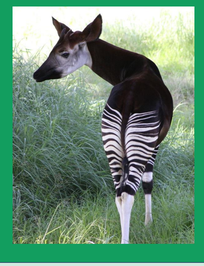
Classification in the Classroom

A Middle School Exploration of Taxonomy, Fossils, and Evolution

Robert O. Clark



The Big Question for Lessons 1 and 2:

How Should the "Mystery Animal" Be Classified?

This mysterious beast belongs to which clade?[4]

Family Bovidae, subfamily Bovinae? (*Bos taurus*)

Family Camelidae? (*Lama glama*)[5]

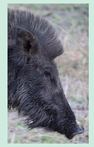
Family Cervidae, subfamily Cervinae? (*Muntiacus reevesi*)[6]

Family Giraffidae? (*Giraffa camelopardalis*)

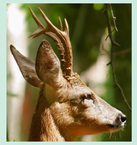
Family Bovidae, subfamily Caprinae? (*Ovis aries*)

Family Equidae? (*Equus grevyi*)

Family Rhinocerotidae? (*Dicerorhinus sumatrensis*)[7]



Family Suidae? (*Sus scrofa*)[8]



Family Cervidae, subfamily Capreolinae? (*Capreolus capreolus*)[9]

The Purpose of the Lessons

Middle school students often struggle with foundational concepts such as common ancestry and classification. Here I present a series of lessons designed to give students an experiential understanding of these ideas, revolving around the classification and identification of a "mystery animal" (the okapi) and the testing of hypotheses about this animal's ancient ancestry.

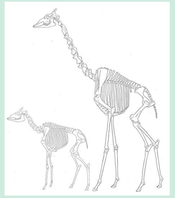
Students in Group 4 attempt to determine the mystery animal's clade by comparing its hooves to the hooves of various perissodactyls and artiodactyls. Will they notice that certain ungulates have a different number of toes than the mystery animal?

Group 2 students compare the striped legs of the mystery animal to the legs of the nine other ungulate species. Will they will be able to look past the color patterns and truly assess the animals' leg morphology?

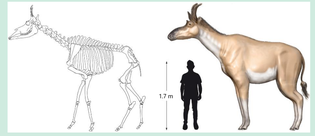
Students in Group 5 discuss which skulls most closely match that of the mystery animal. Will the student on the right be able to persuade her colleagues that the mystery animal belongs to family Giraffidae, or will the student on the left remain convinced of the mystery animal's membership in family Bovidae?

The Big Question for Lesson 3:

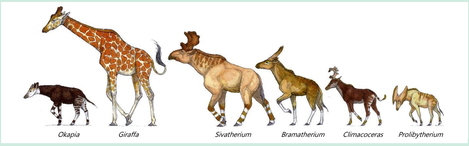
What Did Giraffe Ancestors Look Like?



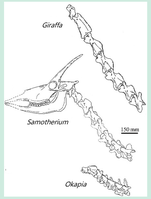
What would be the characteristics of a species transitional between a giraffe and its okapi-like ancestor?[17]



Did *Decennatherium* have the expected features of a giraffe ancestor?[16]



Were the four extinct species on the right actually giraffe ancestors or simply giraffe "cousins"?[19]



How did the cervical vertebrae of *Samotherium* compare to those of *Okapia* and *Giraffa*?[18]

Lesson 1: A Zoological Mystery!

Objectives

- Explore the process of classification
- Model scientific investigation, collaboration, and presentation of research

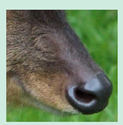
Materials

- Okapi snout, head, neck, leg, and hoof pictures
- Pictures of corresponding features in nine other species
- Mystery animal hypothesis worksheet

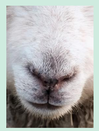
Procedure

- The class is divided into five groups.
- Each group is presented with a picture of the head, snout, neck, legs, or hooves of a "mystery animal" (the okapi). The identity of the animal is kept secret.
- The groups are not told they are studying the same mystery animal.
- Each group compares its mystery animal picture to pictures of the corresponding features of nine other ungulate species in order to hypothesize the mystery animal's clade, recording observations on a worksheet.
- Each group presents its hypothesis to the class, explaining observations that lead to the hypothesis.
- The instructor reveals that all the mystery animal photos are actually from one species, whose identity is still secret.
- After the students discuss this new information within their groups, each group shares whether their hypothesis has changed, attempting to reach a class consensus.
- The instructor concludes the lesson by emphasizing the importance of hypothesis testing and collaboration in research.

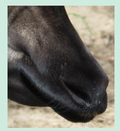
Example: Students in Group 3 compare ungulate mammal snouts.



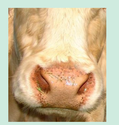
Reeves's Muntjac (*Muntiacus reevesi*)



Sheep (*Ovis aries*)

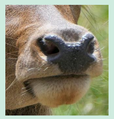


"Mystery Animal" (*Okapia johnstoni*)[10]

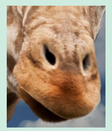


Cattle (*Bos taurus*)

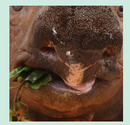
Wild Boar (*Sus scrofa*)



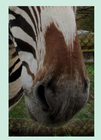
Roe Deer (*Capreolus capreolus*)



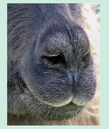
Giraffe (*Giraffa camelopardalis*)



Sumatran Rhinoceros (*Dicerorhinus sumatrensis*)[11]



Grevy's Zebra (*Equus grevyi*)[12]



Llama (*Lama glama*)

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Lesson 2: The Hard Truth

Objectives

- Reveal how additional data can support or weaken a hypothesis
- Show the importance of osteological data to taxonomy

Materials

- Okapi skull picture
- Skull pictures of the nine other species
- Mystery animal skull worksheet

Procedure

- Each of the five groups from Lesson 1 is given a picture of the mystery animal's skull and the skulls of the same nine ungulate species studied in Lesson 1.
- Each group discusses which ungulate skull the mystery animal's skull most closely resembles, recording observations on a worksheet.
- Each group presents to the class its hypothesis of the mystery animal's clade, explaining all observations and reasoning. The groups debate any disparate hypotheses.
- The instructor reveals the name of the mystery animal and its membership in family Giraffidae.
- The instructor concludes the lesson by asking students to share what data the skulls revealed that allowed them to better determine the okapi's clade.

Skull Photographs Used

"Mystery Animal" (*Okapia johnstoni*)[14]

Family Suidae (*Sus scrofa*)[15]

Family Cervidae, subfamily Cervinae (*Muntiacus reevesi*)[15]

Family Camelidae (*Lama glama*)[15]

Family Bovidae, subfamily Caprinae (*Ovis aries*)[15]

Family Cervidae, subfamily Capreolinae (*Capreolus capreolus*)[15]

Family Equidae (*Equus grevyi*)[13]

Family Bovidae, subfamily Bovinae (*Bos taurus*)[15]

Family Rhinocerotidae (*Dicerorhinus sumatrensis*)[14]

Family Giraffidae (*Giraffa camelopardalis*)[15]

Correlation to Next Generation Science Standards

MS-LS4-1 Biological Evolution: Unity and Diversity

Students who demonstrate understanding can:

Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.

MS-LS4-2 Biological Evolution: Unity and Diversity

Students who demonstrate understanding can:

Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.

Lesson 3: Back to the Past

Objective

- Demonstrate how fossils allow scientists to test evolutionary hypotheses

Materials

- Giraffe ancestry worksheet
- Giraffe fossil record worksheet

Procedure

- The instructor asks the class if the okapi and giraffe are only classified together due to common traits or if they share ancestry as well, encouraging a discussion of the extent to which animals change over time.
- Using the giraffe ancestry worksheet, each group compares pictures of giraffe and okapi skeletons and describes the traits a transitional form between okapis and giraffes might possess.
- Each group attempts to sketch its hypothesized transitional form.
- The instructor asks the class to discuss ways these hypotheses might be tested, encouraging students who are unsure to consider what evidence exists of past life on earth.
- The instructor passes out the giraffe fossil record worksheet and discusses the pictures of extinct giraffid skeletons with intermediate neck lengths.[1,2,3]
- Each group compares its hypothesis to the Giraffidae fossil record and discusses which species could have been ancestral to giraffes.
- The instructor concludes the lesson by emphasizing the importance of the fossil record for understanding how life on earth has changed over time.

References and Attributions

1. Danowitz M, Domalski R, Solounias N 2015. The cervical anatomy of *Samotherium*, an intermediate-necked giraffid. R. Soc. open sci. 2(11), 150521.
2. Danowitz M, Vasilyev A, Kortlandt V, Solounias N 2015. Fossil evidence and stages of elongation of the *Giraffa camelopardalis* neck. R. Soc. open sci. 2(10), 150393.
3. Ríos M, Sánchez IM, Morales J 2017. A new giraffid (Mammalia, Ruminantia, Pecora) from the late Miocene of Spain, and the evolution of the sivathere-samothere lineage. PLoS ONE 12(11): e0185378.
4. Okapi head photograph by Steve Wilson, www.flickr.com/photos/pokerbrit/10549264174. Licensed under CC BY 2.0. Mirrored and cropped from original.
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17. Okapi and giraffe skeletal reconstructions ©2018 Robert O. Clark.
18. *Samotherium*, *Okapia* and *Giraffa* cervical vertebrae and skull reconstructions ©2015 Melinda Danowitz, Rebecca Domalski, Nikos Solounias, rsos.royalsocietypublishing.org/content/2/11/150521. Published by the Royal Society under CC BY 4.0. Cropped from original.
19. *Okapia*, *Giraffa*, *Sivatherium*, *Bramatherium*, *Climacoceras*, and *Prolibytherium* life reconstructions ©Daniel Verhelst, www.deviantart.com/gredinia. Cropped from original and used with permission.

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