Evolver Equids: Using Fossil Horses to Teach High School Science

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OVERVIEW

This curriculum uses a well-known and charismatic mammalian family, Equidae, to teach various topics of high school biology.

Students:
- measure hypsodonty indices (HI) of 15 equid species from the early Eocene to the late Pliocene
- observe intraspecific variation and its importance in evolution
- create a phylogeny of horse evolution

The lesson was created in the summer of 2014 during a teacher training program held by the Center for Precollege Education and Training at the University of Florida. The curriculum has since been implemented across the country in middle and high school science classes.

OUTCOMES

Data are based on classroom implementation at St. Ursula Academy, Cincinnati, OH, in 2014 (McLaughlin et al., 2015).

MUCH of the lesson (79%) was spent in deeper investigation of the content (Explain), rather than in addressing prior knowledge (Engage) or simply identifying new concepts (Explore) as specified by the EQUIP instrument.

The high proportion of application, analysis, and creation in the lesson supports the high level of inquiry and engagement.

Students' responses to pre- and post-assessment surveys display satisfaction and learning gains from the lesson.

MESSAGES

"I learned actually how the process of evolution happens, I thought before that if a trait was needed for some reason it would appear. I learned that the trait actually has to be somewhere in genetic variation or caused by DNA mutations."

"I learned that evolution is the change of a species over time, and more specifically over generations. On top of that, contrary to what I used to think, I found out that evolution is not always for the better. Bad traits can be acquired through evolution."

LESSON 1

PART 1 - Paleoenvironmental Reconstruction of the Cenozoic

Students are guided through a discussion of environmental changes during the Cenozoic epochs from the Eocene through the Pleistocene using examples of artists' reconstructions and reinforced with data gathered from the primary literature.

PART 2 - Data Collection

In Part 2, students are given 3D printed teeth from 15 species of horse as depicted below.

- Early Eocene, Wyoming, ~55 Ma
- Early Oligocene, Nebraska, ~33 Ma
- Early Miocene, Florida, ~18 Ma
- Late Miocene, Florida, ~9 Ma
- Early Pleistocene, Florida, ~1 Ma
- Late Pleistocene, Florida, ~200,000 years ago

Using calipers, students take measurements of the anterior-posterior length (APL) of the occlusal surface and the crown height of the 3D prints and record the measurements on the data sheet (at right). Then hypsodonty indices (HI) are calculated for each of the 15 species and also recorded in the data table.

LESSON 2

To complement the macro-scale focus of Lesson 1, Lesson 2 delves into the more mechanistic side of natural selection by focusing specifically on the variation apparent in a single species.

Students are first asked to measure the crown heights, APL, and HI of the six specimens pictured on the sheet (right). They are then asked to observe two morphological character states (as depicted below right):
- protocone (isolated or connected)
- plication (simple of complex)

Then they are asked if the variation they observed is intra-specific or inter-specific variation and what species is (are) represented based on the data collected in Lesson 1.

Lesson 2 is concluded by discussing the importance of variation on evolution.

LESSON 3

Lesson 3 dives into the misconception of "straight-line" evolution, or orthogenesis, as it pertains to horse evolution. As reported in MacFadden et al. (2013), many natural history museums contain exhibits depicting the evolution of horses orthogenetically, perpetuating the misconception that evolution progresses linearly.

The students use the data collected and observations made in Lessons 1 and 2 to create their own phylogenies of horse evolution. In addition to displaying the "branching" evolutionary pattern in horses, they also overlay the predominant type of vegetation to show how closely tied horse evolution is to environmental change.

Students conclude and synthesize the information learned throughout the curriculum by presenting the posters of equid phylogeny to classmates. This requires students not only recall information learned throughout the three lessons, but also to synthesize and communicate that information to peers.

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REFERENCES
