BIOCHEMICAL EVIDENCE FOR EVOLUTION

If two organisms have similar DNA molecules, they have similar proteins. Similar proteins have similar amino acid sequences (orders). Thus, if amino acid sequences are similar, DNA of the organisms is similar.

Scientists believe that similar DNA sequences indicate a common origin. The more similar the DNA of two living organisms, the more closely related they may be to one another.

Hemoglobin, a protein in red blood cells, has been studied. Scientists know the specific amino acids and their arrangements in hemoglobin molecules of humans, gorillas, and horses.

In this investigation, you will:

(a) count and record differences in the sequence of amino acids in similar portions of human, gorilla, and horse hemoglobin.
(b) count and record the molecules of each amino acid present in similar portions of human, gorilla, and horse hemoglobin.
(c) use these data to show how biochemical evidence can be used to support evolution.

Procedure

Part A. Amino Acid Sequence

Figure 26-1 on page 102 represents the amino acid sequence of corresponding portions of the hemoglobin molecules of horses, gorillas, and humans.

• Read the amino acid sequences from left to right beginning at the upper left-hand corner of Figure 26-2. Compare the sequences of humans to the sequences of gorillas and horses. An example of a sequence difference between humans and gorillas is shown in Figure 26-1.

• Record in Table 26-1 the total number of differences in the sequences of gorilla and human amino acids. Then repeat this procedure for horse and human, and for gorilla and horse.

TABLE 26-1. NUMBER OF AMINO ACID SEQUENCE DIFFERENCES

ORGANISMS	NUMBER OF DIFFERENCES
Gorilla and human	
Horse and human	
Gorilla and horse	

Part B. Numbers of Amino Acids

• Count the number of each kind of amino acid in human hemoglobin. Record the totals in the proper column of Table 26-2.

• Count each amino acid in the hemoglobin of gorillas and horses. Record these in Table 26-2.

Human:	Val	His	Pro	This is a sequence difference between human and gorilla.
Gorilla:	Val	His	Gly	This is a sequence difference between gorilla and horse.
Horse:	Val	His	Pro	

This is not a sequence difference between human and horse.

FIGURE 26-1

FIGURE 26-2

Human:	Val	His	Leu	Thr	Pro	Glu	Glu	Lys	Ser	Ala	Val	Thr	Ala	Leu	Try
Gorilla:	Val	His	Leu	Thr	Pro	Glu	Glu	Lys	Ser	Ala	Val	Thr	Ala	Leu	Try
Horse:	Val	Glu	Leu	Ser	Gly	Glu	Glu	Lys	Ala	Ala	Val	Leu	Ala	Leu	Try

Human:	Gly	Lys	Val	Asp	Val	Asp	Glu	Val	Gly	Gly	Glu	Ala	Leu	Gly	Arg
Gorilla:	Gly	Lys	Val	Asp	Val	Asp	Glu	Val	Gly	Gly	Glu	Ala	Leu	Gly	Arg
Horse:	Asp	Lys	Val	Asp	Glu	Glu	Glu	Val	Gly	Gly	Glu	Ala	Leu	Gly	Arg

Human:	Leu	Leu	Val	Val	Tyr	Pro	Try	Thr	Glu	Arg	Phe	Phe	Glu	Ser	Phe
Gorilla:	Leu	Leu	Val	Val	Tyr	Pro	Try	Thr	Glu	Arg	Phe	Phe	Glu	Ser	Phe
Horse:	Leu	Leu	Val	Val	Tyr	Pro	Try	Thr	Glu	Arg	Phe	Phe	Asp	Ser	Phe

Human:	Gly	Asp	Leu	Ser	Thr	Pro	Asp	Ala	Val	Met	Gly	Asp	Pro	Lys	Val
Gorilla:	Gly	Asp	Leu	Ser	Thr	Pro	Asp	Ala	Val	Met	Gly	Asp	Pro	Lys	Val
Horse:	Gly	Asp	Leu	Ser	Asp	Pro	Gly	Ala	Val	Met	Gly	Asp	Pro	Lys	Val

Human:	Lys	Ala	His	Gly	Lys	Lys	Val	Leu	Gly	Ala	Phe	Ser	Asp	Gly	Leu
Gorilla:	Lys	Ala	His	Gly	Lys	Lys	Val	Leu	Gly	Ala	Phe	Ser	Asp	Gly	Leu
Horse:	Lys	Ala	His	Gly	Lys	Lys	Val	Leu	His	Ser	Phe	Gly	Glu	Gly	Val

Human:	Ala	His	Leu	Asp	Asp	Leu	Lys	Gly	Thr	Phe	Ala	Thr	Leu	Ser	Glu
Gorilla:	Ala	His	Leu	Asp	Asp	Leu	Lys	Gly	Thr	Phe	Ala	Thr	Leu	Ser	Glu
Horse:	His	His	Leu	Asp	Asp	Leu	Lys	Gly	Thr	Phe	Ala	Ala	Leu	Ser	Glu

Human:	Leu	His	Cys	Asp	Lys	Leu	His	Val	Asp	Pro	Glu	Asp	Phe	Arg	Leu
Gorilla:	Leu	His	Cys	Asp	Lys	Leu	His	Val	Asp	Pro	Glu	Asp	Phe	Leu	Leu
Horse:	Leu	His	Cys	Asp	Lys	Leu	His	Val	Asp	Pro	Glu	Asp	Phe	Arg	Leu

Human:	Leu	Gly	Asp	Val	Leu	Val	Cys	Val	Leu	Ala	His	His	Phe	Gly	Lys
Gorilla:	Leu	Gly	Asp	Val	Leu	Val	Cys	Val	Leu	Ala	His	His	Phe	Gly	Lys
Horse:	Leu	Gly	Asp	Val	Leu	Ala	Leu	Val	Val	Ala	Arg	His	Phe	Gly	Lys

Human:	Glu	Phe	Thr	Pro	Pro	Val	Glu	Ala	Ala	Tyr	Glu	Lys	Val	Val	Ala
Gorilla:	Glu	Phe	Thr	Pro	Pro	Val	Glu	Ala	Ala	Tyr	Glu	Lys	Val	Val	Ala
Horse:	Asp	Phe	Thr	Pro	Glu	Leu	Glu	Ala	Ser	Tyr	Glu	Lys	Val	Val	Ala

Human:	Gly	Val	Ala	Asp	Ala	Leu	Ala	His	Lys	Tyr	His
Gorilla:	Gly	Val	Ala	Asp	Ala	Leu	Ala	His	Lys	Tyr	His
Horse:	Gly	Val	Ala	Asp	Ala	Leu	Ala	His	Lys	Tyr	His

Name _____ Date _____

TABLE 26-2. NUMBER OF EACH AMINO ACID

AMINO ACID	ABBREVIATION	HUMAN	GORILLA	HORSE
Alanine	Ala			
Arginine	Arg			
Aspartic acid	Asp			
Cysteine	Cys			
Glutamic acid	Glu			
Glycine	Gly			
Histidine	His			
Leucine	Leu			
Lysine	Lys			
Methionine	Met			
Phenylalanine	Phe			
Proline	Pro			
Serine	Ser			
Threonine	Thr			
Tryptophan	Try			
Tyrosine	Tyr			
Valine	Val			

Analysis

1. Where is hemoglobin normally found? _____

2. Circle those words which correctly apply to or describe hemoglobin: protein, carbohydrate, composed of amino acids, chemical molecule, composed of DNA.

3. How many different kinds of amino acids are present in these three animals' hemoglobin? ____

4. (a) Which amino acid is most common in all three animals? _____

   (b) Which amino acid is next most common in all three animals? _____

   (c) Which amino acid is the least common in all three animals? _____

5. Use your data from Table 26-1 to answer these questions.

(a) How similar are the amino acid sequences of human and gorilla hemoglobin? _____

(b) How similar are human and horse hemoglobin? _____

(c) How similar are gorilla and horse hemoglobin? _____

6. Of the different types of amino acids found in hemoglobin,

(a) how many are present in the same exact number in humans and gorillas? _____

(b) in humans and horses? _____

(c) in gorillas and horses? _____

7. On the basis of your answer to question 6,
(a) how similar are the chemical makeups of human and gorilla hemoglobin? _____

(b) how similar are human and horse hemoglobin? _____

(c) how similar are gorilla and horse hemoglobin? _____

8. Which two animals seem to have more similar hemoglobin? _____

9. The sequence of amino acids corresponds to the sequence of base molecules in DNA. Are the base sequences of DNA most similar in human and gorilla, gorilla and horse, or human and horse?

_____

10. In numbers, explain how the base sequences (genes) for hemoglobin formation on human chromosomes differ from those in gorillas. (How many bases are different?) _____

11. What genetic mechanism may have been responsible for this base sequence change? _____

_____

12. Give reasons for supporting or rejecting the following statement. Upon examination, segments of human and gorilla DNA responsible for inheritance of hemoglobin should appear almost chemically alike. _____

_____

_____

13. Give reasons for supporting or rejecting the following statement. Evolutionary relationships are stronger between living organisms which have close biochemical (protein) similarities than between living organisms which do not have close biochemical similarities. _____

_____

_____

_____