Name:_____ Doc #: 84

Evidence of Evolution

The amino acids below are found in the protein beta hemoglobin. This protein is generally 148 amino acids in length. To conserve space, only the amino acids where differences exist have been provided to you.

Amino Acid Number	Species 1	Species 2	Species 3	Species 4	Species 5
1	Valine	**Valine**	Threonine	**Valine**	Valine
2	Histidine	**Histidine**	Leucine	**Histidine**	Histidine
4	Threonine	**Threonine**	Serine	**Threonine**	Threonine
5	Proline	**Proline**	Alanine	**Proline**	Glycine
8	Lysine	**Lysine**	Aspartic Acid	**Lysine**	Lysine
9	Serine	**Asparagine**	Alanine	**Serine**	Serine
10	Alanine	**Alanine**	Histidine	**Alanine**	Alanine
12	Threonine	**Threonine**	Threonine	**Threonine**	Alanine
13	Alanine	**Threonine**	Serine	**Alanine**	Alanine
21	Aspartic Acid	**Aspartic Acid**	Glutamic Acid	**Aspartic Acid**	Aspartic Acid
22	Glutamic Acid	**Glutamic Acid**	Lysine	**Glutamic Acid**	Glutamic Acid
33	Valine	**Leucine**	Valine	**Valine**	Valine
50	Threonine	**Serine**	Serine	**Threonine**	Threonine
52	Aspartic Acid	**Aspartic Acid**	Serine	**Aspartic Acid**	Aspartic Acid
56	Glycine	**Glycine**	Serine	**Glycine**	Serine
69	Glycine	**Glycine**	Serine	**Glycine**	Glycine
73	Aspartic Acid	**Aspartic Acid**	Glutamic Acid	**Aspartic Acid**	Aspartic Acid
76	Alanine	**Asparagine**	Histidine	**Alanine**	Alanine
87	Threonine	**Glutamine**	Glutamine	**Threonine**	Glutamine
104	Argenine	**Lysine**	Lysine	**Lysine**	Argenine
111	Valine	**Valine**	Serine	**Valine**	Valine
112	Cysteine	**Cysteine**	Alanine	**Cysteine**	Cysteine
113	Valine	**Valine**	Glutamic Acid	**Valine**	Valine
114	Leucine	**Leucine**	Serine	**Leucine**	Leucine
115	Alanine	**Alanine**	Glutamic Acid	**Alanine**	Alanine
116	Histidine	**Histidine**	Leucine	**Histidine**	Histidine
120	Lysine	**Lysine**	Histidine	**Lysine**	Lysine
121	Glycine	**Glycine**	Aspartic Acid	**Glycine**	Glycine
122	Phenylalanine	**Phenylalanine**	Lysine	**Phenylalanine**	Phenylalanine
123	Threonine	**Threonine**	Serine	**Threonine**	Threonine
125	Proline	**Glutamine**	Alanine	**Proline**	Glutamine
126	Valine	**Valine**	Valine	**Valine**	Leucine
130	Tyrosine	**Tyrosine**	Phenylalanine	**Tyrosine**	Tyrosine

1) The old way of comparing the amino acid sequences between organisms was to count the differences between amino acids by hand and develop a phylogenic tree based on the number of differences between the organisms. Using the data above, compare the number of differences between Species 1 to each of the other species. Record your information in the data table below.

Species	Differences in Amino Acids from Species 1
Species 2	
Species 3	
Species 4	
Species 5	

2) Based on the differences in amino acid sequences, what species is most closely related to Species 1? (use the table you created on the previous page)

_____

_____

The table shows an amino acid comparison of cytochrome c, a protein involved in cellular respiration in aerobic organisms.

Amino Acid Composition of Cytochrome c in Some Organisms

Amino Acid	Fruit Fly	Screwworm Fly	Hornworm Moth	Silkworm Moth	Comparison	# of Differences
Alanine	10%	10%	10%	10%	Fruit and Screwworm	
Arginine	4%	4%	4%	4%	Fruit and Hornworm	
Aspartic Acid	6%	6%	6%	6%	Fruit and Silkworm	
Cysteine	6%	6%	6%	4%	Screwworm and Hornworm	
Glutamic Acid	12%	12%	8%	8%	Screwworm and Silkworm	
Glycine	4%	2%	4%	4%	Hornworm and Silkworm	
Valine	2%	1%	4%	6%		

3) According to the table above, the organisms most closely related to each other are

_____

_____

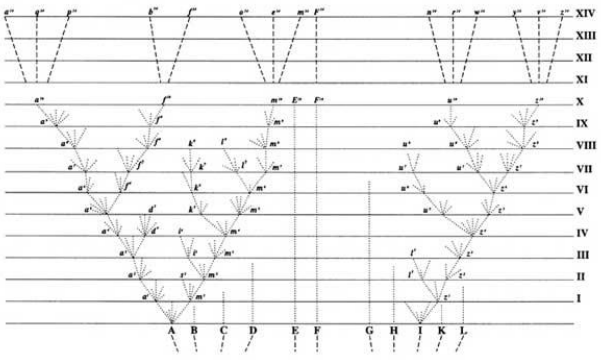
4) According to the table above, the organisms least closely related to each other are

_____

_____

There are many ways to illustrate the evolutionary relationships between organisms. **Cladograms** illustrate the pattern of relatedness between species. A **phylogram** shows the evolutionary relationships among various species that are believed to have a common ancestor.

PHYLOGRAM



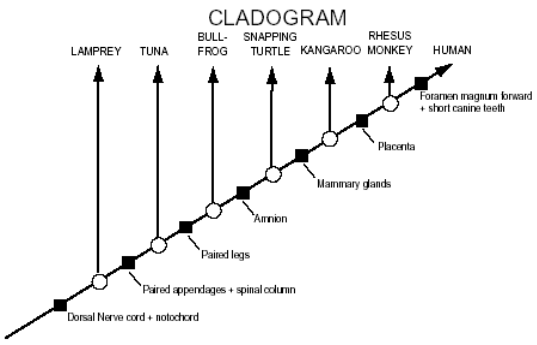


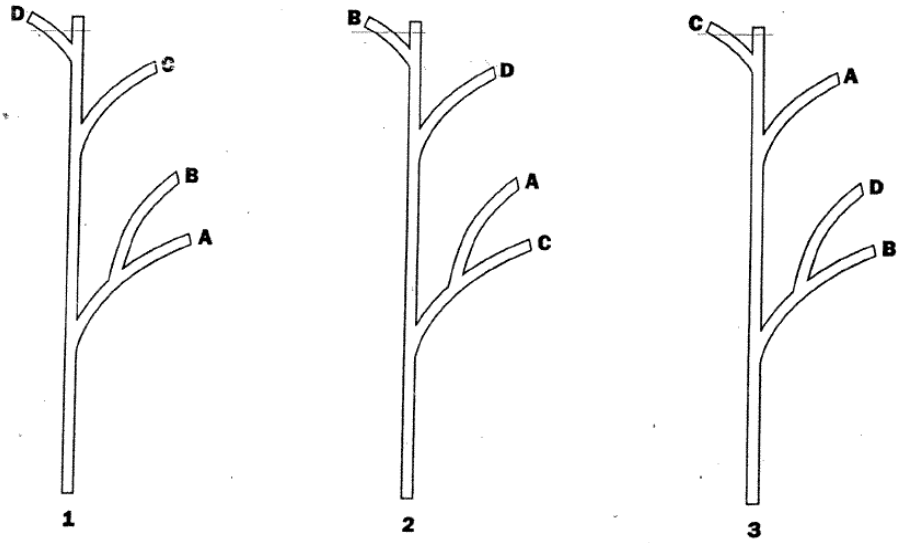
Figure 1: Methods of illustrating evolutionary relationships. phylogram on left, cladogram on right.

How Genes Work

How closely related are various species of living thing? Evolutionary trees, such as the ones below, can provide clues. The branches of evolutionary trees show the evolutionary patterns of the related species. The tree trunk represents time, with the top being the most recent point. The place where a branch splits off from the trunk or another branch indicates the time when a species evolved. The closer branches are to one another, the more closely related are the species.

Today, conformation of such a tree's structure often comes from DNA analysis. The evolutionary trees below show three possible evolutionary relationships for species A, B C, and D. Also below are the DNA nucleotide sequences that code for a type of protein found in each species. Your task is to determine which tree best represents the evolutionary relationship among the four species. Study the evolutionary trees and the DNA segments. Then respond to the following questions.

Hypothetical Evolutionary Trees



Nucleotide sequences of a type of protein found in each of the four species	
Species A	ACTGTTGCTTGGACTGAAATCCGAGGGTTTACTGTACCGCCTAGGTTAGTTGAT
Species B	ACTGTTGATTCGACAGAAACCCGAGGCTTTACTGTACTGCCAAGGTTAGGTGAT
Species C	ACTGTTGATTGGACTGAAATCCGAGGGTTTACTGTACTGCCTAGGTTAGTTGAT
Species D	ACTGTTGATTCGACTGAAATCCGGGGCTTTACTGTACTGCCAAGGTTAGGTGAT

Analysis questions:

5) Compare each nucleotide sequence with the others. How many nucleotides differ when you compare:

A and B	A and C	A and D	B and C	B and D	C and D

6) For the nucleotide data to be relevant, what must you assume about the proteins? (think in terms of what part of the body they come from)

7) What do you look for when you compare the DNA to determine how closely the four species are related?

8) Which of the three phylogenetic trees (cladograms) is most likely to represent the evolutionary relationship among the four species? Explain.