

InTeGrate

*Interdisciplinary Teaching of Geoscience
for a Sustainable Future*



The Changing Biosphere: Lessons from the Past

Environmental Change and Horses



This work is supported by a National Science Foundation (NSF) collaboration between the Directorates for Education and Human Resources (EHR) and Geosciences (GEO) under grant DUE - 1125331



Equidae (Horse Family)

Taxonomic family that includes horses, zebras, and asses/donkeys.



Tibetan wild ass (*Equus kiang*)
at the Prague Zoo. Photo by
Bodlina.



Domesticated horse
(*Equus caballus*)

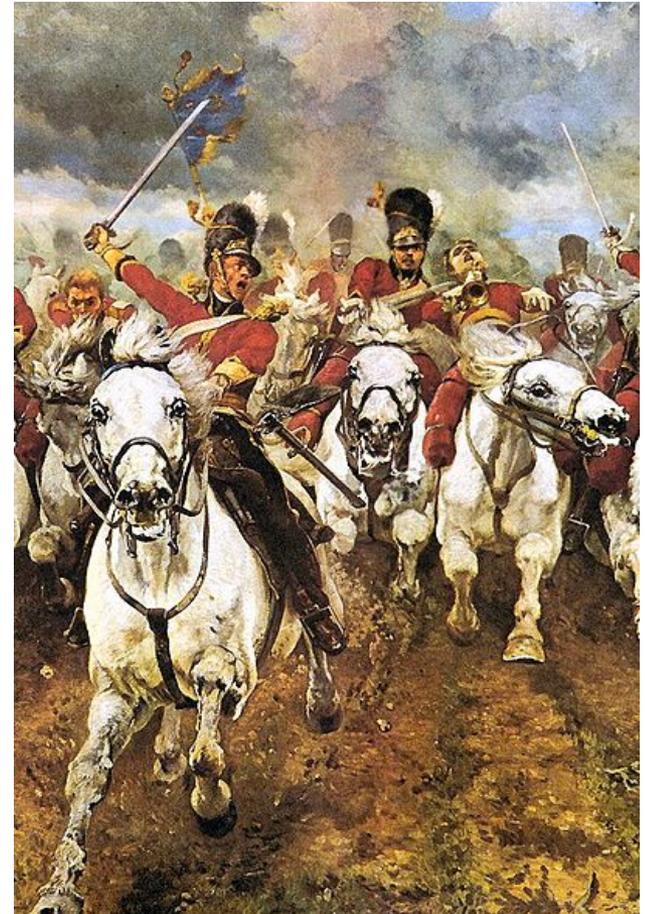


Plains Zebra (*Equus quagga*).
Photo by Gusjer.



Equidae have had profound impacts on societies:

- Food (meat and milk)
- Transportation
- Work
- Wars
- Recreation



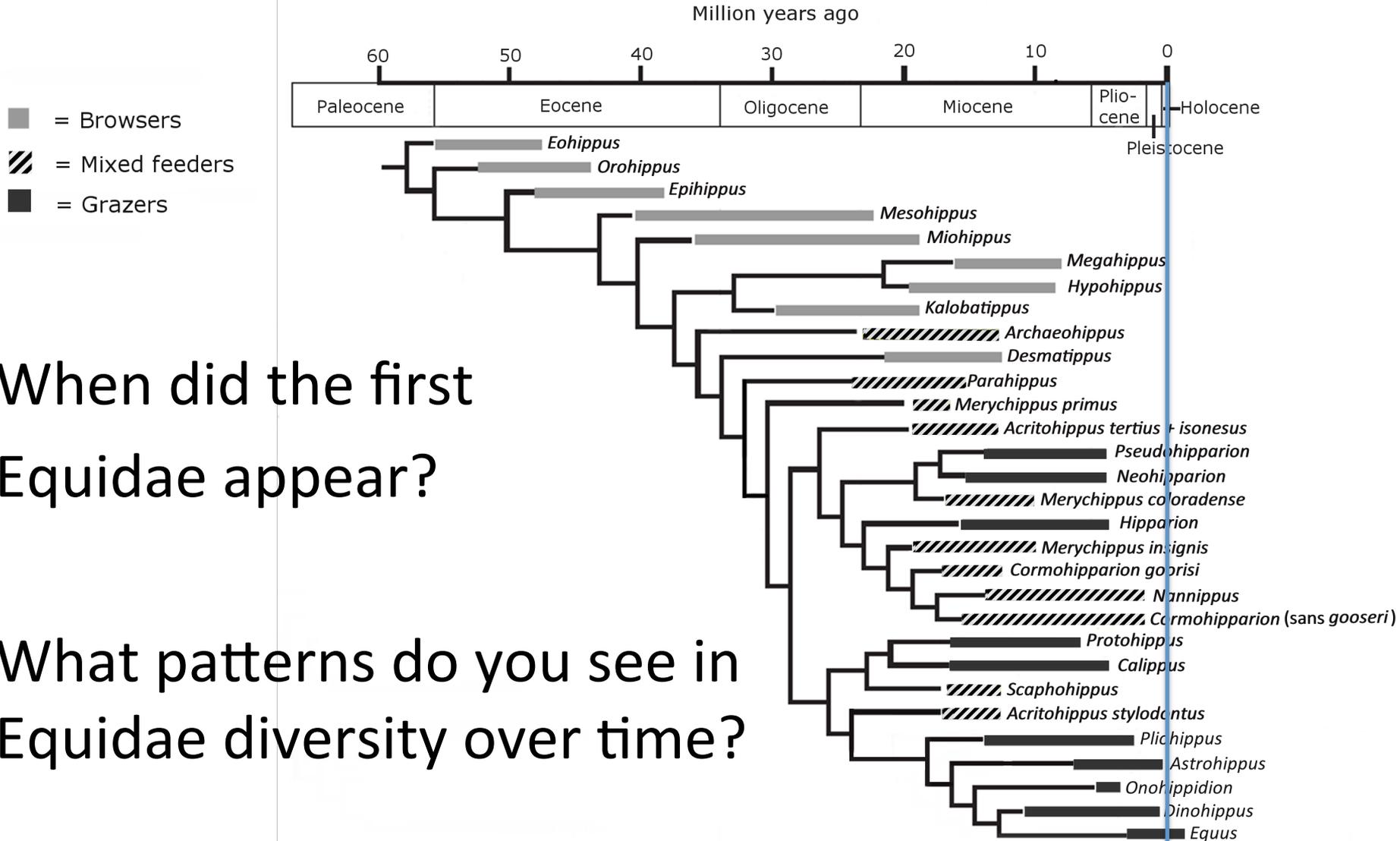


Equidae Diversity

- Today the Equidae has only one genus (*Equus*) with seven species (3 wild asses, 3 zebras, and the horse).
- In the past, there were many more taxa in the horse family:



Equidae Diversity





Adaptive Radiation of Equidae

- Equidae fossils are abundant and widespread, providing a well-documented example of **adaptive radiation**.
- **Adaptive radiation** is the process in which organisms diversify into several new forms. This is particularly common when changing environmental conditions lead to new challenges or resources.
- Knowing how species have responded to environmental changes can help us better understand the impacts of human-caused climatic and habitat changes on species.



Video: The Making of the Fittest

So, how do new species arise?

- How did dark-colored pocket mice first appear in a population of light-colored pocket mice?
- Why would dark-colored pocket mice become more common over time on the lava flows?



Case Study: Climate, Biomes, & Equidae

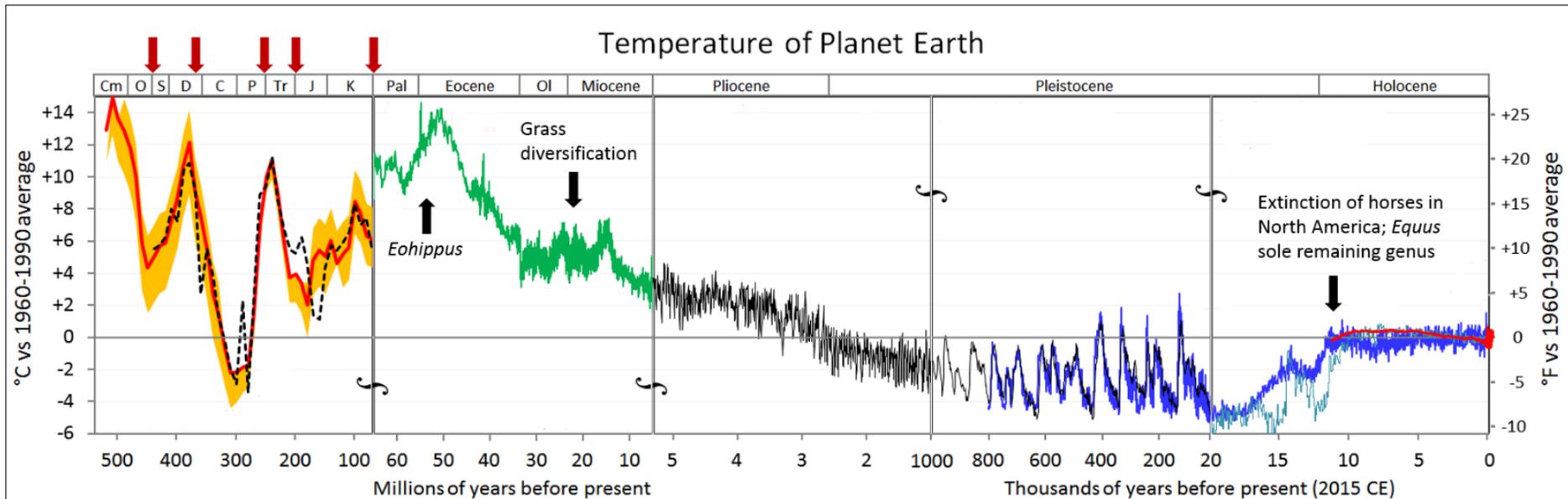
In today's activity, you will explore how environmental changes can shape life on Earth, using Equidae as a case study. By the end of the activity you should be able to:

1. Describe how biodiversity increases with the evolution of new species and decreases by extinction.
2. Evaluate evidence and propose ideas about why changing climatic conditions and an increase in grasslands led to changes in horse morphology and diversity.
3. Recognize that scientific ideas are subject to change based on new evidence.



Part 1: Climate, Grass, and Equidae

Temperature anomaly, or difference from 1960-1990 average. Above the line is warmer than average, below colder.

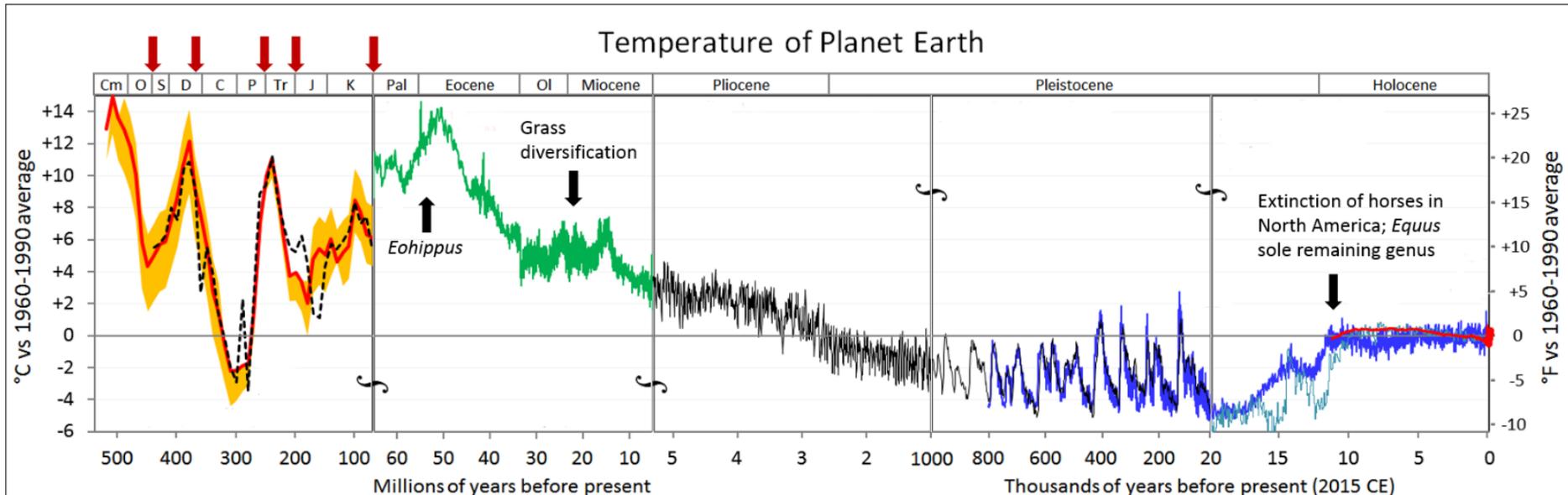


Form groups of 2 or 3 and do Part 1. Be ready to report back to class in 10 minutes.



Part 1 Report Out

- How did climates and biomes change from the Eocene to Miocene?
- What impact did this have on Equidae diversity?





Part 2

The expansion of grassland biomes would have presented new challenges and new opportunities.

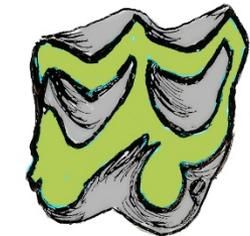
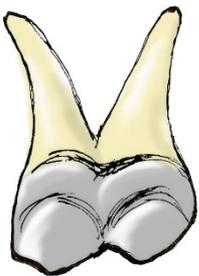
How did Equidae adapt to these? Let us explore how teeth of some Equidae changed in Part 2 (Be ready to discuss in 8 minutes).



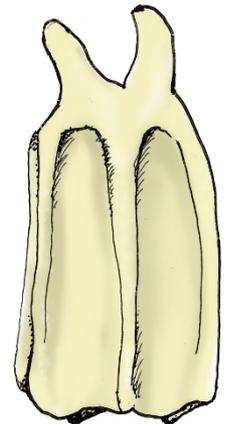
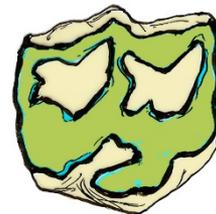
Part 2 Report Out

Imagine *Parahippus* and *Merychippus* individuals in a grassland.

1. Whose teeth would wear down faster eating grass?
2. What happens if teeth get worn down?
3. How will this affect number of offspring produced?
4. If tooth morphology is a genetic trait passed from parent to offspring, how would the number of individuals with each type of tooth change in future generations?



Parahippus



Merychippus



Part 3

Now let us explore how the feet/legs of Equidae changed in Part 3 (Be ready to discuss in 8 minutes).



Forest in Chile
Photo by Albh.

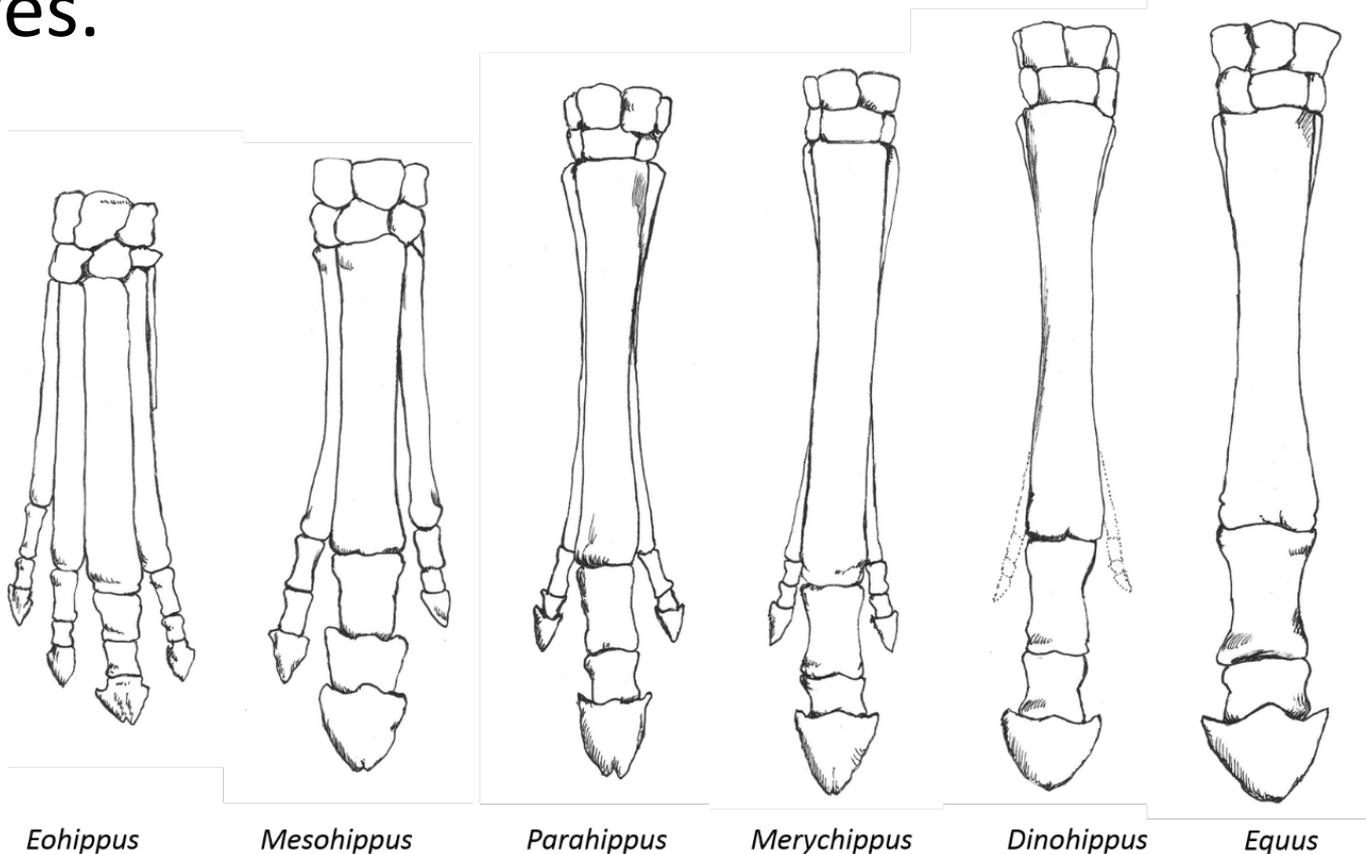


Oglala National Grassland, Nebraska



Part 3 Report Out

Propose a connection between grasslands and the development of longer feet/legs with single-toed hooves.





Part 4

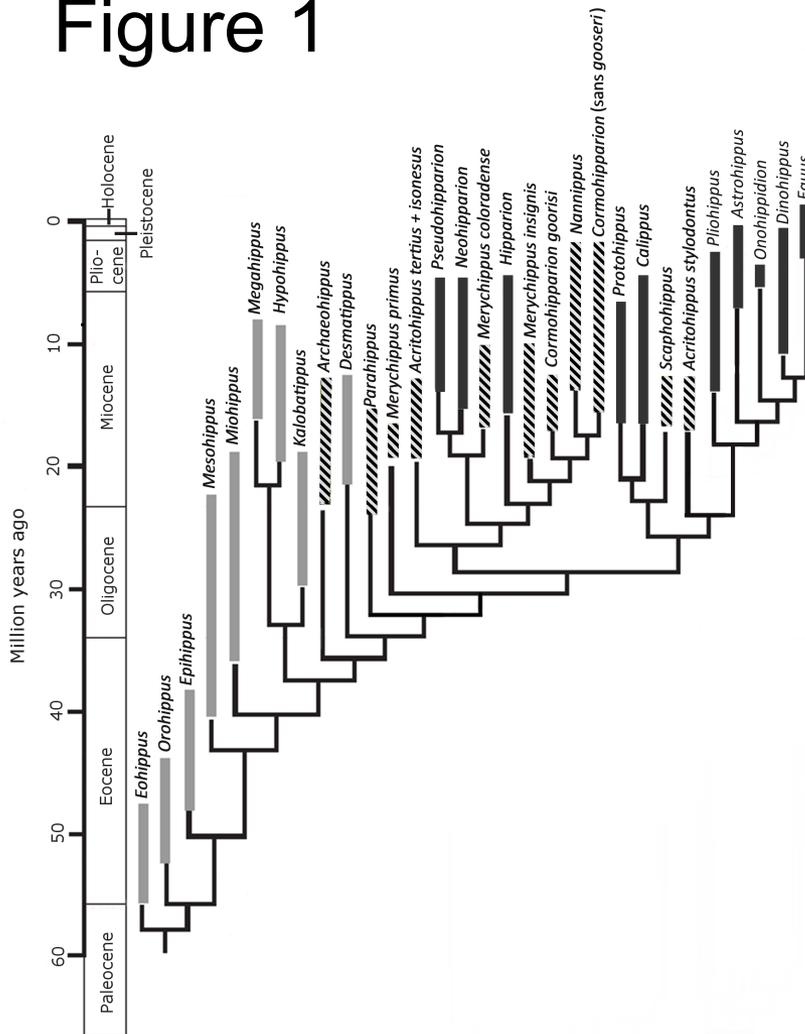
Horses have often been used as an example of evolution because of their abundant and widespread fossils. However, fewer fossils were available in the past. As new fossils have been discovered, scientific ideas about evolution have been revised.

Let us explore this in Part 4 (Be ready to discuss in 8 minutes).



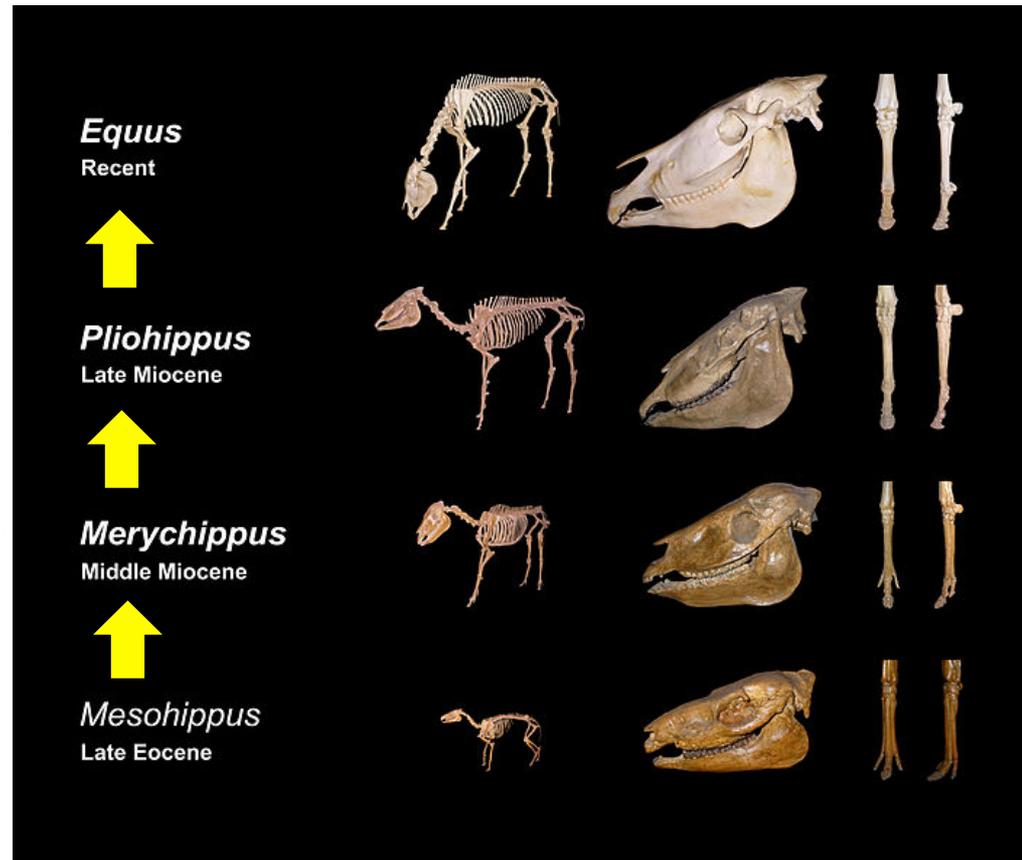
Part 4 Report Out

Figure 1



A.

B.





Part 4 Report Out

Although the branching family tree is more accurate, why do you think some textbooks and museum displays show patterns like Figure 5?



References

- Slide 2:
 - *Equus quagga* Image Source: http://commons.wikimedia.org/wiki/File:Common_zebra_1.jpg. This photo is used under a Creative Commons Attribution 2.0 Generic License.
 - *Equus caballus* Image Source: http://commons.wikimedia.org/wiki/File:Horse_007.jpg. This image is in the public domain.
 - *Equus kiang* Image Source: http://www.biodiversityofindia.org/index.php?title=File:Equus_kiang_holdereri02.jpg. This photo is used under a GNU Free Documentation License and the Creative Commons Attribution 3.0 Unported license.
- Slide 3:
 - Clydesdales Image Source: <https://pixabay.com/en/clydesdale-plowing-horse-1106337>. Released under Creative Commons CC0.
 - "Scotland Forever!" Image Source: https://commons.wikimedia.org/wiki/File:Scotland_Forever_crop.jpg Image is in the public domain because author died in 1933 and copyrighted in US before Jan. 1, 1923.



References

- Slide 5 & 16 data sources:
 - Mihlbachler, M.C., Rivals, F., Solounias, N., Semperebon, G.M. 2011. “Dietary Change and Evolution of Horses in North America.” *Science* 331, 1178-1181.
 - MacFadden, B.J. 2005. “Fossil horses: evidence for evolution.” *Science* 307, 1728-1730.
 - Paleobiology Database (paleobiodb.org)
- Slides 9 & 10:
 - Image modified from Glen Fergus, http://en.wikipedia.org/wiki/Paleoclimatology#/media/File:All_palaeotemps.png
- Slide 12
 - Illustrations by Michelle Tribble, <https://tribbill.wordpress.com/>. Reuse is permitted under a Creative Commons Attribution-Non-Commercial-Share Alike 3.0 license.



References

- Slide 13:
 - Valdivian forest, Chile Image by Source: <https://commons.wikimedia.org/w/index.php?curid=22934013> This photo by Albh is offered under a CC BY-SA 3.0 license.
 - Oglala National Grassland Image Source: https://en.wikipedia.org/wiki/Oglala_National_Grassland#/media/File:Oglala_National_Grassland.jpg. Image released into the public domain by owner.
- Slide 14
 - Illustrations by Michelle Tribble, <https://tribbill.wordpress.com/>. Reuse is permitted under a Creative Commons Attribution-Non-Commercial-Share Alike 3.0 license.
- Slide 16
 - Image by H. Zell, http://commons.wikimedia.org/wiki/File:Equine_evolution.jpg. Reuse permitted under a Creative Commons Attribution-Share Alike 3.0 Unported license.