

Comparison of the Beta chain of the hemoglobin molecule in eight selected species.

Blood was drawn from 8 different species of mammals and the amino acid sequence of the hemoglobin was analyzed.

KEY TO ABBREVIATIONS OF THE AMINO ACIDS:

ALA:	alanine	GLU:	glutamic acid	PRO:	proline
ARG:	arginine	GLY:	glycine	SER:	serine
ASN:	asparagine	HIS:	histidine	THR:	threonine
ASP:	aspartic acid	LEU:	leucine	TYR:	tyrosine
CYS:	cysteine	LYS:	lysine	VAL:	valine
GLN:	glutamine	PHE:	phenylalanine		

KEY TO SPECIES

- A: human
- B: chimpanzees
- C: gorillas
- D: gibbons (lesser ape form)
- E: rhesus monkeys (Old World monkey form)
- F: squirrel monkeys (New World monkey form)
- G: lemurs (prosimian form)
- H: horses (not a primate!)

The table below lists the amino acids for selected positions on the protein chain.

1. Formulate a hypothesis on how closely related each animal is to a human (put each in a ranked order like you did with the skulls):
1. _____
2. Analyze the Beta chains of the eight species by circling any amino acids that are different than a human (column A).
3. Add up the circled differences and put the total at the bottom of each column.
4. Calculate the percent difference in each column for the 146 amino acids and fill in that row under each column.
5. Decide what your independent and dependent variables are. Decide which type of graph best represents the data and construct this graph on the axes provided. Include a title and label your axes.
6. Conclude which creatures are most related to humans and do a cladogram using the provided letters in the species key.
7. Analyze your data by answering the questions.

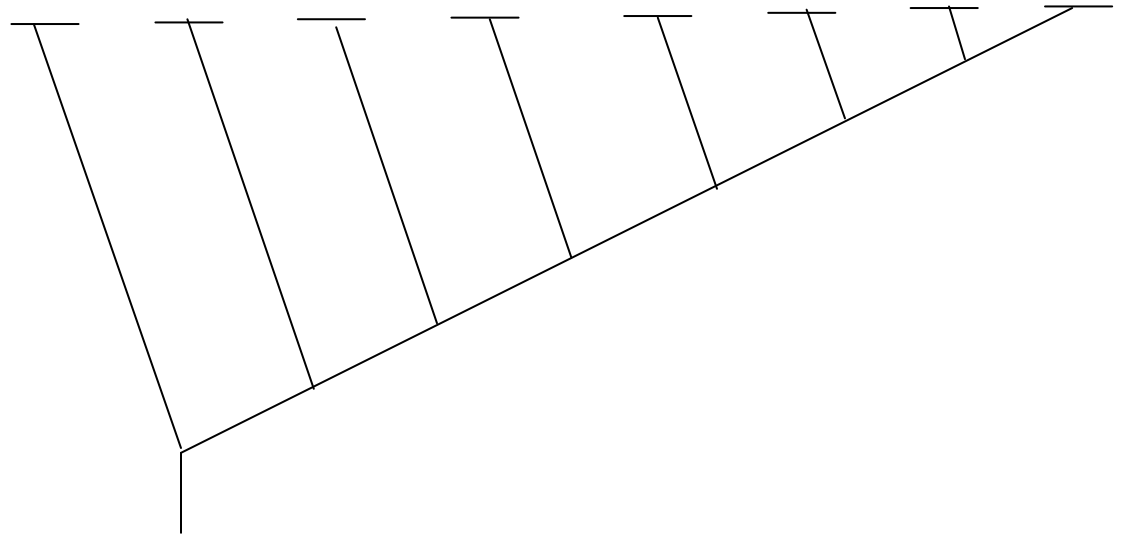
PLEASE NOTE THAT THERE ARE A TOTAL OF 146 AMINO ACIDS IN THIS PORTION OF THE HEMOGLOBIN MOLECULE. ONLY THE POSITION NUMBERS OF THOSE AMINO ACIDS THAT SHOW ANY DIFFERENCES BETWEEN THE SPECIES LISTED ARE INCLUDED IN THIS EXERCISE.

	SPECIES							
	A	B	C	D	E	F	G	H
# in chain 1	VAL	VAL	VAL	VAL	VAL	VAL	THR	VAL
2	HIS	HIS	HIS	HIS	HIS	HIS	LEU	GLU
4	THR	THR	THR	THR	THR	THR	SER	SER
5	PRO	PRO	PRO	PRO	PRO	GLY	ALA	GL Y
6	GLU	GLU	GLU	GLU	GLU	ASP	GLU	GLU
8	LYS	LYS	LYS	LYS	LYS	LYS	ASP	LYS
9	SER	SER	SER	SER	ASN	ALA	ALA	ALA

10	ALA	ALA	ALA	ALA	ALA	ALA	HIS	ALA
12	THR	THR	THR	THR	THR	ALA	THR	LEU
13	ALA	ALA	ALA	ALA	THR	ALA	SER	ALA
16	GLY	GLY	GLY	GLY	GLY	GLY	GLY	ASP
20	VAL	VAL	VAL	VAL	VAL	VAL	VAL	GLU
21	ASP	ASP	ASP	ASP	ASP	GLU	GLU	GLU
22	GLU	GLU	GLU	GLU	GLU	ASP	LYS	GLU
33	VAL	VAL	VAL	VAL	LEU	VAL	VAL	VAL
43	GLU	GLU	GLU	GLU	GLU	GLU	GLU	ASP
50	THR	THR	THR	THR	SER	THR	SER	ASP
52	ASP	ASP	ASP	ASP	ASP	ASP	SER	GLY
56	GLY	GLY	GLY	GLY	GLY	ASN	SER	GLY
69	GLY	GLY	GLY	GLY	GLY	GLY	SER	HIS
70	ALA	ALA	ALA	ALA	ALA	ALA	ALA	SER
72	SER	SER	SER	SER	SER	SER	SER	GLY
73	ASP	ASP	ASP	ASP	ASP	ASP	GLU	GLU
75	LEU	LEU	LEU	LEU	LEU	LEU	LEU	VAL
76	ALA	ALA	ALA	ALA	ASN	THR	HIS	HIS
80	ASN	ASN	ASN	ASP	ASN	ASN	ASN	ASN
87	THR	THR	THE	LYS	GLN	GLN	GLN	ALA
104	ARG	ARG	LEU	ARG	LYS	ARG	LYS	ARG
111	VAL	VAL	VAL	VAL	VAL	VAL	SER	ALA
112	CYS	CYS	CYS	CYS	CYS	CYS	ALA	LEU
113	VAL	VAL	VAL	VAL	VAL	VAL	GLU	VAL
114	LEU	LEU	LEU	LEU	LEU	LEU	SER	VAL
115	ALA	ALA	ALA	ALA	ALA	ALA	GLU	ALA
116	HIS	HIS	HIS	HIS	HIS	HIS	'LEU	ARG
120	LYS	LYS	LYS	LYS	LYS	LYS	HIS	LYS
121	GLU	GUS	GLU	GLU	GLU	GLU	ASP	ASP
122	PHE	PHE	PHE	PHE	PHE	PHE	LYS	PHE
123	THR	THR	THR	THR	THR	THR	SER	THR
125	PRO	PRO	PRO	GLN	GLN	GLN	ALA	GLU
126	VAL	VAL	VAL	VAL	VAL	LEU	VAL	LEU
129	ALA	ALA	ALA	ALA	ALA	ALA	ALA	SER
130	TYR	TYR	TYR	TYR	TYR	TYR	PHE	TYR
3.	#							
4.	%							

5. Graph:

6. Cladogram:



Distant Common Ancestor

7. Analysis/Conclusion:

- a. How different are humans and chimpanzees?
- b. What pattern of relatedness did you observe from the percentage differences among various species?
- c. Which species share recent common ancestors? Distant common ancestors?
- d. You drew a "family tree" (cladogram) of the organisms named showing when they diverged from one another? Would such a family tree be very accurate? Why or why not?
- e. The amino acid numbers that are not shown on your table have the same sequence for all species. Why might this be so?
- f. As a rule, what general conclusion can you draw regarding how closely related species are and how their beta chain hemoglobin amino acid sequences compare? Explain any exceptions to that rule.
- g. Was your hypothesis correct? If not explain why.