Primate and Human Evolution - A Skull Comparison

Introduction
Skulls are one of the most descriptive parts of an individual’s skeleton. Skulls alone can give clues as to the age, sex, size, ethnicity, and occasionally socio-economic status of an individual. In studying human evolution, skulls can show many subtle differences between species, and gradual changes from apelike early human ancestors to more modern looking human species.

Materials
Skulls, pencil, calculator, metric ruler, protractor, and a bow caliper. Two comparison charts as reference material. Please be very careful in handling the skulls. They can be broken if you are not careful, even when turning them over on the lab tables. Many of the teeth are fragile, and will not tolerate being bumped by the edges of lab tables, so handle them over a towel, or on graph paper.

Skull Analysis
Figure 1 indicates some of the major differences between chimpanzee and human skulls. Although this comparison is between two modern species, it does suggest the types of characteristics that should present in intermediate forms when common ancestry is assumed.

Figure 1: Comparison of Chimpanzee and Human Skulls

<table>
<thead>
<tr>
<th>Chimpanzee</th>
<th>Human</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Heavy brow ridges; low-crowned,</td>
<td>1. Almost no brow ridges; high</td>
</tr>
<tr>
<td>sloping cranium</td>
<td>forehead and high-crowned cranium</td>
</tr>
<tr>
<td>2. Muzzle-like face</td>
<td>2. Flattened face</td>
</tr>
<tr>
<td>3. Large canines</td>
<td>3. Small canines</td>
</tr>
<tr>
<td>4. No chin</td>
<td>4. Well-developed chin</td>
</tr>
<tr>
<td>5. Posterior skull attachment</td>
<td>5. Central skull attachment</td>
</tr>
<tr>
<td>(position of foramen magnum)</td>
<td>(position of foramen magnum)</td>
</tr>
<tr>
<td>6. Occipital crest for attachment</td>
<td>6. No occipital crest, neck muscles not</td>
</tr>
<tr>
<td>of heavy neck muscles</td>
<td>as heavy and attached lower</td>
</tr>
</tbody>
</table>

An understanding of hominid evolution is based on the study of fossil bones, teeth, and artifacts, such as tools, associated with the specimens. Analysis of the fossils involves detailed measurements and careful comparisons. In this exercise, you will analyze certain skeletal materials and fossil replicas by making measurements and calculating indices, as well as conduct qualitative comparisons of the available specimens.
Indices are useful for comparative purposes because they overcome the problems caused by differences in the size or variations of the specimens. An index is the ratio calculated by dividing one measurement by another, and it indicates the proportional relationship of the two measurements. Calipers and meter sticks are to be used in making the measurements, and all measurements are to be in millimeters. Figure 2 shows how to make the measurements. The indices are calculated by dividing one measurement by another and multiplying by 100, (round-off to the nearest whole #).

Although your measurements will be less precise than those in a professional analysis, you will gain an understanding of the process and recognize the difficulty in making conclusions from an analysis of a single specimen. Handle the skulls carefully because they can be easily damaged. Avoid making marks or scratches on the specimens. The measurements are best made by working in groups!

**Cranial (Cephalic) Index**

When this index is determined for living forms, it is called a cephalic index. The term cranial index is used in reference to non-living specimens. An index of less than 75 indicates a long headed condition. An index of 80 or more identifies a round-headed individual.

Figure 2: Measurements to be Made for Skull Analysis

(1)  \[\text{Cranial Index (Cephalic)} = \frac{\text{Cranial Breadth}}{\text{Cranial Length}} \times 100\]

NOTE: (See Figure 2a and 2b)

Cranial breadth: maximum width of the cranium

Cranial length: maximum difference between the posterior surface and the small prominence (glabella) between the brow ridges.
**Skull Proportion Index**

The skull is composed of the face and the cranium, and the skull proportion index identifies the proportional relationship between these two components. The greater the value of the index, the larger the cranium is in relation to the face.

\[
(2) \quad \text{Skull Proportion Index} = \frac{\text{Cranial Breadth}}{\text{Facial Breadth}} \times 100
\]

**NOTE:** (See Figure 2a)

*Cranial breadth:* maximum width of the cranium

*Facial breadth:* maximum distance between the lateral surfaces of the cheekbones (zygomatic arches)

**Facial Projection Index**

A projecting, muzzle-like face is a primitive condition among primates. This index identifies the degree of facial projection in a specimen. The greater the value of the index, the greater the facial projection.

\[
(3) \quad \text{Facial Projection Index} = \frac{\text{Facial Projection Length}}{\text{Total Skull Length}} \times 100
\]

**NOTE:** (See Figure 2b)

*Facial Projection Length:* distance between the anterior margins of the auditory canal and upper jaw (maxilla). Note: Remove lower jaw to make this measurement.

*Total Skull Length:* maximum distance between the posterior surface of the cranium and the anterior (front) margin of the upper jaw (maxilla)

Figure 3: Measurements to be made for Vertebral Attachment Length

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**Skull and Vertebral Attachment Index**
In quadrupeds, the foramen magnum is located towards the back of the cranium. However in bipeds, the foramen magnum is more centrally located. The greater the value of the index, the more centrally located the foramen magnum.

\[
4 \text{ (4) Skull and Vertebal Attachment Index } = \frac{Vertebraal\ Attachement\ Length}{Total\ Skull\ Length} \times 100
\]

NOTE: (See Figure 2b and 3)

*Vertebraal Attachment Length:* distance between the anterior margins of the foramen magnum and the posterior surface of the cranium

*Total Skull Length:* maximum distance between the posterior surface of the cranium and the anterior margin of the upper jaw (maxilla)

**Canine-Incisor Index**
A long canine compared to the length of the incisors is a primitive condition among primates. This index identifies the relative length of the canines. The greater the value of the index, the more equal the canines and incisors are in length.

NOTE: (See Figure 2a)

\[
5 \text{ (5) Canine - Incisor Index } = \frac{Incisor\ Length}{Canine\ Length} \times 100
\]

*Canine Length:* length of the left canine

*Incisor Length:* length of the second left incisor

**PROCEDURE**
1. Obtain one of eight skulls by rotating through the eight stations. Each student will be responsible for determining the measurements of specific skulls.

2. Determine the (1) cranial index, (2) skull proportion index, (3) facial projection index, (4) skull and vertebral attachment index, and (5) canine incisor index for the skull. All of the specimens have ink pen dots to help you in measuring the skulls. **Record your data in Table 1 in the Report.**

3. Use the Skull Comparison Chart to compare the skulls as to the following characteristics (a-c) and rate each on a 1-6 scale. **Record your data in Table 1 in the Report.**

<table>
<thead>
<tr>
<th>a. Brow Ridges</th>
<th>b. Forehead</th>
<th>c. Chin</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 = most pronounced</td>
<td>1 = most sloping</td>
<td>1 = no chin</td>
</tr>
<tr>
<td>6 = least pronounced</td>
<td>6 = best developed</td>
<td>6 = best developed</td>
</tr>
</tbody>
</table>

4. Repeat with each of the seven remaining skulls by rotating through the stations. Note: Each student in the group should measure at least two skulls. Indicate your skull measurements by checking the appropriate boxes in Table 1.

5. Determine the cephalic index for each member of your laboratory group to the nearest whole number. Submit your data to the class and **record the class data in Table 2 in the Report.**

6. Determine the average cephalic index and the range for the class.

7. Answer the questions, and generate two graphs in the laboratory report.
<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Gorilla gorilla (Gorilla)</th>
<th>Pan troglodyte (Chimpanzee)</th>
<th>Australopithecus boisei - Nutcracker Man</th>
<th>Australopithecus afarensis-Lucy</th>
<th>Homo erectus - Peking Man</th>
<th>Homo sapiens Neanderthalensis</th>
<th>Homo sapiens sapiens (Cro Magnon)</th>
<th>Homo sapiens sapiens (Modern)</th>
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<tbody>
<tr>
<td>Cranial Breadth</td>
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<td>Cranial Length</td>
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<td>Cranial Index (equation 1)</td>
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<td>Skull Proportion Index (equation 2)</td>
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<td>Facial Projection</td>
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<td>Vertebral Attach.</td>
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<td>Skull and Vertebral Attachment Index (equation 4)</td>
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<td>Left Canine Length</td>
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<td>Left Second Incisor Length</td>
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<td>Canine-Incisor Index (equation 5)</td>
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Table 2: Cephalic Indices for Biology Students

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<th>4.</th>
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<td>31.</td>
<td>32.</td>
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<td>34.</td>
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</tbody>
</table>

Your Cephalic index _________ Class Range: ______________ Class Average: ________

1. Create a histogram of the cephalic indices for your class on the graph below. Label your axis, and a title!

2. Considering the distribution of the data in the graph above, what difficulties are encountered in trying to make firm conclusions about a species from a single fossil specimen?

__________________________________________________________________________________
__________________________________________________________________________________
__________________________________________________________________________________
__________________________________________________________________________________
3. Why are indices better than simple measurements for comparing fossil specimens?

__________________________________________________________________________________

__________________________________________________________________________________

__________________________________________________________________________________

4. Which fossil hominid skull(s) have a cranial (cephalic) index that falls within the class average index? Explain while referencing your data.

__________________________________________________________________________________

__________________________________________________________________________________

5. Have there been any skull changes in humans during the last 40,000 years? Explain your response.

__________________________________________________________________________________

__________________________________________________________________________________

__________________________________________________________________________________

__________________________________________________________________________________

6. For each hominid skull, plot the skull proportion index (X), and the facial projection index (Y) using the graph below. Make a line of best fit. Label each plot (point) as to the specimen’s name. Give a title!
7. **What is the relationship** between skull proportion and facial projection as seen in the graph? What does the graph illustrate?

__________________________________________________________________________________

__________________________________________________________________________________

8. Why is it impossible for humans to have evolved from modern apes?

__________________________________________________________________________________

__________________________________________________________________________________

9. We observed that when fossil hominid skulls are arranged from **oldest to most recent**, they generally show small differences from skull to skull, trending toward the modern condition. What does this suggest about their biological relationship?

__________________________________________________________________________________

__________________________________________________________________________________

10. We also observed that when fossil hominid skulls are arranged from **oldest to most recent**, the oldest showed more ape-like features than later ones. What does this suggest about the biological relationship, if any, between apes and humans? (Keep in mind your answer to #8)

__________________________________________________________________________________

__________________________________________________________________________________

11. **Summarize** the human evolutionary trends based on your analysis for **cranium size**, **face**, **brow ridges**, and **skull attachment to the vertebral column**.

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