Evolution*

Purpose

The objective of this lesson is to use a variety of GIS techniques to compare and contrast different skulls spanning millions of years.

Objectives

- Students will be able to anatomical differences and similarities between apes and humans
- Students will be able to categorize fossil forms of hominids by examining their anatomical features
- Students will be able to measure and compare anatomical features
- Students will be able to organize, collect, and classify data
- Students will be able to learn GIS and computer skills

Background

How do scientists use comparative anatomy to infer evolutionary relationships among species?

Materials for lab

Arcview or ArcVoyager
Data for lab: evbc.tif - A template for measuring brain capacity
evlfarea.tif - A template for measuring lower face area
evolu.tif - A template for a general picture of skull comparison
evoluba.tif - A template for measuring brain area
evoluja.tif - A template for recording lower jaw angle
evtable.dbf - A table for collected data
A blank template of the lower jaw angle, this can be printed as a layout within the project
A blank chart, located as an excel file with the data
Student activity pages

Activity Procedures

Before you begin…
1. Start ArcVoyager.
2. Click on Creating New Worlds: Turn Me Loose
3. Click on Creating New Worlds: Startup Project
4. Click on the magnifying glass icon to start the new project
1. Highlight the Views icon [Views] and then click the Open button to open a blank map view.

2. Under the View menu, select Properties… We want to rename this view Skulls. Click OK.

3. Click on the Add Theme button [Add]. Navigate to the drive and directory where the evolution/data folder is located. Change the Data Source Types to Image Data Source.

4. Highlight all of the listed images in the evolution\data directory by holding down the <shift> key and clicking the mouse:

   evbc.tiff  evlfarea.tiff  evolu.tiff  evoluba.tiff  evoluja.tiff

5. Click OK to add theme to the Skulls view.

6. Click on the box next to the map theme evolu.tiff to make that layer appear in the blank window. Five skulls should appear in the map area.

**Step 1: Collecting the Brain Cavity Data**

1. From the Window menu, choose voyager.apr – this returns us to the main project window where we need to highlight the Tables icon [Tables].

2. Click the Add button and navigate to the drive and directory where the evolution\data folder is stored. Highlight evoblank.dbf and click OK. This empty table gives you the format of data sheet you need to record in later operation.

3. Click back on the Skulls view and check the box next to the evbc.tiff layer. Notice that nothing new appeared on the screen. ArcView shows maps in layers and sometimes layers are covered by different layers. Click on the evbc.tiff layer and drag it to the top of the list within the gray Table of Contents. A number of circles should appear on top of the skulls.

4. Use the Zoom In button [Zoom In] to draw a box around the human skull, located in the upper left corner of the map, as seen on the next page:
5. Under the View menu, choose Properties… We want to change the Map Units and Distance Units to millimeters. Click OK.

6. Next, click and hold on the Draw button and choose the Draw Circle button.

7. Your cursor will turn into crosshairs (+). Move the cursor into the middle of the circle drawn on the Human skull. Click and drag the mouse to make a circle just like the blue one. Release the mouse button.

8. Look in the bottom left corner of your screen to find the radius. Write that number down on the chart provided by your teacher.

9. Use the Pan button to move to a different skull. Repeat steps 16-18 for the Ape and four other skulls. Don’t forget to record the radius of each on your chart.

**Step 2: Collecting Lower Face Area Data**


2. Next, click on the box next to the name evlfarea.tif to make it active. Click and drag that map layer to the top of the Table of Contents.

3. Using the Pan button, find the Human skull.

4. Find the Measure tool and click on it.

5. Click on the letter a once and then measure over to letter b and double-click to end the measurement. Record the length in millimeters, found in the bottom left corner of the screen, on the data table under the column A_to_B.

6. Now click on the letter c and then measure over to letter d and double-click to end the measurement. Record the length in millimeters on the data table under the column C_to_D.

7. Using the Pan button, move over to the Ape skull and repeat steps 24 and 25.
8. Repeat steps 25 and 26 for the remaining skulls. Be sure to record the data in the table!

**Step 3: Collecting Brain Area Data**

1. In the Skulls view, uncheck the box next to the map theme evlfarea.tiff and check the box next to evoluba.tiff. Click and drag it to the top of the Table of Contents.

2. Using the Pan button $\mathbf{\text{P}}$, locate the Human skull.

3. Click on the Measure tool $\mathbf{\text{M}}$ and locate the letters on the lower face of the skull.

4. Click on the letter e and then measure over to letter f and double-click to end the measurement. Record the length in millimeters on the data table under the column E_to_F.

5. Click on the letter g and then measure over to letter h and double-click to end the measurement. Record the length in millimeters on the data table under the column G_to_H.

6. Repeat steps 31 and 32 for the remaining skulls on the screen, entering in the information on the chart.

**Step 4: Recording Jaw Angle Data**

1. Using a protractor, measure the jaw angles for all six skulls using the Jaw Angle Worksheet provided by your teacher. Record this information on your chart under the Jaw_Angle column.

**Step 5: Bow Ridge Data**

1. Uncheck all map layers in the Table of Contents except for the evolu.tiff. Use the Zoom In button $\mathbf{\text{Z}}$ and look at each skull just above the eye sockets. On your data table under the Bow_Ridge column, indicate a “P” for present or an “A” for an absence of a bony ridge just above the eye sockets.

**Step 6: Comparing Ape and Human Skulls**
1. From the Window menu, choose \texttt{voyager.apr} – this returns us to the main project window where we need to highlight the Tables icon.

2. Click the \texttt{Add} button and navigate to the drive and directory where the \texttt{evolution\data} folder is stored. Highlight \texttt{evfinish.dbf} and click \texttt{OK}. This table will allow you to query data in next step. Compare your data to what you find in the table.

3. We want to be able to see the data table and map at the same time, so under the Window menu, choose \texttt{Tile}. This makes all of the windows fit onto the screen at one time. Make your screen look similar to the one below:

4. Click on the Select None button \(\square\) to de-select all of the records in the table.

5. In the data table, hold down the \textless shift\textgreater{} key and click on both the \texttt{Human} and \texttt{Ape} records. Both should turn yellow.

6. From the Window menu, choose \texttt{Voyager.apr} – this returns us to the main project window where we need to highlight the Charts icon.
7. Click the New button.

8. Name the chart Ape and Human and choose Name from the Label series using menu.

9. Hold down the <shift> key and highlight the following fields from the fields column: Brain_capa, Brain_area, and Lower_face. Click the Add button to add them to the Groups column, as seen below:

10. Click OK.

11. From the Tool bar, choose the Pie Chart Gallery button. Choose the pie chart on the left. Click OK. Using the new pie chart, answer question 1 on the Student Activity Sheet.

Step 7: Comparing Hominids

1. Back in the data table, choose Select None. Hold down the <shift> key and highlight the following records: Robustus, Africanus, Erectus, and Neanderthal.
2. From the Window menu, choose Voyager.apr – this returns us to the main project window where we need to highlight the Charts icon.

3. Click New.

4. Name the chart Hominids and choose Name from the Label series using menu.

5. Hold down the <shift> key and highlight the following fields from the fields column: Brain_area, Lower_face, and Jaw_angle. Click the Add button to add them to the Groups column, as seen below:

6. Click OK.

7. From the Tool bar, choose the Pie Chart Gallery button. Choose the pie chart on the left. Click OK. Using the new pie chart, answer question 2 on the Student Activity Sheet.

Step 8: Characterizing as Ape, Human, or Intermediate
Based on the information below, answer question 3 on the Student Activity Sheet:

- A large brain area and the absence of a bow ridge is characteristic of a human.
- A small brain area and a bow ridge is characteristic of an ape.
- Less lower face area and more brain area is also characteristic of a human.
- More lower face area and less brain size is characteristic of an ape.
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