

Name _____

Relationship to the AP Biology Curriculum Framework

Big Idea 1: The process of evolution drives the diversity and unity of life.

Essential knowledge 1.B.2: Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.

Learning Objectives:

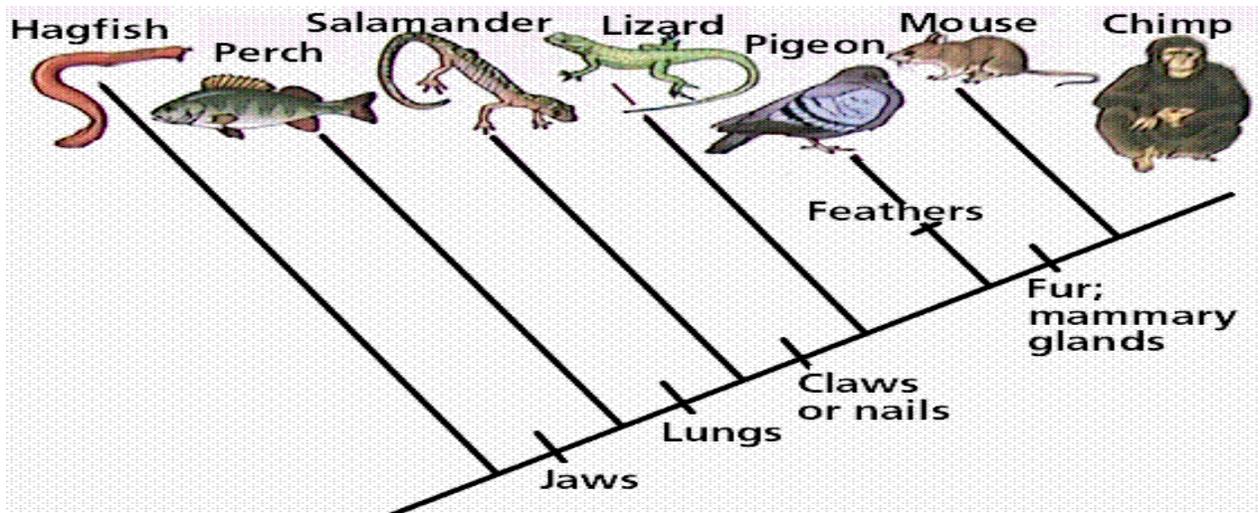
LO 1.17 The student is able to pose scientific questions about a group of organisms whose relatedness is described by a phylogenetic tree or cladogram in order to (1) identify shared characteristics, (2) make inferences about the evolutionary history of the group, and (3) identify character data that could extend or improve the phylogenetic tree.

LO 1.18 The student is able to evaluate evidence provided by a data set in conjunction with a phylogenetic tree or a simple cladogram to determine evolutionary history and speciation.

LO 1.19 The student is able create a phylogenetic tree or simple cladogram that correctly represents evolutionary history and speciation from a provided data set.

[Introduction]

Cladistics is the study of evolutionary classification. Cladograms show evolutionary relationships among organisms. Comparative morphology investigates characteristics for homology and analogy to determine which organisms share a recent common ancestor. A cladogram will begin by grouping organisms based on a characteristics displayed by ALL the members of the group. Subsequently, the larger group will contain increasingly smaller groups that **share the traits** of the groups before them. However, they also exhibit distinct changes as the new species evolve. Further, molecular evidence from genes which rarely mutate can provide molecular clocks that tell us how long ago organisms diverged, unlocking the secrets of organisms that may have similar convergent morphology but do not share a recent common ancestor.



1. Which organisms in the cladogram in figure 1 have fur and mammary glands?

2. Which organisms in the cladogram in figure 1 have jaws?

3. Based on the cladogram in figure 1, which shared a common ancestor most recently – a mouse and a lizard or a mouse and a perch?

4. Which two organisms would you expect to have a closer matching DNA sequence for a gene that is NOT under selective pressure in nature – Hagfish and Pigeon or Hagfish and Salamander?

Part I: Now you will use evidence to construct two cladograms.

Procedure:

1. Using the explanations below, determine which of the characteristics each animal has. In the Data Table provided (on your Cladogram Worksheet), place an "x" in the box if the animal has the characteristic.

Explanations of Characteristics:

set #1: Dorsal nerve cord (running along the back or "dorsal" body surface)
Notochord (a flexible but supporting cartilage-like rod running along the back or "dorsal" surface)

set #2: Paired appendages (legs, arms, wings, fins, flippers, antennae)
Vertebral column ("backbone")

set #3: Paired legs

set #4: Amnion (a membrane that holds in the amniotic fluid surrounding the embryo; may or may not be inside an egg shell)

set #5: Mammary glands (milk-secreting glands that nourish the young)

set #6: Placenta (structure attached to inside of uterus of mother, and joined to the embryo by the umbilical cord; provides nourishment and oxygen to the embryo)

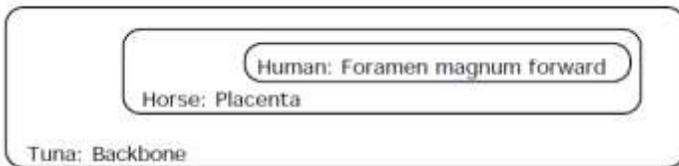
set #7: Canine teeth short (same length as other teeth)

Foramen magnum forward (spinal cord opening, located forward, under skull)

Step 1: DATA TABLE

		Animals						
SETS	TRAITS	Kangaroo	Lamprey	Rhesus Monkey	Bullfrog	Human	Snapping Turtle	Tuna
SET 1	Dorsal Nerve Cord Notochord							
SET 2	Paired Appendages Vertebral column							
SET 3	Paired legs							
SET 4	Amnion (Amniotic sac)							
SET 5	Mammary Glands							
SET 6	Placenta							
SET 7	Canine teeth short Foramen magnum fwd							
	TOTALS of Xs----->							

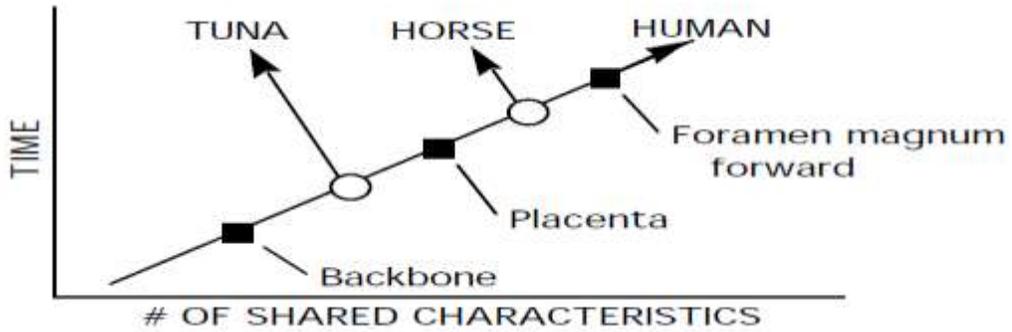
Step 2: Below the Data Table on your Worksheet, make a Venn diagram, placing your seven animals in groups to illustrate those characteristics which different animals have in common. See example below:



Step 2: Venn diagram:

Step 3: Using the Venn diagram of the groupings just completed (as a guide), draw a cladogram to illustrate the ancestry of these animals. The diagram should reflect shared characteristics as time proceeds. An example is shown below. Notice how the different animals are all at the same time level (across the top) since they all live today.

Example of Cladogram



My Cladogram:

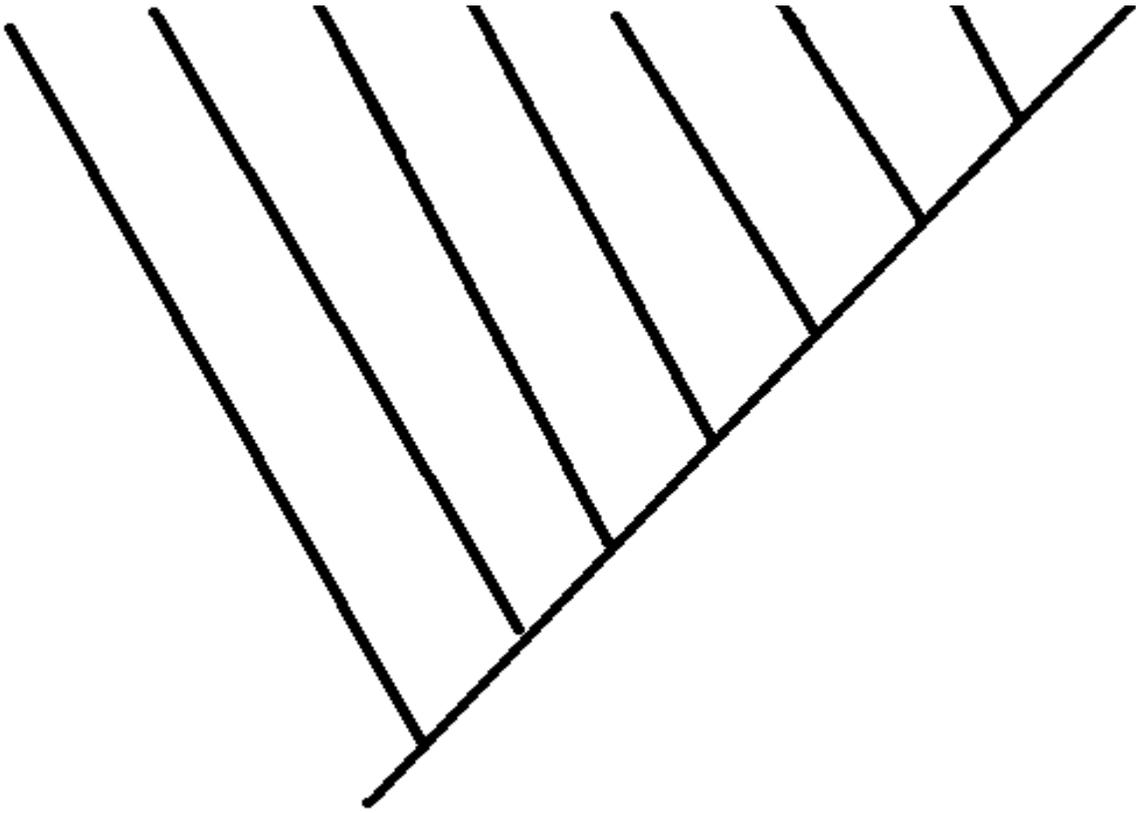
5. State/discuss at least three types of information which can be obtained from a cladogram.

6. Three previously unknown vertebrates have been discovered in a rain forest in South America. One animal is very similar to an iguana lizard. The second animal resembles a large rat. The third is similar to a goldfish. Place these animals on your cladogram and explain why you placed them where you did in the space below.

Part I: Morphological Evidence: Using your text and prior knowledge, determine the morphological characteristics of the organisms in the following table. For every characteristic the organism possesses, put a check in that box. The table is partially completed for you.

Organism	Eukaryote	Multicellular	Segmented body	Jaws	Limbs or Fins	Hair	Placenta	Has bone	Differences from ancestor cell
Universal Common Ancestor Cell									0
Amoeba									
Kangaroo			X						
Earthworm			X						
Cat			X						
Shark			X		X				
Dolphin			X		X	X			
Lizard			X						
Sponge									

Draw a cladogram of these organisms based upon the morphological data above. Properly show all organisms and shared morphological characteristics.



Part II Molecular Evidence: Cytochrome c is a protein located in the mitochondria of cells involved with cellular respiration. Compare each organism's Cytochrome c DNA sequences with the ancestor cell and each other. Circle or highlight the differences (mutations) present in the cytochrome c DNA sequences from ancestor cell.

Cytochrome c DNA Sequence Data

Organism	DNA Sequence	# of mutations
Ancestor Cell	ATTAGCGACCAGTATATCCTACAATCCGTCTACTTCATT	none
Amoeba	ATTAGCGACCAGTTTATCCTACAATCCCGTCTACTTCAT	
Kangaroo	CTAATCCCCCGTTTATCCTACTTTCCCATCTACTAAGT	
Earthworm	CTTATCGACCCGTTTATCCTACATTCCCGTCTACTTCGT	
Cat	TTAATCCCCCGTTTATCCTACTTTCCCATCTACTAAGT	
Shark	CTTATCCCCCGTTTATCCTACTTTCCCGTCTACTTCGT	
Dolphin	CTAATCCCCCGTTTATCCTACTTTCCCATGTAGTAAGT	
Lizard	CTAATCCCCCGTTTATCCTACTTTCCCGTCTACTTCGT	
Sponge	ATTATCGACCAGTTTATCCTACATTCCCGTCTACTTCGT	

Using the data above, complete your cladogram in the space provided below.

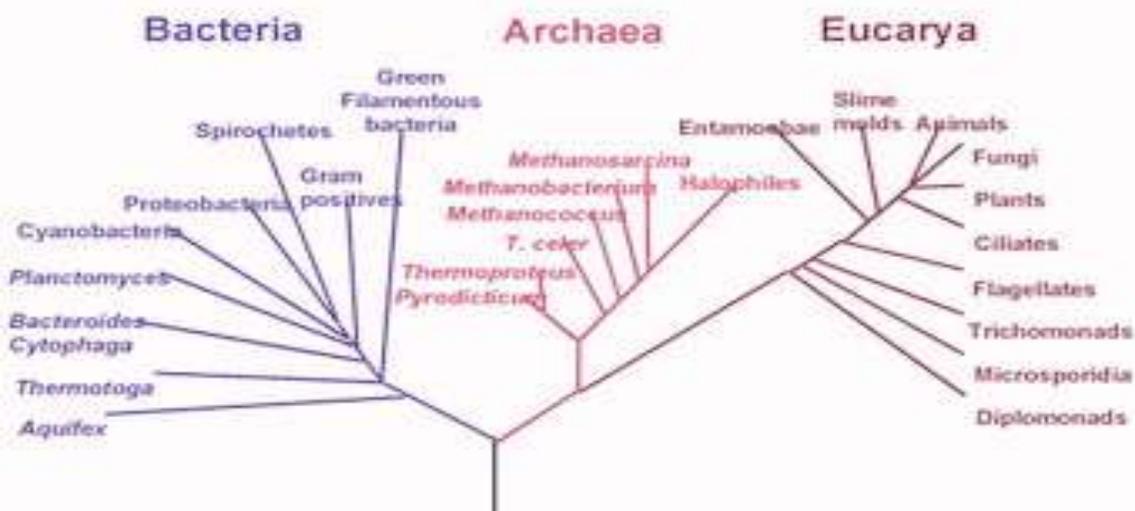
7. How did your morphological cladogram compare with your cladogram based on the cytochrome c DNA evidence.

8. Compare and contrast convergent evolution with divergent evolution. Which two organisms show convergent evolution in the cladogram above? Why might these two organisms have similar morphology despite not sharing a recent common ancestor?

9. Which type of evidence for evolution is most accurate in determining evolutionary relationships – morphology or molecular and why?

Part III: A phylogenetic tree is a tree showing the evolutionary interrelationships among various species that are believed to have a common ancestor. A phylogenetic tree is a form of a cladogram. In a phylogenetic tree, each node with descendants represents the most recent common ancestor of the descendants, and edge lengths correspond to time estimates. An example of a phylogenetic tree follows.

Phylogenetic Tree of Life



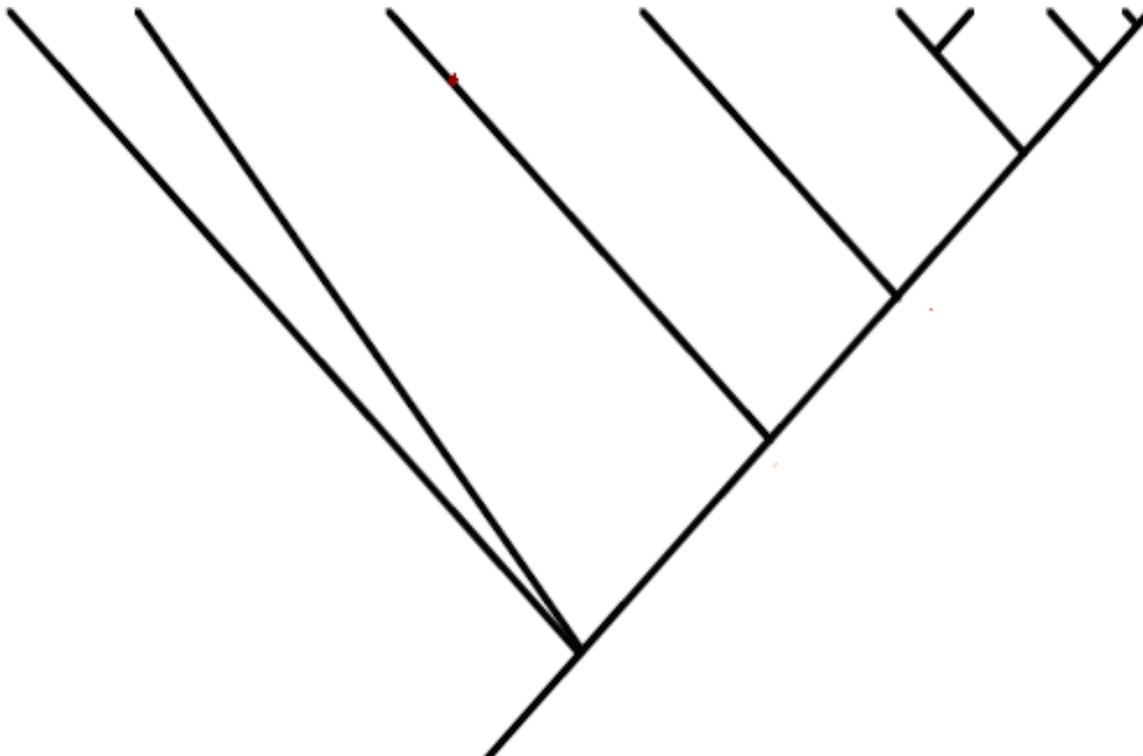
Source: <http://www.dnabaser.com/articles/phylogenetic-tree/phylogenetic-tree-big.jpg>

Now we will make a phylogenetic tree for eight different species using the differences in amino acid sequences in Cytochrome c protein.

Method:

	horse	donkey	whale	chicken	penguin	snake	moth	yeast	wheat
horse	0	1	5	11	13	21	29	45	46
donkey		0	4	10	12	20	28	46	45
whale			0	9	10	18	27	45	44
chicken				0	3	18	29	46	46
penguin					0	17	27	45	46
snake						0	29	46	46
moth							0	48	45
yeast								0	47
wheat									0

Use the data you collected to complete the cladogram which follows.



10. Use the information provided to assist you in answering the questions on the following page.

**THE NUMBER OF AMINO ACID DIFFERENCES IN CYTOCHROME *c*
AMONG VARIOUS ORGANISMS**

	Horse	Donkey	Chicken	Penguin	Snake
Horse	0	1	11	13	21
Donkey		0	10	12	20
Chicken			0	3	18
Penguin				0	17
Snake					0

Phylogeny is the evolutionary history of a species.

- (a) The evolution of a species is dependent on changes in the genome of the species. **Identify** TWO mechanisms of genetic change, and **explain** how each affects genetic variation.
- (b) Based on the data in the table below, **draw** a phylogenetic tree that reflects the evolutionary relationships of the organisms based on the differences in their cytochrome *c* amino-acid sequences and **explain** the relationships of the organisms. Based on the data, **identify** which organism is most closely related to the chicken and **explain** your choice.

(c) **Describe** TWO types of evidence—other than the comparison of proteins—that can be used to determine the phylogeny of organisms. **Discuss** one strength of each type of evidence you described.

(d) Explain why more closely related organisms have more similar Cytochrome C.

(e) What is the main difference between a cladogram and a phylogenetic tree?

(f) List four characteristic of the universal common ancestor