Investigating Common Descent

Introduction:

Our investigations into the evidence for evolution have revealed that scientists use the fossil record, comparative anatomy (homologous structures), comparative biochemistry, comparative cytology, and comparative embryology to determine if organisms exhibit evolutionary relationships and as such, share common ancestry.

Today, your task is to determine the evolutionary relationships between apes and humans. Gibbons, gorillas, chimpanzees, and orangutans are four groups that are part of the ape family. Gibbons and orangutans represent the Asian side of the family; chimpanzees and gorillas represent the African side of the ape family. Today we will focus on the evolutionary relationships among gorillas, chimpanzees, and humans.

Objective: To investigate the evolutionary relationships among chimpanzees, gorillas and humans.

Procedure: Part I

1. Examine **Table 1: Characteristics of Apes and Humans** and **Figure 1: Comparative Anatomy of Apes and Humans**. Using what you have learned concerning evidence of evolution and the information presented in Table 1: Characteristics of Apes and Humans and Figure 1: Comparative Anatomy of Apes and Humans, **discuss why apes are considered the most closely related organisms to humans. Use evidence to back up your answer.**

Table 1: Characteristics of Apes and Man

Characteristics	Apes	Man
Posture	Bent over or quadrupedal; "Knuckle-walking common	Upright or bipedal
Feet	Low arches; opposable big toes; capable of grasping	High arches; big toes in line with other toes; adapted for walking
Leg and arm length	Arms longer than legs; arms adapted for swinging; usually among trees	Legs usually longer than arms; legs adapted for walking
Teeth	Prominent teeth; large gaps between canines and nearby teeth	Reduced teeth; gaps reduced or absent
Skull	Bent forward from spinal column; rugged surface; prominent brow ridges	held upright on spinal column; smooth surface
Face	Sloping; jaws jut out; wide nasal opening	Vertical profile; distinct chin; narrow nasal opening
Brain size	280 to 705 cm^3 (living species)	400 to 2000 cm^3 (fossil to present)
Age at Puberty	Usually 10 to 13 years	Usually 13 years or older
Breeding season	Estrus at various times	continual

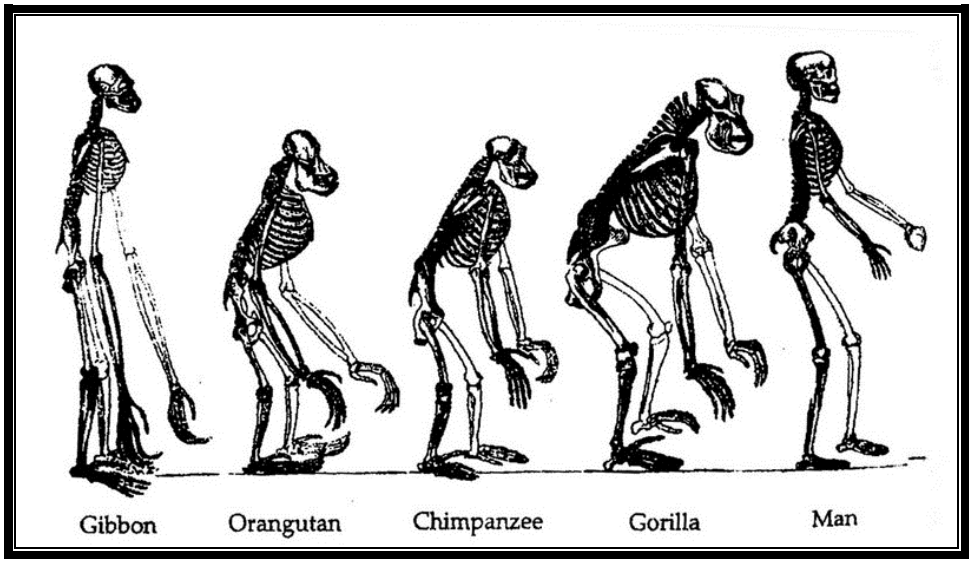

Figure 1: Comparative Anatomy of Apes and Humans

2. Examine the morphological tree in Figure 2, which shows evolutionary relationships among organisms derived from comparisons of skeletons and other characteristics. Find Point A, the part of the tree that shows the relationships among gorillas, chimpanzees and humans. A represents the common ancestor. **Develop three hypotheses to explain how these three species are related.** Write each hypothesis in words and illustrate each hypothesis with a morphological tree starting with A (common ancestor). You may use G, C, and H to represent gorilla, chimpanzee, and human respectively.

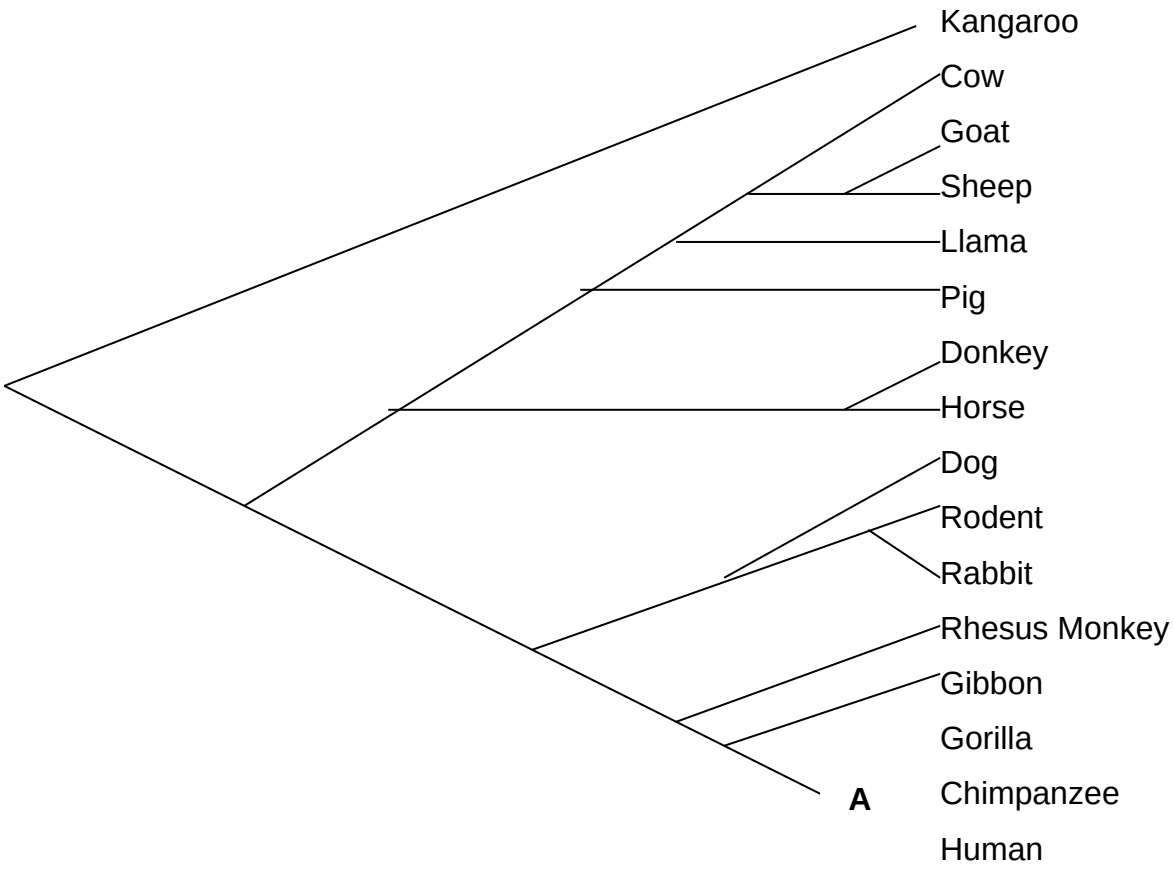

Figure 2: Degree of Morphological Similarity

3. Working in groups, “synthesize” strands of DNA using colored paper clips to represent the four nitrogenous bases, adenine, thymine, guanine, and cytosine.
   - ✓ Black = adenine (A)
   - ✓ White = Thymine (T)
   - ✓ Green = Guanine (G)
   - ✓ Red = Cytosine (C)

Each student will synthesize one strand of DNA. Attach paper clips in the order given below. After synthesizing the DNA strand, attach a label using masking tape to the paper clip in position 1.

Group Member 1: Strand 1
Human DNA
Position 1 Position 20
A-G-G-C-A-T-A-A-A-C-C-A-A-C-C-G-A-T-T-A (this represents a small section of the gene that codes for human hemoglobin)

Group Member 2: Strand 2
Chimpanzee DNA
Position 1 Position 20
A-G-G-C-C-C-C-T-T-C-C-A-A-C-C-G-A-T-T-A (this represents a small section of the gene that codes for chimpanzee hemoglobin)

Group Member 3: Strand 3
Gorilla DNA
Position 1 Position 20
A-G-G-C-C-C-C-T-T-C-C-A-A-C-C-A-G-G-C-C (this represents a small section of the gene that codes for gorilla hemoglobin)

Group Member 4: Strand 4
Common Ancestor DNA
Position 1 Position 20
A-G-G-C-C-G-G-C-T-C-C-A-A-C-C-A-G-G-C-C (this represents a small section of the gene that codes for hemoglobin protein of a common ancestor to the gorilla, chimpanzee, and human.) **Put this strand aside, you will use it later on in this lab.**

4. Lay strands 1-3 in rows with position 1 and the label all facing in the same direction.

5. Compare the Human DNA to the Chimpanzee DNA base by base. Count the number of bases that match and the number of bases that do not match and record this information in the table below. Now compare the Gorilla DNA to the Human DNA and record your answers in the same table.

Human DNA Compared to:	Number of Matches	Unmatched Bases
Chimpanzee DNA		
Gorilla DNA		

Analysis of Part I:

1. How do the gorilla DNA and the chimpanzee DNA compare with the human DNA?
2. What does the data suggest about the relationship among humans, gorillas, and chimpanzees?
3. Do the data support any of your hypotheses? ***Explain your answer***.
4. What kinds of data may provide additional support for your hypotheses?

Part II:

Biologists have determined that some mutations in DNA occur at a regular rate. They can use this rate as a "molecular clock" to predict when two organisms began to separate from a common ancestor. Most evolutionary biologists agree that humans, gorillas, and chimpanzees shared a common ancestor at one point in their evolutionary history. They disagree, however, on the specific relationships among these three species. In this part of the lab, you will use data from your paper-clip model to evaluate different hypotheses about the relationships among humans, gorillas, and chimpanzees.

Procedure:

1. Assume that the common ancestor DNA (strand 4) you synthesized represents a section of the hemoglobin gene of a hypothetical common ancestor. Compare this common ancestor DNA to al three other strands of DNA, one strand at a time. Count the number of bases that are the same and the number that differ between the common ancestor DNA and human DNA. Record your answers in the table below. Repeat this comparison of common ancestor DNA to the chimpanzee sample and then the gorilla sample. Record these answers in the table as well.

Common Ancestor DNA compared to:	Number of Matches	Unmatched Bases
Human DNA		
Chimpanzee DNA		
Gorilla DNA		

Analysis for Part II:

1. Which DNA is most similar to the common ancestor DNA?
2. Which two DNA sequences were the most similar in the way they compared to the common ancestor DNA?
3. Which hypotheses you created in Part I is best supported by this data? (write out the hypothesis)
4. Do your findings ***prove*** that this hypothesis is correct? ***Why or why not?***
5. Based on this hypothesis that was best supported by the data, which of the following statements is more accurate? ***Explain your answer***.
    a. Humans and apes have a common ancestor.
    b. Humans have evolved from apes.
6. According to the data collected, which of the following statements is more accurate? ***Explain your answer.***
    a. Chimpanzees and humans have a common ancestor.
    b. Chimpanzees are the direct ancestors of humans.