

## Activity: Molecular Clocks

### AP Biology

A molecular clock uses changes in the DNA sequences of a common gene to measure the time since related organisms diverged. To set, or calibrate, a molecular clock, we need to calculate how much DNA sequences for common genomic regions have diverged over a known period of time for the organisms we are studying.

The percent sequence divergence is a straightforward calculation. First, you need to determine how many differences there are between two DNA sequences from the same gene in different species. Figure 1 below shows some imaginary DNA sequences from three primate species. Use the information in Figure 1 to complete Data Table 1.

Figure 1: DNA Sequence Data

	1	21
human	ACTAGCAACGGATACCATAG	GTATATCTAGGCTACATTGT
chimp	ACTAGCAACGGTTACCACAG	GTATATCAAGGCAACATTGT
baboon	ACTGGCTGCGGATGCCTCAG	ATTATCAAGGCTACAATGT
	41	61
human	TAGCTTACCGATAGTACTGG	TGACTCTAGAATGCCTAGTC
chimp	TACCTTACCGCTAGTACTGG	TGACTCTCGAATGCCTTGTC
baboon	TACCATAGCGATACTTGTGG	TGACTGTGCGATTGCCTAGTG

Data Table 1: Percent Divergence

Species Pair	Known Divergence Time (million years)	Number of Differences	Proportion Divergence (number of differences / total length of sequence)	Percent Divergence (proportion divergence x 100)
Human-Chimp	5.5			
Human-Baboon	60			
Human-Gibbon	30	15		

## Using the Data

1. Create a graph by plotting known divergence time on the x-axis and percent divergence on the y-axis. The slope of this graph is the calibration of this molecular clock--the rate at which this sequence evolves per 1 million years. What is the calibration of this clock?
2. The percent divergence between humans and gorillas at this locus (gene) is estimated to be around 14.3%. Use your graph to estimate how long ago humans and gorillas diverged:
3. What are two assumptions made by this molecular clock? Answer in complete sentences, and explain how you know that the molecular clock is operating on these assumptions.
4. Below is a table showing percent divergence and known divergence time for 4 species pairs.

Species-Pair	Known Divergence Time	Percent Divergence
A-B	300 million years	43
A-C	8 million years	4.7
A-D	159 million years	21.8
A-E	84 million years	16.1

A) Calibrate this molecular clock. You do not need to create a graph but you can if you find it helpful. What is the calibration of this molecular clock?

B) Is this gene evolving more slowly or more quickly than the gene used in the first example? How do you know?

C) Fossil evidence indicates that species F diverged from species A about 220 million years ago. Draw a phylogenetic tree that includes A, B, C, D, E, and F. You should draw this tree to scale--branch lengths should correspond to evolutionary distance. Please indicate the scale that you used (i.e., how many centimeters or millimeters are you using to indicate what percentage divergence or millions of years of divergence time). You may do this on an additional piece of paper if you think you need more space.