Evolving Equids: Using Fossil Horses to Teach High School Science

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OVERVIEW

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

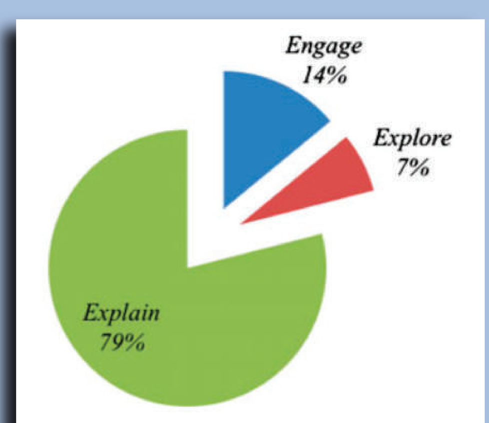
Students:
- measure hypsodonty indices (HI) of 15 equid species from the early Eocene to the late Pleistocene
- look at changes in HI in relation to changes in paleoenvironment
- observe intraspecific variation and its importance in evolution
- create a phylogeny of horse evolution


Credit: Danielle Byerly

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

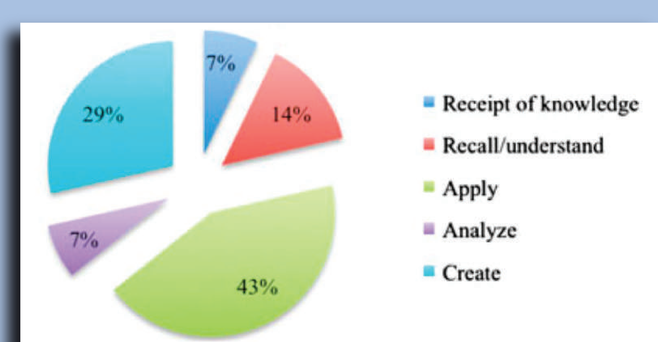
OUTCOMES

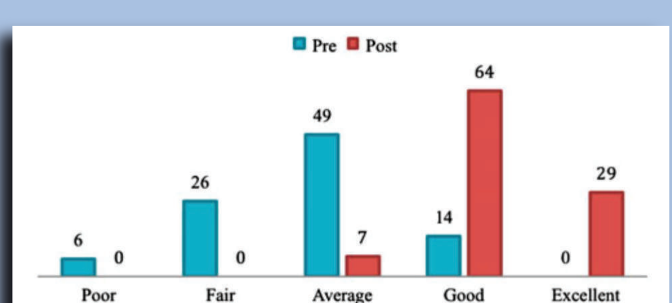
Data are based on classroom implementation at St. Ursula Academy, Cincinnati, OH, in 2014 (McLaughlin et al., 2015).



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.

"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."

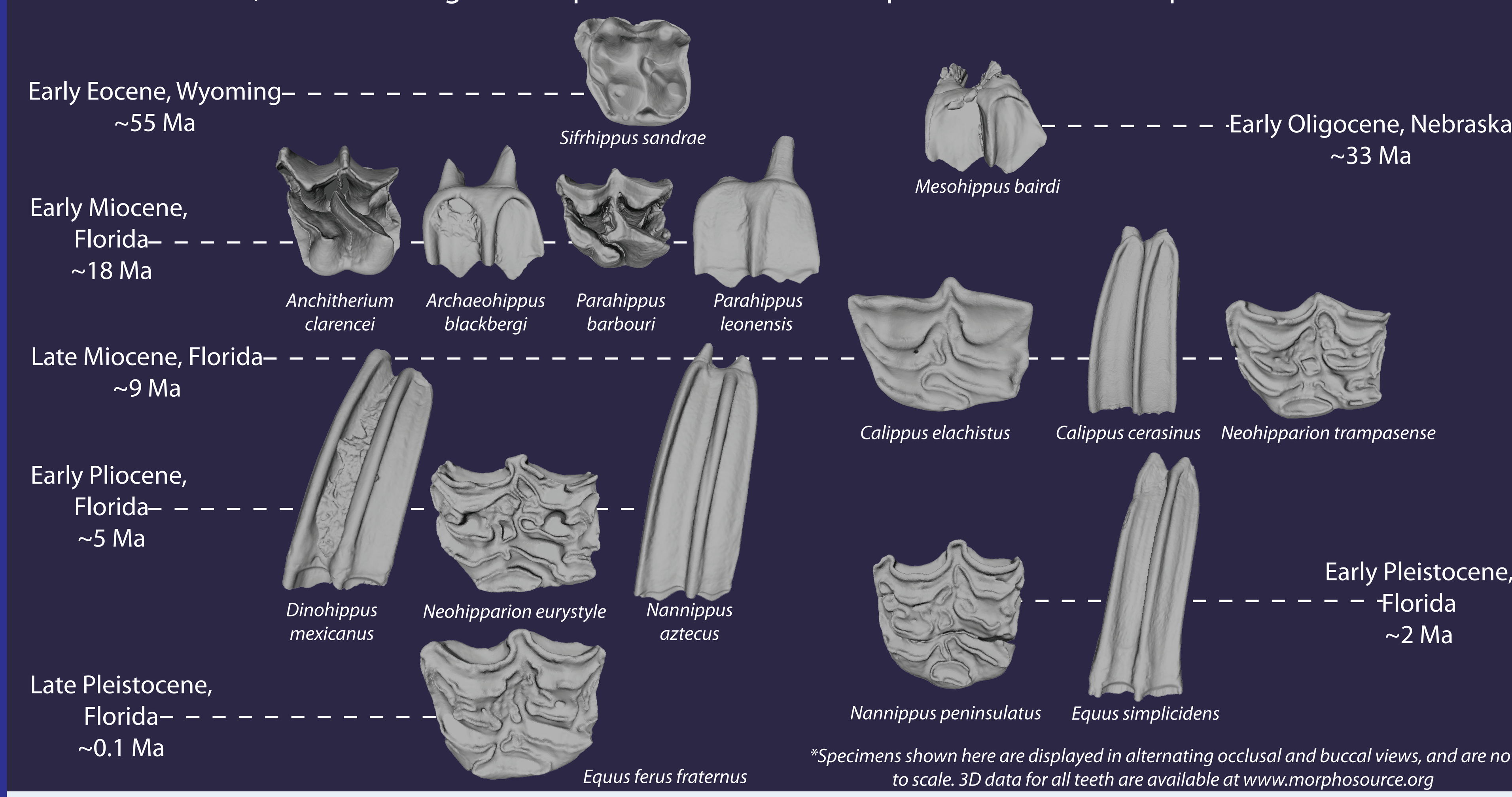
LESSON 1

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.

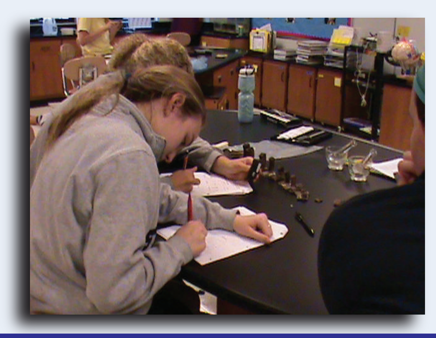
PART 2- Data Collection

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



**Specimens shown here are displayed in alternating occlusal and buccal views, and are not to scale. 3D data for all teeth are available at www.morphosource.org*

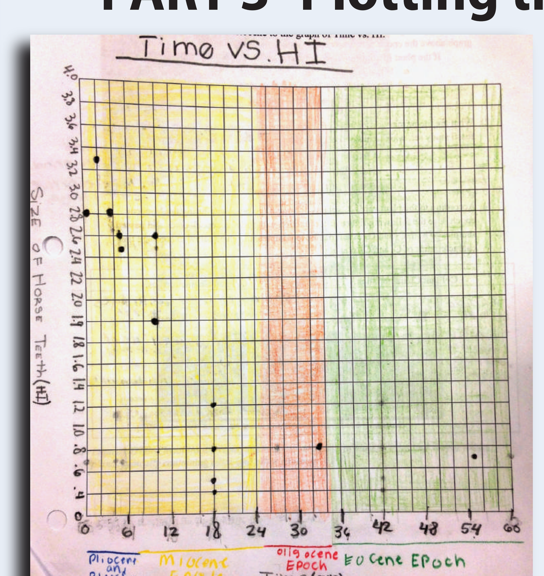
Using calipers, students take measurements of the anterior-posterior length (APL) of the occlusal surface and the crown height of the 3D prints and record the measurements on the data sheet (at right). Then hypsodonty indices (HI) are calculated for each of the 15 species and also recorded in the data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



Horse Tooth Data Table (3D printed specimens)

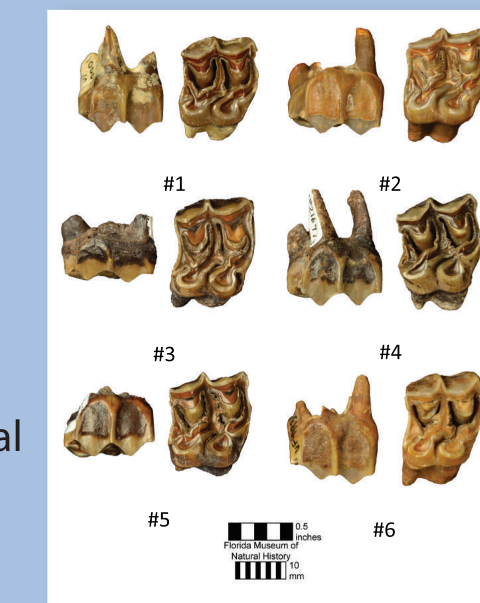
Age (Ma)	Location	Species	Catalog Number (Tooth number)	Crown Height (mm)	APL (mm)	HI (height/APL)
55	Wyoming	*Sifrhippus sandrae*	*UF 252687* **(1)**			
33	Nebraska	*Mesohippus bairdi*	*UF 137889* **(2)**			
18	Thomas Farms, Gilchrist County, Florida	*Anchitherium clarencei*	*UF 2211401* **(3)**			
		Parahippus leonensis	*UF 6597* **(4)**			
		Archaeohippus blackbergi	*UF/FGS 11166* **(5)**			
		Parahippus barbouri	*UF 270648* **(6)**			
9	Love Site, Alachua County, Florida	*Calippus elachistus*	*UF 53577* **(7)**			
		Calippus cerasinus	*UF 60323* **(8)**			
		Neohipparion trampasense	*UF 62299* **(9)**			
5	Bone Valley, Polk County, Florida	*Dinohippus mexicanus*	*UF 124196* **(10)**			
		Neohipparion eurystyle	*UF 208601* **(11)**			
		Nannipus aztecus	*UF 302417* **(12)**			
2	Santa Fe River Bed, Columbia County, Florida	*Nannipus peninsulatus*	*UF 22614* **(13)**			
	Haile Site 15A, Alachua County, Florida	*Equus simplicidens*	*UF/TRO 32072* **(14)**			
0.1	Waccasassa River Site 9, Levy County, Florida	*Equus ferus fraternus*	*UF/TRO 2149* **(15)**			

PART 3- Plotting the Data and Interpretation



- HI vs. Age of Fossil is plotted
- Predominant vegetation (as covered in Part 1) is shaded on the graph
  - Green for mainly forests
  - Orange for forests and grasslands
  - Yellow for mostly grasslands
- Students observe a correlation between increased hyposodonty and an increase in grassland area

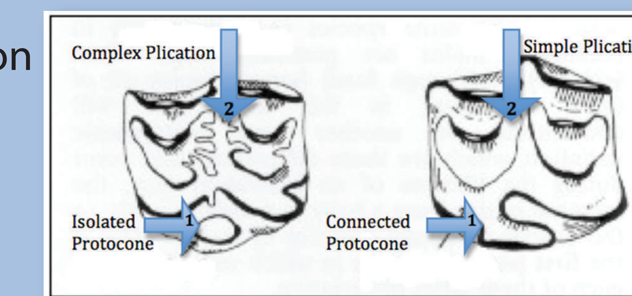
LESSON 2



To compliment 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.

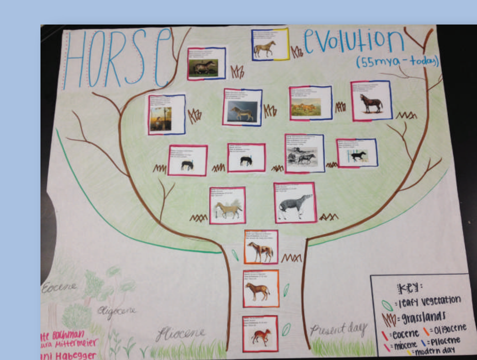
Students are first asked to measure the crown heights, APLs, and HIs of the six specimens pictured on the sheet (right). They are then asked to observe two morphological character states (as depicted below right):
- protocone (isolated or connected)
- plication (simple of complex)

Then they are tasked 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 othogenesis, as it pertains to horse evolution. As reported in MacFadden et al. 2012, 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 throughtout the curriculum by presenting the posters of equid phylogeny to classmates. This requires students to not only recall information learned thoughout the three lessons, but also to synthesize and communicate that information to peers.

ACKNOWLEDGEMENTS

The authors thank the Frances P. Smallwood Foundation, the National Center for Research Resources Science Education Partnership Award (1 R25 RR023294-01A2), and the National Science Foundation (PIRE 0966884) for supporting this project financially and for the many scientists, educators, and students who have assisted in the formation and improvement of this curriculum.

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