LESSON 1
Exploring the Geologic Time Scale via Changes in Fossilized Horse Teeth in Response to Co-evolution of Plants

VOCABULARY

EPOCH: a period of time in history
FOSSIL: any preserved evidence of life from a past geological age, such as the impressions and remains of organisms embedded in stratified rocks
MORPHOLOGY: the form and structure of an organism
PALEONTOLOGIST: a person who studies forms of life existing in prehistoric or geologic times, as represented by the fossils of plants, animals and other organisms

LESSON SUMMARY

As an opening activity the class is presented with a slide show of illustrations representing the physical landscape of each of the five epochs explored in this lesson. As a class students make observations about the types of flora present in each epoch. Next, in collaborative learning groups students measure and sketch physical characteristics of fossilized horse teeth from a 3D printed study set provided by the FLMNH. Each group produces a graph that summarizes the trend between age of the fossil and hypsodonty index (HI, essentially the length of the tooth divided by the width). Plant information cards summarizing each epoch are also provided to each group and superimposed on the student graph. Guided analysis questions allow students to develop an explanation for the change in horse teeth in response to plant evolution.

STUDENT LEARNING OBJECTIVES

• Students will construct an explanation based on evidence from fossilized horse teeth for how natural selection leads to adaptation of populations.
• Students will be able articulate how species evolve in response to climate change and other species (coevolution).

MATERIALS

• 3D printed fossil horse teeth study set (1 set of 15 teeth per student group)
• Calipers (1 per student group)
• Colored pencils or crayons (green, orange, and yellow)
• Soft leaf and rough grass samples for grinding
• Mortar and pestle (either one for demonstration or one per group)
• Epoch Plant Cards
• Student Page: Exploring Changes in Horse Teeth Lab Procedure

KEY QUESTION(S):
What can fossilized horse teeth and changes in plant species tell us about the evolution of horses during the Cenozoic Era?

OVERALL TIME ESTIMATE:
Two 45 minute class periods

LEARNING STYLES:
Visual, Kinesthetic, Auditory, Cooperative
BACKGROUND INFORMATION

The rationale behind this lesson was to provide the students with a genuine scientific method for investigating how change occurs in a taxon over time. Hypsodonty is simply a scientific term for the height of a tooth relative to its overall size. Hypsodonty indices (HIs) are often used by scientists who study mammals as a proxy for this tooth height. One could imagine that simply measuring the crown height of a large animal, such as a mammoth, would provide a much larger crown height as compared to any horse. However, horse teeth are significantly smaller, but some horses have longer teeth relative to their size. Therefore, measuring hypsodonty, by dividing crown height by anterior-posterior length, allows for control on the size of a tooth to obtain a more accurate representation of tooth length. (Stromberg [2005] provides an excellent overall of the use of hypsodonty in paleontology)

Horses are used in this curriculum for several important reasons. First of all, they are easily recognizable to the general public and not an animal only known from fossils. Importantly, fossil horses have an extraordinary fossil record in North America with fossil specimens coming from the early Eocene (~55 Ma) to just 10,000 years ago. Lastly, the major change in dietary strategy in horses from browsing (like the feeding style of a giraffe) to grazing (like horses today) is strongly correlated with climate change — and therefore ecological change — and seen evolutionarily in the higher-crowned teeth of more recent horses.

ADVANCE PREPARATION

- 3D print Fossil Horse Teeth Study Set
  
  (Implementation note: The 3D printing files for the fossil horse teeth are located at MorphoSource.org. Our friends at Paleoteach have created a tutorial for using the MorphoSource database and downloading the files for printing. You can access the tutorial here: http://www.paleoteach.org/specimens/fossil-horses/database-inquiry/ You may need to convert these files into a different format, depending on the 3D printer. MeshLab is opensource software that can convert the files into the STL format, which is what our printers at the University of Florida require. 3D printing needs to be planned well in advance of implementation, as depending on the speed of the printer, the number of sets you are printing, and the potential backlog of the 3D printer, it may take several days for your 3D models to be ready.)

- Read Background Information

- Print Epoch Cards in color (consider laminating for future use) (1 set per group)

- Print Student Page: Exploring Changes in Horse Teeth Lab Procedure and Data Sheet (1 copy per group)

- Watch video discussing how to use the calipers and take crown length and APL measurements (https://youtu.be/SWr2jMu322g)

- Prepare images of epoch landscapes for projection (http://prod.cpet.ufl.edu/wp-content/uploads/2014/12/EPOCHS-slideshow.pptx)

- Examine teeth from study set and practice taking crown length and APL measurements to demonstrate to students

- Locate samples of C₃ and C₄ plants for use during Day Two, Part IV or identify samples on campus for students to discover as browsers and grazers.
PROCEDURE AND DISCUSSION QUESTIONS WITH TIME ESTIMATES

DAY ONE

1. **1-3 MINUTES** Distribute the 3D printed study sets, calipers and Student Page: Exploring Changes in Horse Teeth Lab Procedure and Data Sheet to each group (2-3 students are suggested for groups for the duration of this curriculum module)

2. **5-7 MINUTES** Project paintings with artists’ renderings of each of the major epochs on the screen and ask students to make and record observations in Pre-Lab section of the Exploring Changes in Horse Teeth Lab Procedure and Data Sheet
   *(Implementation note: Do this as a whole class discussion and guide students to see the environmental differences, particularly drawing their attention to the moist, warm environment and flora present in each. As a wrap up for this lesson, return to these pictures and discuss how horses evolved in response to the environment, introducing additional adaptations students are likely familiar with such as a longer neck better adapted for grazing and change to standing on one toe that allows for an elongated leg that is better adapted for running in the hard ground of grasslands to escape predators.)*

3. **8-10 MINUTES** Draw students’ attention to the Horse Tooth Variation Guide embedded in Part II of the and Student Page: Exploring Changes in Horse Teeth Lab Procedure and Data Sheet. Show the How to measure horse teeth video. Demonstrate how to make the measurements and check for correct APL alignment using the modern horse head with embedded teeth in jaw, as necessary and if available.

4. **25 MINUTES** Circulate as students record data and make variation observations of the study set specimens (Parts I & II)

DAY TWO

1. **1-3 MINUTES** Redistribute study sets and other materials as necessary to students.

2. **2 MINUTES** Instruct students to create a scatter plot style graph of the data they collected the previous day, on the provided graph paper in Part III of the and Student Page: Exploring Changes in Horse Teeth Lab Procedure and Data Sheet. *(Implementation note: two versions of the graph paper have been provided, depending on the level of the students and the teacher’s learning goals.)*

3. **15-20 MINUTES** Circulate as students create graphs in Part III and also quietly pass out the Epoch Cards that will be required for Part IV-one set to each group.

4. **20 MINUTES** Instruct students to use the Epoch Cards, physically ground samples of a of a C₃ and C₄ plant and the information embedded in the Student Page: Exploring Changes in Horse Teeth Lab Procedure and Data Sheet to complete Part IV. Circulate and support student exploration as necessary.
   *(Implementation note: student groups can be provided plant samples to grind and observe differences at the group level, as a whole-class demonstration, or as a station that student groups visit. Teachers can also consider having students be browsers and grazers and explore the schoolyard for their own representative samples.)*

ASSESSMENT SUGGESTIONS

- Collect Data Sheet (embedded in the Student Lab Procedure) from lab groups

EXTENSIONS

Exploring the relationship between changes in CO₂ levels in the environment and the evolution of C₄ plants *(IN DEVELOPMENT)*
RESOURCES/REFERENCES


Presentation by Dr. Bruce MacFadden: Fossil Horses: Icons of Evolution Exhibits https://vimeo.com/120397381 (The video quality is not great, but Dr. MacFadden provides an excellent overview of the topic that inspired this curriculum.)

<table>
<thead>
<tr>
<th>Epoch</th>
<th>Age (Ma)</th>
<th>Location</th>
<th>Species</th>
<th>Catalog Number</th>
<th>Crown Height (mm)</th>
<th>APL (mm)</th>
<th>HI (height/ APL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>55</td>
<td></td>
<td>Wyoming</td>
<td><em>Sifrhippus sandrae</em></td>
<td>UF 252687</td>
<td>2.9 mm</td>
<td>6.1 mm</td>
<td>0.48</td>
</tr>
<tr>
<td>33</td>
<td></td>
<td>Nebraska</td>
<td><em>Mesohippus bairdi</em></td>
<td>UF 137889</td>
<td>9.2 mm</td>
<td>13.8 mm</td>
<td>0.67</td>
</tr>
<tr>
<td>18</td>
<td></td>
<td>Thomas Farms, Gilchrist County, Florida</td>
<td><em>Anchitherium clarencei</em></td>
<td>UF 221401</td>
<td>12.6 mm</td>
<td>19.9 mm</td>
<td>0.63</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Parahippus leonensis</em></td>
<td>UF/FGS 6597</td>
<td>15.9 mm</td>
<td>16.7 mm</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Archaeohippus blackbergii</em></td>
<td>UF/FGS 11166</td>
<td>7.7 mm</td>
<td>10.1 mm</td>
<td>0.76</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Parahippus barbouri</em></td>
<td>UF 270648</td>
<td>14.6 mm</td>
<td>16.1 mm</td>
<td>0.91</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>Love Site, Alachua County, Florida</td>
<td><em>Calippus elastistus</em></td>
<td>UF 53577</td>
<td>35.0 mm</td>
<td>13.9 mm</td>
<td>2.52</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Calippus cerasinus</em></td>
<td>UF 60323</td>
<td>36.2 mm</td>
<td>17.2 mm</td>
<td>2.11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Neohipparion trampasense</em></td>
<td>UF 62299</td>
<td>48.2 mm</td>
<td>21.4 mm</td>
<td>2.25</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Bone Valley, Polk County, Florida</td>
<td><em>Dinohippus mexicanus</em></td>
<td>UF 124196</td>
<td>60.7 mm</td>
<td>24.2 mm</td>
<td>2.51</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Neohipparion eurystyle</em></td>
<td>UF 208601</td>
<td>61.7 mm</td>
<td>23.6 mm</td>
<td>2.61</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Nannipus aztecus</em></td>
<td>UF 302417</td>
<td>37.7 mm</td>
<td>14.3 mm</td>
<td>2.64</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Santa Fe River Bed, Columbia County, Florida</td>
<td><em>Nannipus peninsulatus</em></td>
<td>UF 22614</td>
<td>49.9 mm</td>
<td>18.3 mm</td>
<td>2.73</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Equus (plesippus) simplicidens</em></td>
<td>UF/TRO 32072</td>
<td>76.1 mm</td>
<td>29.3 mm</td>
<td>2.60</td>
</tr>
<tr>
<td>0.1</td>
<td></td>
<td>Waccasassa River Site 9, Levy County, Florida</td>
<td><em>Equus ferus</em></td>
<td>UF/TRO 2149</td>
<td>79.9 mm</td>
<td>28.0 mm</td>
<td>2.85</td>
</tr>
</tbody>
</table>
At the beginning of the Eocene, the high temperatures and warm oceans created a moist, balmy environment, with forests spreading throughout the Earth from pole to pole. Apart from the driest deserts, scientists hypothesize the Earth was entirely covered in forests. Polar forests were quite extensive. Fossils and preserved remains of trees such as swamp cypress and dawn redwood from the Eocene have been found in the Arctic. Fossils of subtropical and even tropical trees and plants from the Eocene have also been found in Greenland and Alaska. Tropical rainforests grew as far north as northern North America and Europe. Palm trees were growing as far north as Alaska and northern Europe during the early Eocene, although they became less abundant as the climate cooled.

Cooling began mid-epoch, and by the end of the Eocene continental interiors had begun to dry out, with forests thinning considerably in some areas. The newly evolved grasses were still confined to river banks and lake shores, and had not yet expanded into plains and savannahs. The cooling also brought seasonal changes. Deciduous trees, better able to cope with large temperature changes, began to overtake evergreen tropical species. By the end of the epoch, deciduous forests covered large parts of the northern continents, including North America, Eurasia and the Arctic, and rainforests only remained in equatorial South America, Africa, India and Australia. Antarctica, which began the Eocene fringed with a warm temperate to sub-tropical rainforest, became much colder as the epoch progressed; the heat-loving tropical flora was wiped out, and by the beginning of the Oligocene, the continent hosted deciduous forests and vast stretches of tundra.
OLIGOCENE FLORA (33.9 - 23 MA)

Angiosperms continued their expansion throughout the world as temperate deciduous forests replaced tropical and sub-tropical forests. Grasslands began to expand and forests (especially tropical ones) began to shrink. Grasses, a product of the cooler, drier climate, became one of the most important groups of organisms on the planet. As they spread extensively over several million years, they fed herds of grazing mammals, sheltered smaller animals and birds, and stabilized soil, which in turn reduced erosion. They are high-fiber, low-protein plants and must be eaten in large quantities to provide adequate nutrition. Because they contain tiny silica fragments, though, they are tough to chew and wear down animal teeth. Grasses, which grow throughout the blade, are adapted to recover quickly after their tips are grazed. However, even at the end of the epoch, grass was not as common as one would observe in a modern savannah today.
MIOCENE FLORA (23-5.3 MA)

Plant studies of the Miocene have focused primarily on spores and pollen. Such studies show that by the end of the Miocene 95% of modern seed plant families existed. A mid-Miocene warming, followed by a cooling is considered responsible for the retreat of tropical ecosystems, the expansion of northern coniferous forests, and increased seasonality. Prior to this time all plants were classified as C\textsubscript{3} because the CO\textsubscript{2} is first incorporated into a 3-carbon compound. In C\textsubscript{3} the enzyme rubisco is involved in the uptake of CO\textsubscript{2}. While C\textsubscript{3} plants function very well in cool, moist conditions as the temperature warmed, a new photosynthetic pathway evolved. This new pathway was called C\textsubscript{4} because the CO\textsubscript{2} is first incorporated into a 4-carbon compound. C\textsubscript{4} plants photosynthesize faster than C\textsubscript{3} plants under high light intensity and high temperatures.

Although the C\textsubscript{4} pathway is more complicated (requires more enzymes and specialized plant anatomy), C\textsubscript{4} plants do not need to keep stomata open as much and lose less water to transpiration (evaporation of water through stomata). The C\textsubscript{4} pathway also causes the uptake of more silica (a glass-like material) that resulted in the diversification of modern grasses and sedges. The evolution of gritty, fibrous, fine-tolerant grasses led to a major expansion of grass-grazer ecosystems, with roaming herds of large, swift grazers pursued by predators across broad sweeps of open grasslands, displacing desert, woodland, and browsers.

Rhinoceros, camels, and horses of the Miocene era. This is the original painting for the mural in the recently restored Hall of Prehistoric Mammals in the Lila Acheson Wing of the American Museum of Natural History in New York City.
PLIOCENE FLORA (5.3 – 2.6 MA)

The change to a cooler, dry, seasonal climate had considerable impacts on Pliocene vegetation, reducing tropical species worldwide. Deciduous forests proliferated, coniferous forests and tundra covered much of the north, and grasslands spread on all continents (except Antarctica). Tropical forests were limited to a tight band around the equator, and in addition to dry savannas, deserts appeared in Asia and Africa. In the higher latitudes, cool-weather plants evolve. Hardy plants that can tolerate a short growing season, such as sedges, mosses, and lichens, inhabit the almost permanently frozen tundra. In slightly warmer regions, taiga forests consist mostly of evergreens. In lower latitudes, grasslands are marked by fewer and fewer trees. These habitats offer limited food sources for animals and support less diversity.
PLEISTOCENE FLORA (2.6 - 0.01 MA)

During the Pleistocene, glaciers repeatedly advance from the Arctic north over Europe and North America, then retreat. The first major glacial flow occurs about 1.6 Ma. Ice, up to a mile thick in places, spreads from Greenland over the Arctic Sea into northern Europe and Canada. As the ice advances, temperatures ahead of the flow drop significantly.

The temperature change has a profound impact on life. Mammoths, rhinos, bison, reindeer, and musk oxen all evolve to have warm, woolly coats to protect them from frigid conditions. These new mammals feed on the small bushes and hardy grasses that tolerate cold as they follow the moving line of glaciers. Glacial retreats allow for the temporary return of warm-weather plants such as oak and beech trees, lush grasses, and flowers. During these “interglacial” periods, species that sought shelter in the warmer south return to their old habitats.

http://en.wikipedia.org/wiki/Pleistocene
Exploring Changes in Horse Teeth — Lab Procedure and Data Sheet

INTRODUCTION
Horses are beloved creatures, and paleontologists have compiled one of the most extensive fossil records of any animal that has existed in North America. In this lab you will examine 3D printed models of fossil horse teeth from the Florida Museum of Natural History vertebrate paleontology collection housed at the University of Florida to determine what patterns of change have occurred in horses.

PRE-LAB
Observe five paintings from different epochs (periods in time) as they are projected. For each image, write down three observations in the space below. Since plants are the basis of an ecosystem, at least one of your observations must deal with the vegetation.

Painting 1 - Eocene Epoch (55.8-33.9 Ma)

Painting 2 - Oligocene Epoch (33.9-23 Ma)

Painting 3 - Miocene Epoch (23-5.3 Ma)

Painting 4 - Pliocene Epoch (5.3-2.6 Ma)

Painting 5 - Pleistocene Epoch (2.6-0.017 Ma)
PROCEDURE

PART I

1) Use the horse data table to familiarize yourself with the 3D models and determine which model tooth corresponds to each listed fossil.

2) Choose ONE horse tooth from each epoch and sketch it in the space provided below. (NOTE: you have multiple specimens from each epoch in the provided study set. Just choose one and make a quick representative sketch to indicate relative size and complexity.)

REPRESENTATIVE HORSE TEETH SKETCHES FROM EACH EPOCH

EOCENE

OLIGOCENE

MIOCENE

PLIOCENE

PLEISTOCENE
PART II

1) Using the calipers measure the height of each tooth. Measure from the bottom of the crown (NOTE: This does NOT include the root of the tooth) to the highest point on top surface (See diagram A). Next, measure the anterior-posterior length (APL) of each tooth. This is the length from the part of the tooth closest to the horse’s muzzle to the part of the tooth closest to the back of the horse’s jaw. (See diagram B and a modern horse head with teeth embedded in the jaw for clarification, if necessary). Record the measurements on the data sheet provided below.

2) Calculate the hyposodonty index (HI) of each tooth using the following formula:
   \[ HI = \frac{\text{crown height}}{\text{APL}} \]
   Record the HI values on the data table.

3) Complete the epoch column: *Ma = millions of years ago
   - Current epoch: Holocene
   - Pleistocene epoch: 2.588Ma-0.0117Ma (2.5my)
   - Pliocene epoch: 5.332-2.588Ma (2.7my)
   - Miocene epoch: 23.03-5.332Ma (18my)
   - Oligocene epoch: 33.9-23.03Ma (10my)
   - Eocene epoch: 55.8-33.9Ma (22my)

Figure from MacFadden (1988) *Fossil horses from “Eohippus” (Hyracotherium) to Equus, 2: rates of dental evolution revisited*
<table>
<thead>
<tr>
<th>Epoch</th>
<th>Location</th>
<th>Species</th>
<th>Catalog Number</th>
<th>Crown Height (mm)</th>
<th>APL (mm)</th>
<th>HI (height/APL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>55</td>
<td>Wyoming</td>
<td>Sifrhippus sandrae</td>
<td>UF 252687</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Nebraska</td>
<td>Mesohippus bairdi</td>
<td>UF 137889</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Thomas Farms, Gilchrist County, Florida</td>
<td>Anchitherium clarencei</td>
<td>UF 221401</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Parahippus leonensis</td>
<td>UF/FGS 6597</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Archaeohippus blackbergi</td>
<td>UF/FGS 11166</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Parahippus barbouri</td>
<td>UF 270648</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Love Site, Alachua County, Florida</td>
<td>Calippus elachistus</td>
<td>UF 53577</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Calippus cerasinus</td>
<td>UF 60323</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Neohippiparion trampasense</td>
<td>UF 62299</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Bone Valley, Polk County, Florida</td>
<td>Dinohippus mexicanus</td>
<td>UF 124196</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Neohippiparion eurystyle</td>
<td>UF 208601</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nannipus aztecus</td>
<td>UF 302417</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Santa Fe River Bed, Columbia County, Florida</td>
<td>Nannipus peninsulatus</td>
<td>UF 22614</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Haile Site 15A, Alachua County, Florida</td>
<td>Equus (plesippus) simplicidens</td>
<td>UF/TRO 32072</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.1</td>
<td>Waccasassa River Site 9, Levy County, Florida</td>
<td>Equus ferus</td>
<td>UF/TRO 2149</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
PART III:

1) Graph the tooth measurements using the grid below. Time is the independent variable (x-axis) and the tooth hypsodonty index (HI) is the dependent variable (y-axis).

2) Add the names of the 5 Epochs below the corresponding year ranges: Eocene, Oligocene, Miocene, Pliocene and Pleistocene to the graph of Time vs. HI.
PART III:

1) Graph the tooth measurements using the grid below. Time is the independent variable (x-axis) and the tooth hypsodonty index (HI) is the dependent variable (y-axis).

2) Add the names of the 5 Epochs below the corresponding year ranges: Eocene, Oligocene, Miocene, Pliocene and Pleistocene to the graph of Time vs. HI.
PART IV:
CHANGES IN HORSE TEETH IN RELATIONSHIP TO CHANGES IN PLANTS

Complete the following using the provided Epoch Cards:

1) Using the criteria listed below shade/color directly onto the graph from Part III the primary type of plant life present in each epoch. (Note: color the entire space on the graph above the epoch name, not just the epoch name).

   If the plant life during the epoch could be categorized as:
   
   - Mainly forests: Green
   - Forests and grasslands (not savannas): Orange
   - Primarily grasslands and savannas: Yellow

2) Observe the sample plants provided. What are the primary differences between forest leaves and grasses? From the fossil study set, which kind of teeth would be more effective for eating grasses?

3) According to the plant cards, C₄ plants became more prevalent during the Miocene epoch. Use the following figures of phytoliths in conjunction with the epoch cards and samples of C₃ and C₄ extant plants, to complete the chart below to compare the characteristics of C₃ and C₄ plants.

<table>
<thead>
<tr>
<th>C₃ Plant Characteristics</th>
<th>C₄ Plant Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
C3 & C4 GRASS PHYTOLITHS
from: http://www.bio.uu.nl/~palaeo/research/namibia/namibia.htm

Figure NOTE: Phytoliths are rigid, microscopic structures of varying sizes and shapes found in plants, typically containing silica and other minerals.
4) Using the graph developed in Part III above and the plant information cards, propose the relationship between plant evolution and horse evolution.

5) In this exercise you saw that the Earth's climate changes over time. If Earth's climate was to change again and tropical forests covered the majority of the land, how would you expect the morphology of horse teeth to change? (Assume horses have enough genetic diversity present for tooth modifications…. that's a big assumption to make!)

6) What might happen to modern horses if the climate changed and tropical forests covered the majority of the earth and there was no diversity present in the genes for tooth modification?