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TIPS, TRICKS & TECHNIQUES

Teaching Evolutionary Concepts in Elementary School

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Abstract

Charles Darwin would be pleased to know that elementary school children in states that have adopted the Next Generation Science Standards *(NGSS) are expected to demonstrate their understanding of several core evolutionary concepts, including trait variation and inheritance, fossils and extinct organisms, common ancestry, natural selection, and adaptation. However, he might also wonder how this is accomplished in the demanding 21st-century science curriculum. In files linked to this article, we provide four lesson plans – with engaging examples, natural selection games, and other interactive activities – that were designed to cover the NGSS Disciplinary Core Ideas in evolutionary biology for grades 3–5, in two one-hour lessons. The lesson plans were developed by college students under the guidance of evolutionary biologists and in consultation with elementary school teachers, and then field tested in elementary school classrooms, as described in an accompanying research article.*

Key Words: *adaptation; common ancestry; evolution; natural selection; Next Generation Science Standards; phylogeny; science curricula; science education.*

Evolution by natural selection is of practical importance in medicine, public health, biotechnology, resource management, and agriculture, as well as being the key to understanding life (Dobzhansky, 1973). Nevertheless, many adults in the United States fail to understand evolution (Gregory, 2009), and research has shown that misconceptions developed in childhood are partly to blame (Gregory, 2009; Prinou et al., 2011; Emmons et al., 2018; Lucci & Cooper, 2019). To address this and other shortcomings of the U.S. educational system, the *Next Generation Science Standards* (NGSS) provide clear guidance about which biological concepts and facts students at each grade level should know (California Department of Education, 2019). Natural selection and related ideas are included in the third-grade NGSS (California Department of Education, 2019).

What are the most effective ways to introduce natural selection and related concepts to children? How much classroom time should be devoted to these topics? Which evolutionary concepts do children find most challenging, and which misconceptions might need to be addressed? With these questions in mind, we reviewed the available literature, visited elementary schools to assess what the students knew about evolution, and then worked with elementary school teachers to develop lesson plans to cover all of the NGSS Disciplinary Core Ideas in evolutionary biology. In total, 21 lesson plans were developed and taught in different elementary school classrooms, with standardized multiple-choice quizzes to assess what the students had learned. An accompanying research article in this issue of *ABT* describes in detail the methods and results of this study (Grether, 2021).

Here, we provide links to four of the most successful lesson plans (Lesson Plans 1–4), two examples of multiple-choice quizzes (Quizzes 1 and 2), and the targeted learning objectives (Table S1; see below for a list of Supplemental Material available with the online version of this article). Each lesson plan was designed to be implemented in two one-hour sessions, but they could be split or combined into shorter or longer modules. One quiz could be used, along with other assessment techniques, to evaluate what students in a particular class know about evolutionary concepts prior to the selection of a specific lesson plan or module, and the other quiz could be used to evaluate how much the students retained from the lessons.

Each lesson plan includes an interactive activity to help the students grasp the simplicity and inevitability of natural selection. For example, in Lesson Plan 1, the students simulate differential predation by picking up colored paper circles (the prey) placed against a white background. The surviving colored circles then "reproduce," and the process is repeated. The students observe that the proportion of white circles, which blend in best with the background, is increasing. Then the background is switched to black, the selection process is repeated, and the students observe that the frequency of white circles is now decreasing. This is followed by a classic example of natural selection in action: the increase in melanic morphs of the peppered moth (*Biston betularia*) during the industrial revolution (Majerus, 2009).

Evolutionary tree-building exercises are another common feature of the lesson plans (see Figure 1). For example, Lesson Plan 2 includes an activity in which the students construct a phylogenetic tree for amniotes and map the unique characteristics of each group onto the tree (feathers in birds, hair in mammals, etc.). One of the

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Figure 1. Third-graders learning about evolutionary ancestry through a phylogeny-building activity.

main points of this lesson is that evolution is like a branching tree in which all living organisms at the tips of the tree are equally highly evolved. This exercise is coupled with a lesson on vestigial traits (e.g., the rudimentary wings of flightless birds; James & Olson, 1983; Fong et al., 1995).

Getting students to engage in activities such as these and understand and retain the core evolutionary concepts requires careful planning, skillful classroom management, and well-timed commentary with discussion to ensure that the students do not miss salient points. The fact that we managed to accomplish this after just one prior meeting with the students suggests that it would be relatively easy for experienced teachers to implement the same lesson plans.

○ Supplemental Material

- Table S1 Learning Objectives.docx
- Quiz 1.docx
- Quiz 2.docx
- Lesson Plan 1.docx
- Lesson Plan 1 Appendix 1.1.docx
- Lesson Plan 1 Appendix 1.2.pptx
- Lesson Plan 1 Appendix 1.3.docx
- Lesson Plan 1 Appendix 1.4.docx
- Lesson Plan 1 Appendix 1.5.pptx
- Lesson Plan 2.docx
- Lesson Plan 2 Visuals.pptx
- Lesson Plan 3.docx
- Lesson Plan 3 Lesson 1.pptx
- Lesson plan 3 Lesson 2.pptx
- Lesson Plan 3 Lesson 3.pptx
- Lesson Plan 4.docx
- Lesson Plan 4 Appendix 1a.pptx
- Lesson Plan 4 Appendix 1b.pptx
- Lesson Plan 4 Appendix 1c.docx

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