Lesson Plan: Mosaic Evolution

General Description
Students describe, measure and compare cranial casts from modern apes (gorillas and chimpanzees), modern humans, and fossil hominids (erect and bipedal forms evolutionarily separated from apes) in an illustration of mosaic evolution. (Hominoid is the collective term for apes and humans.) The purpose of the activity is for students to discover for themselves what some of the similarities and differences are that exist between these forms.

Objectives
Students will be able to
1. handle and read measuring instruments
2. identify skeletal and dental features, and landmarks required for measurement and description
3. describe features of a given specimen as either similar to, different from or the same as those present in another specimen
4. summarize data from the cranial specimens

Concepts
1. Transitional forms in an evolutionary sequence are generally mosaic; some traits evolve more rapidly than others.
2. Documenting similarities and differences between species is fundamental to understanding their biological and evolutionary relationships.
3. Modern humans have not evolved from modern apes: both have evolved from a common ancestor.

Time
around 50 minutes if the activity is started promptly

Prerequisite Skills
No prerequisites

Materials
A variety of hominoid skulls, may include Homo sapiens (modern human), Homo habilis, Homo neanderthalensis (Neanderthal), Australopithecus boisei, Australopithecus afarensis (“Lucy”), Gorilla gorilla, and Pan troglodytes (chimpanzee). Included with each skull is a picture or drawing of the hominoid in its habitat.
Rulers with metric scales and string for making measurements
Notecards describing the different cranial features
Overheads: phylogeny and blank chart
Introduction:
Students describe, measure and compare cranial casts from modern apes (gorillas and chimpanzees), modern humans, and fossil hominids (erect and bipedal forms evolutionarily separated from apes). (Hominoid is the collective term for apes and humans.) The purpose of the activity is for students to discover for themselves what some of the similarities and differences are that exist between these forms and to develop a meaningful example of mosaic evolution. Important inquiry components of the activity are indicated by *.

Procedure:
Have the room set up with one station for each skull. Each station should have 4-5 chairs so all students have a seat. (It may be tempting to put them all on a front table, but this causes congestion and confusion among students.)

Introduction [5 minutes] Very briefly explain to students the different features they will be measuring, and show them where they are on the skulls. They may have completed a Pre-Activity Worksheet covering skull morphology. If this is the case, have students confirm their answers to that worksheet with a partner.

Skull Examinations [15-20 minutes] Break students up into the same number of groups as there are skulls. Give each student a copy of the Mosaic Evolution because the details of each measurement and observation are spelled out on it. Groups will move from one skull station to another, with each station having a different skull to examine. Each group will measure only one feature, and will measure the same feature on each skull. If there are more skulls than features, have some groups measure the same features and therefore check each others’ work. In their groups, students should determine a method for measuring their assigned feature. Encourage them to explore multiple options and decide on the method that they think is the most appropriate (*). There is no standardized way to measure the features in this exercise. The important part is that every skull is measured in the same way. Have students take turns being responsible for the measurements in order to keep everyone involved as much as possible. Remind students to record all measurements in millimeters (not inches), and to handle the skulls with care. Students must move among the stations quickly in order to measure every skull. You might encourage students to make some metric out of their measurements that account for the different sizes of the skulls. For example, if measuring the location of the foramen magnum, students might determine the foramen’s distance from the jaw and the distance from the jaw to the back end of the skull, and make a ratio.

Analysis [5-10 minutes] After the students have measured and described the specimens, have them use the phylogeny on the worksheet to determine and describe the changes in their feature over the course of human evolution (*). This will require some guidance from you. One way to get them started is to have them write their measurements on the phylogeny next to the species names. (This gives them a visual representation of their data.)

Summary [10 minutes] Bring all the groups together and have each group describe their findings (*). The key question to pose to the group is: Do some of the characters seem to change at the same time, or in response to changes in some other (environmental) factor? To answer this question, students will need to pay attention to the findings of other groups. Record students’ findings on the chart or on the overhead with the phylogeny on it.
[5 minutes] Summarize the activity by describing how the facial features demonstrate mosaic evolution.

If instructed by your professor, administer the Individual Accountability question.
**Importance of Measured Features**

Browridge: this area protects the eyes, provides structural support for the pressures caused by large muscles in the face, and may provide some shading from the sun.

Foramen Magnum: the position of the foramen magnum is related to the posture and type of locomotion used—a posterior location indicates quadrupedal locomotion while a more anterior location indicates more bipedal locomotion.

Dentition: dentition is mostly related to the diet of the species, but in some species the canine teeth are sexually dimorphic.

Sagittal Crest and Zygomatic Arches: the sagittal crest is the attachment point for the jaw muscles, and larger crests indicate larger jaw muscles. The jaw muscles must fit underneath the zygomatic arches, so species with larger zygomatic arches had bigger jaw muscles and should also have had a larger sagittal crest.

Brain Cavity and Forehead Slope: the slope of the forehead determines the amount of room available for the frontal lobe of the brain, the region generally associated with intelligence.
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<tr>
<th></th>
<th>brow ridge</th>
<th>foramen magnum</th>
<th>dentition</th>
<th>sagittal crest</th>
<th>zygomatic arches</th>
<th>brain cavity</th>
<th>forehead slope</th>
<th>eye sockets</th>
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<tr>
<td><em>Pongo pygmaeus</em></td>
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<td><em>Gorilla gorilla</em></td>
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<td><em>Pan troglodytes</em></td>
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<td><em>Australopithecus boisei</em></td>
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<td><em>Australopithecus afarensis</em></td>
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<td><em>Homo habilis</em></td>
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<td><em>Homo erectus</em></td>
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<td><em>Homo neanderthalensis</em></td>
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<td><em>Homo sapiens</em></td>
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Pre-Activity Worksheet: Mosaic Evolution

General Description
In the activity you will do this week during your learning/discussion group, you create an example of mosaic evolution by examining the skulls of different relatives and ancestors of humans. Your main task will be to track changes in various features of the hominoid skull through its evolutionary history. In order to be prepared for this activity, complete this worksheet.

Reading
Browse the “Vertebrate” chapter in your text (Ch. 34). Carefully read the sections on the primates and the evolution of *Homo sapiens* (sections 34.3 34.4).

Definitions
Write a definition of the following words. Use your text, textbook glossary, and your previous knowledge to create the best definition possible. Remember to connect your definitions to mosaic evolution.

1) hominoid

2) australopithecine

3) foramen magnum (and its purpose)

4) mosaic evolution

Questions
Indicate the position of the following features on this line drawing of a human skull (you may need to use outside resources to answer this question):
browridge
zygomatic arches or bones
mandible
temporal bones
sagittal crest
molars
frontal bone
occipital bone
orbits

Which skull feature is the most important for humans? What criteria are you using to make that judgment?
Today we will be examining some morphological features in skulls from several species of hominoids (apes and humans). Each group will be examining changes in one feature, and will present their findings to the rest of the class. Once your group is assigned a feature to examine, use the description below to measure the important characters on each of the skulls. Record these on the data sheet. You will then use these data to examine the evolution of your feature with the help of the hominoid phylogeny included in this handout. You might also note relevant information regarding the environment or other biology of the species whose skulls you are examining. **HANDLE THE SKULLS WITH EXTREME CARE — THEY ARE VERY DELICATE.**

<table>
<thead>
<tr>
<th>Feature we examined:</th>
<th>Method of measurement:</th>
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<tbody>
<tr>
<td>feature</td>
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<td>species</td>
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Answer the following questions after you have recorded data on all the skulls.

1. What do you think the function of your feature is?

2. Using the descriptions of the species AND the hypothesized evolutionary relationships among these species, determine the places during evolution when major changes in your feature are likely to have occurred. Label them clearly. Can you find any relationships between these changes and changes in how the species lived?

Once all groups have reported, answer the following question.
3. Are there relationships between changes in certain characters?
Individual Accountability: Mosaic Evolution

Demonstrate your new understanding of mosaic evolution by answering the following question.

Mosaic evolution describes a pattern of change. What can scientists learn about organisms and their evolutionary history by understanding mosaic evolution in a particular lineage? Defend your answer in four or five sentences.