each figure, and how these results support the conclusions of the study.	**SEP5** **SP5** **NS4**
The next steps Students design a follow-on experiment to this study that either addresses flaws or unanswered questions in the research at hand or builds on it to explore a new question.	**SEP6** **SP6** **VC1** **NS5**

ARTICLE OVERVIEW

Article summary (recommended for educator-use only)

The story of Charles Darwin's finches on the Galápagos islands is one of the most widely used textbook examples of evolution by natural selection. Beak sizes diverged as a result of selective pressures such as drought, competition, and food source availability. However, it has been difficult to understand how this change occurred at the genetic level. Lamichhaney *et al*. used genomic techniques to search for a gene that plays a role in beak size. This research could help scientists begin to understand how genetics might change in response to pressures, and then ultimately lead to a rapid diversification and speciation.

Importance of this research

In earlier research, Lamichhaney and colleagues had previously scanned the genomes of the Galápagos finch populations and found that the *ALX1* was a candidate gene for beak shape regulation. In this study, they searched for a gene, or locus, that played a role in finch beak size. The objective was to determine how beak sizes diverged as a result of a severe drought in 2004–2005.

Experimental methods

- Screened entire genomes of six species of finches to look for genetic variants.
- Genotyped finch individuals that were present during the drought of 2004–2005.
- Sequenced the genomes of finches.
- Generated phylogeny trees by aligning nucleotides of variable positions.
- Performed pairwise, genome-wide fixation index to determine if any regions of the genome showed major differences among the finches.
- Analyzed single nucleotide polymorphisms within the *HMGA2* gene that plays a role in beak size.

Conclusions

- Narrowed down the region of the finch genome that showed the strongest differences between the large, medium, and small beaked finches.
- *HMGA2* gene showed a strong association with beak size.
- *HMGA2* locus allows for a diversity among finch beak size and also for finch fitness.

LEARNING STANDARDS ALIGNMENT

The following tables provide an overview of the learning standards covered by this article, including the A Framework for K-12 Science Education (Framework), Common Core State Standards English Language Arts-Literacy (CCSS ELA), Common Core State Standards Statistics and Probability (CCSS HSS), AP Science Practices, and Vision and Change for Undergraduate Education. Where applicable, activities and information will be marked with specific standards to which they are linked.

A Framework for K-12 Science Education		
Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking (SEP5) Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations **Constructing Explanations and Designing Solutions (SEP6)** Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.	**LS3.B: Variation of traits** Environmental factors can also cause mutations in genes, and viable mutations are inherited. Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depend on both genetic and environmental factors. **LS4.C: Adaptation** The differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. Adaptation also means that the distribution of traits in a population can change when conditions change.	**Patterns** Different patters may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. **Cause and effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Common Core State Standards English Language Arts-Literacy		
Key Ideas and Details	Craft and Structure	Integration of Knowledge and Ideas
RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. **RST.9-10.2** Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text. **RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. **RST.11-12.2** Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.	**RST.9-10.4** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics. **RST.9-10.5** Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy). **RST.9-10.6** Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address. **RST.11-12.4** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics. **RST.11-12.5** Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas. **RST.11-12.6** Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.	**RST.9-10.8** Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. **RST.9-10.9** Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts. **RST.11-12.8** Evaluate the hypotheses, data, analyses, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. **RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

AP Science Standards	
AP Science Practices	AP Biology Content Standards
Science Practice 5 (SP5) The student can perform data analysis and evaluation of evidence. **Science Practice 6 (SP6)** The student can work with scientific explanations and theories.	**Essential knowledge (EK1.A.1)** Natural selection is a major mechanism of evolution. **Essential knowledge (EK1.A.2)** Natural selection acts on phenotypic variations in populations. **Essential knowledge (EK1.B.2)** Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested. **Essential knowledge (EK1.C.3)** Populations of organisms continue to evolve.

Connections to the Nature of Science	
Vision and Change for Undergraduate Biology Education Core Competencies and Disciplinary Practices	A Framework for K-12 Science Education Understandings About the Nature of Science
Ability to apply the process of science (VC1) Understand the process of science and how scientists construct new knowledge by formulated hypotheses and then testing them against experimental and observational data.	**Scientific investigations use a variety of methods (NS1)** New technologies advance scientific knowledge. **Scientific models, laws, mechanisms, and theories explain natural phenomena (NS4)** Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. **Science is a way of knowing (NS5)** Science knowledge has a history that includes the refinement of, and changes to, theories, ideas, and beliefs over time.