Pliocene Mollusk Communities and the Neogene Atlas
Instructor Guide

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In this activity, students will investigate changes in the diversity of coastal mollusk communities during the Late Pliocene Epoch. Students will first identify which geological formations are aligned temporally. Then, they will assess a set of bivalve and gastropod genera found in three states: Virginia, Georgia, and Florida. By comparing and contrasting genera from the different samples, they will be able to:

a) compare how diversity changes along the North American coastline
b) use their knowledge of the life habits of major genera to understand what the environment was like in the sampled areas
c) generate a sketch of what the ecological community might have looked like

Students should take away the following big ideas:

- Diversity increases as you move closer to the tropics.
- Understanding the ecology and life habits of fossil animals allows us to understand what the ancient environment was like.
- As a general rule, bivalves are more numerous than gastropods in most mollusk communities.

Students should also learn how to collect data consistently from each sample, and graph their results in a bar graph format.

This activity uses the following terms and concepts:

- paleoenvironment, paleoenvironmental reconstruction, paleoecology
- taxa, species, genera, families, communities, species diversity, gastropods, bivalves
- life history, life habits, infauna, filter feeders, deposit feeders, shelf environments
- formation, member, Pliocene, organic content

The following instructor guide is not a strict answer key, but rather contains possible ideas that students may bring up in their answers, as well as topics that you may wish to address in discussion with your class. On the following pages the student activity the instructor suggestions are in bold, and the rest of the text is from the student activity guide.

Supplemental Resources

The following research papers are useful places to learn more about the Pliocene ecosystems of the southeastern United States and their evolution--in terms of both the physical environment and species present--over the past three million years.

Allmon, W. D. 1993. Age, Environment and Mode of Deposition of the Densely Fossiliferous Pinecrest Sand (Pliocene of Florida): Implications for the Role of Biological Productivity in Shell Bed Formation. Palaios 8: 183-201.

Allmon, W. D. 2001. Nutrients, temperature, disturbance, and evolution: a model for the late Cenozoic marine record of the western Atlantic. Palaeogeography, Palaeoclimatology, Palaeoecology 166: 9-26.

Allmon, W. D., G. Rosenberg, R. W. Portell, and K. Schindler. 1996. Diversity of Pliocene-Recent mollusks in the Western Atlantic: extinction, origination, and environmental change. Pp. 271-302 in Jackson, J. B. C., A. F. Budd, and A. G. Coates, Evolution and Environment in Tropical America, The University of Chicago Press, Illinois.

Introduction

Pliocene Mollusk Communities and the Neogene Atlas

In this activity, we will visit mollusk communities across the Pliocene coastline of North America, from Virginia to Florida. During the exercise, we will learn about species diversity and distribution in Pliocene coastal environments, and use that information to discover what the paleoenvironment was like.

We will use data tables and life history information found on the Neogene Atlas of Ancient Life (www.neogeneatlas.net). Bulk shell samples from different locations have been collected and itemized on the Atlas, and you'll use the information found there to compare different mollusk communities.

The diagram on the following page illustrates which formations are found in the same unit of time. Older formations are at the bottom of the figure and younger ones are closer to the top. Time periods are listed on the left-hand axis. For the purposes of this activity, units of time that contain multiple formations will be called "**time slices.**" These time slices travel horizontally across the diagram, like layers on a cake. We will be comparing communities that occur in the same time slice, but different geographic areas.

Why do you think it might be important to compare samples across the same restricted time slice, instead of just any samples in the Upper Pliocene (or the entire Pliocene)?

When we look at samples that occurred in the same time range, we are able to take a "snapshot" of the Earth at one particular time. The Pliocene Epoch is about 3 million years long, allowing a lot of time for change in species and community structure! As we narrow down the range of time we're surveying, we are able to zoom in on one small area with relatively similar climatic, environmental, and geological conditions.

When doing comparative studies, it's important to think about what we are trying to learn, and have as few variables as possible that might confound the information we're collecting. In this case, we're trying to find out what types of changes occur in different communities that coexist at the same time but in different environments. If our time range was too broad, environmental conditions might have changed across the board, making our comparison less robust.

Part I

<u>The Yorktown Formation</u>

To compare the diversity of mollusk communities, we'll need to collect some information from each sample. Look at the Faunal Lists page on the Neogene Atlas (*http://neogeneatlas.net/faunallists/*) and locate sample **94LCA-CB-16**. Record the following information:

State **Virginia**
Formation **Yorktown**
Member or Group **Rushmere**
Total Number of Bivalve Taxa **26**
Total Number of Gastropod Taxa **13**

Find out which families of bivalves make up 5% or of the sample by clicking on the taxon names. Record the name of the family and the percentage of the sample.
Mactridae 35%
Lucinidae 30%
Nuculanidae 9%

Find out which families of gastropods make up 2% or more of the sample by clicking on the taxon names. Record the name of the family and the percentage of the sample.
Calyptraeidae 4%

Click on the name of each family to learn more about its ecology, life history, and life habits.
Based on the life habits of the major mollusk groups in this community, what do you think the paleoenvironment was like at this location?

The major bivalve groups in this location are small to large infaunal filter-feeders and deposit feeders. Most live infaunally (below the surface) and burrow in the substrate. The major gastropod group is a small-limpet-like snail that forms clumps and encrusts on hard surfaces or other organisms. The marine environment here was probably organic-rich sandy mud in a shallow or estuarine setting. Many bivalves remain buried underneath the sediment, while others may be closer to the surface and may have small encrusting snails attached to them.

Go back to the Faunal Lists page. Are any of the other Yorktown Members in the same time slice as your first sample?
No

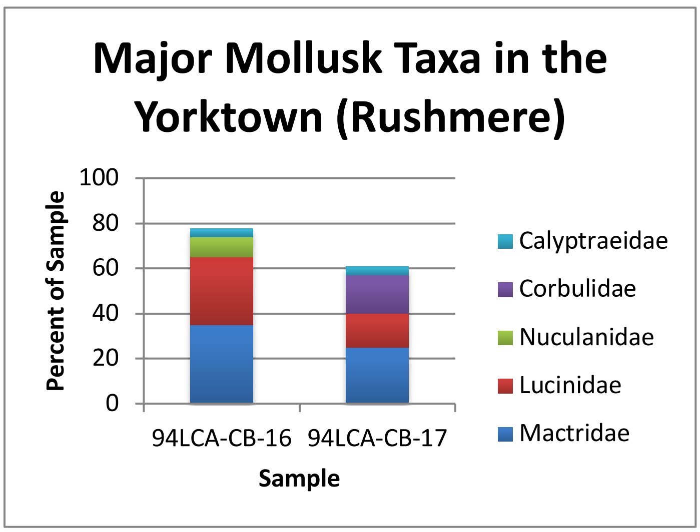
Let's collect the same data from another Yorktown sample in this time slice.

Sample Number **94LCA-CB-17**
State **Virginia**
Formation **Yorktown**
Member or Group **Rushmere**
Total Number of Bivalve Taxa **32**
Total Number of Gastropod Taxa **13**

Families of bivalves making up 5% or more of the sample:
Mactridae 25%
Corbulidae 17%
Lucinidae 15%

Families of gastropods making up 2% or more of the sample.
Calyptraeidae 4%

Using a bar graph, graph the percent abundance of these taxa across the two samples you just surveyed.



What similarities and differences do you notice across these two Yorktown samples? Why do you think they are similar or different?
For Bivalves, both samples are dominated by Mactridae and Lucinidae. For gastropods, both samples are dominated by Calyptraeidae. However, sample 16 has more Nuculanidae while sample 17 has more Corbulidae. They are similar because they are part of the same formation. However, the abundance of Corbulidae may have been influenced by fluctuating environmental conditions, which they are able to tolerate more readily. Nuculanidae are deposit feeders, so the environment they were found in probably has a higher organic content within the sediment.

Based on what you know about the life habits of the major mollusk groups in your samples, draw a reconstruction of the paleoenvironment in the Yorktown during this time period.
Answers will vary. Look for drawings that match the student's description of what they think the paleoenvironment looked like.

Part II

Moving Down the Coast

We'll now compare the Yorktown VA community to locations in other states. Which other formations on the Faunal Lists page are found in the same time slice as the formations you just looked at?
Duplin, Tamiami (Pinecrest)

Gather the same data as you gathered in Part I from two Georgia samples and four Florida samples.
Note: There are 7 Florida samples to choose from, and students are told to pick randomly. The information for all 7 samples is presented below, for your quick reference. Two of the Florida samples have a very different distribution from the others, and are dominated by calyptraeid snails. This can lead to some interesting discussions about diversity and species distribution. However, if you feel that this topic is too complex for your students' level, you may wish to direct the students to use certain samples and exclude these two outliers.

Sample Number **95LCA-GA-3B**
State **Georgia**
Formation **Duplin**
Member or Group **None**
Total Number of Bivalve Taxa **21**
Total Number of Gastropod Taxa **7**

Families of bivalves making up 5% or more of the sample:
Lucinidae 36%
Mactridae 20%
Astartidae 5%

Families of gastropods making up 2% or more of the sample.
Turritellidae 20%

Sample Number **95LCA-GA-4**
State **Georgia**
Formation **Duplin**
Member or Group **None**

Total Number of Bivalve Taxa **35**
Total Number of Gastropod Taxa **12**

Families of bivalves making up 5% or more of the sample:
Lucinidae 30%
Arcidae 16%
Mactridae 15%
Nuculanidae 10%
Pectinidae 6%
Crassatellidae 5%

Families of gastropods making up 2% or more of the sample.
None

Sample Number **LA-11-7-91-1**
State **Florida**
Formation **Tamiami**
Member or Group **Pinecrest Beds**
Total Number of Bivalve Taxa **19**
Total Number of Gastropod Taxa **23**

Families of bivalves making up 5% or more of the sample:
Mytilidae 28%

Families of gastropods making up 2% or more of the sample.
Calyptraeidae 47%

Sample Number **LA-11-7-91-7**
State **Florida**
Formation **Tamiami**
Member or Group **Pinecrest Beds**
Total Number of Bivalve Taxa **28**
Total Number of Gastropod Taxa **42**

Families of bivalves making up 5% or more of the sample:
Nuculanidae 26%
Corbulidae 12%
Lucinidae 10%

Carditidae 8%
Arcidae 7%

Families of gastropods making up 2% or more of the sample.
Turritellidae 6%
Olividae 5%
Calyptraeidae 3%
Naticidae 2%
Nassariidae 2%

Sample Number **LA-11-7-91-12**
State **Florida**
Formation **Tamiami**
Member or Group **Pinecrest Beds**
Total Number of Bivalve Taxa **39**
Total Number of Gastropod Taxa **46**

Families of bivalves making up 5% or more of the sample:
Veneridae 15%
Lasaeidae 5%

Families of gastropods making up 2% or more of the sample.
Calyptraeidae 45%
Columbellidae 4%

Sample Number **LCA-3-89-1**
State **Florida**
Formation **Tamiami**
Member or Group **Pinecrest Beds**
Total Number of Bivalve Taxa **66**
Total Number of Gastropod Taxa **50**

Families of bivalves making up 5% or more of the sample:
Lucinidae 16%
Veneridae 10%
Ostreidae 8%
Corbulidae 8%
Arcidae 6%

Nuculanidae 5%

Families of gastropods making up 2% or more of the sample.
Vermetidae 5%
Strombidae 3%

Sample Number **LCA-3-89-13B**
State **Florida**
Formation **Tamiami**
Member or Group **Pinecrest Beds**
Total Number of Bivalve Taxa **60**
Total Number of Gastropod Taxa **32**

Families of bivalves making up 5% or more of the sample:
Lucinidae 19%
Corbulidae 17%
Veneridae 9%
Arcidae 8%
Nuculanidae 5%
Mactridae 5%

Families of gastropods making up 2% or more of the sample.
Turritellidae 7%
Vermetidae 3%
Calyptraeidae 2%

Sample Number **LCA-3-89-15**
State **Florida**
Formation **Tamiami**
Member or Group **Pinecrest Beds**
Total Number of Bivalve Taxa **53**
Total Number of Gastropod Taxa **38**

Families of bivalves making up 5% or more of the sample:
Lucinidae 14%
Corbulidae 11%
Arcidae 9%
Nuculanidae 9%

Veneridae 9%
Carditidae 7%

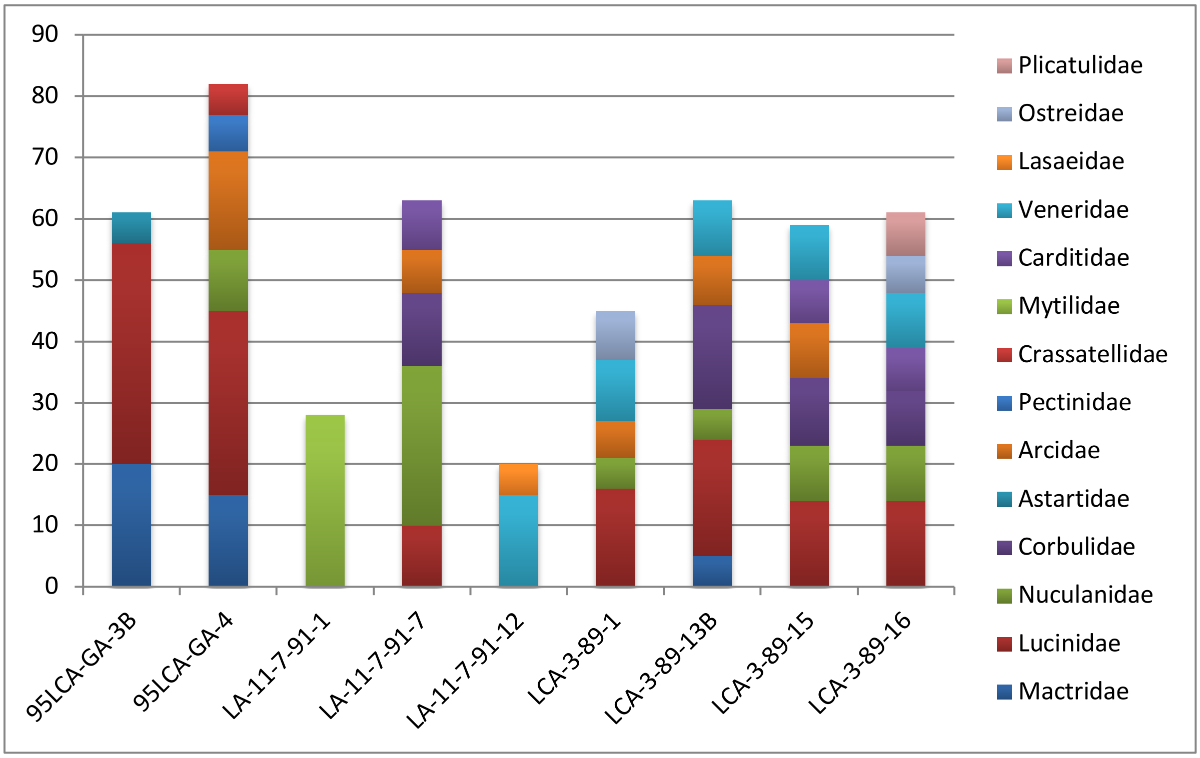
Families of gastropods making up 2% or more of the sample.
Vermetidae 8%
Naticidae 2%

Sample Number **LCA-3-89-16**
State **Florida**
Formation **Tamiami**
Member or Group **Pinecrest Beds**
Total Number of Bivalve Taxa **41**
Total Number of Gastropod Taxa **40**

Families of bivalves making up 5% or more of the sample:
Lucinidae 14%
Corbulidae 9%
Nuculanidae 9%
Veneridae 9%
Carditidae 7%
Plicatulidae 6%
Ostreidae 6%

Families of gastropods making up 2% or more of the sample.
Naticidae 4%
Calyptraeidae 4%
Turritellidae 2%
Vermetidae 2%

Using a bar graph, graph the percent abundance of the major bivalve and gastropod taxa across the seven samples you just surveyed.



What similarities and differences do you notice across the samples? How do they compare to the Yorktown communities?

In the Duplin, we see that Mactridae and Lucinidae are still major players, but more diversity is emerging, especially in sample GA-4. In addition, the Lucinidae are becoming more abundant in the Duplin samples. The gastropod community has changed from Calyptraeidae to Turritellidae, although only one of the Duplin samples has more than 2% of the community taken up by gastropods.

In the Florida samples, diversity spikes. Lucinidae are still common in most of the samples, but there are a lot of other families present. Two of the samples, LA-11-7-91-1 and LA-11-7-91-12 have extremely reduced bivalve diversity. If students chose these samples are , they may notice that the Calyptraeidae heavily dominate these communities. Although there is no "right" answer for why, students may consider that the gastropod community in this area is reducing the available space for bivalves.

Overall, students should notice that diversity of the samples increases the farther south you travel.

Based on what you know about the life habits of the major mollusk groups in your samples, what do you think the paleoenvironment was like in the Duplin and Tamiami Formations? Draw reconstructions of the paleoenvironment in Georgia and Florida during this time period.

The Duplin was similar to the Yorktown, but probably more sandy and less muddy. The Tamiami was a much more tropical, sandy nearshore shelf environment, with dense aggregations of bed-forming species.

Part III

Understanding Paleoecology

How did the diversity of your samples change as you travelled along the coast of North America? Look both at the total number of bivalve vs. gastropod taxa in each community as well as the mollusk families that made up the largest proportions of the samples.

Both in terms of total taxa and number of dominant families, diversity increased to the south. In Florida, gastropod diversity also increased dramatically.

Why do you think the diversity of the communities changed in the way it did?

The water is warmer - we tend to see throughout the biosphere (both today and in the past) that tropical temperatures generate and maintain high diversity.

Did you notice anything about the distribution of bivalves versus gastropods?

There are typically far fewer gastropods than bivalves in most samples.

Why do you think this occurred?

Trophic level – bivalves are usually filter feeders, meaning there are more available resources for them, while gastropods are usually scavengers.
Competition – bivalves can grow quickly and take up more room, crowding gastropods out (there are two samples where we can see the opposite effect occurring).
We looked at communities that occurred at the same time but in different geographic locations. What if we were looking at a community in the same geographic location, but over different times? What are some ways that community structure could change, and what are some environmental factors that could cause those changes?

Diversity could increase or decrease. A community could stay the same, or be wiped out entirely. The main environmental factor that could cause those changes is variation in global temperature, which could contribute to a change in the water temperature, or something as dramatic as changing the sea level.