

PRACTICE PROBLEMS 6

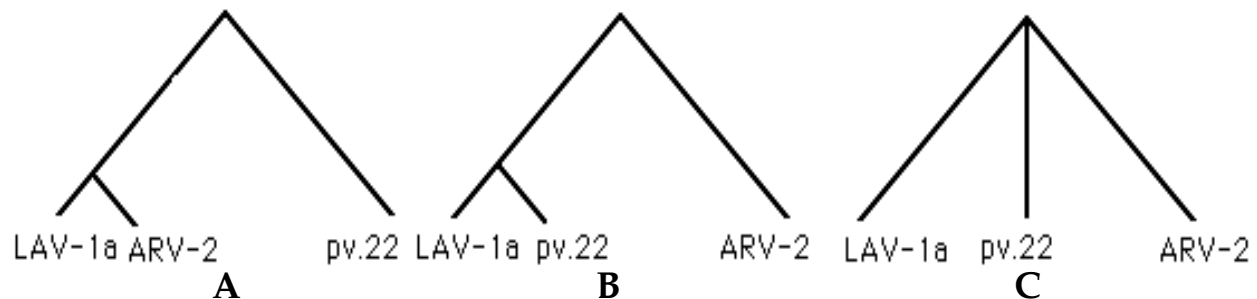
1. Li and collaborators calculated the average sequence divergence for synonymous substitutions in a large number of protein-coding genes, and for a large number of comparisons of mammals of different orders. The average divergence, corrected for multiple hits, was 0.744. All the orders of mammals are believed to have had a common ancestor about 80 My ago. Calculate the average rate of synonymous substitution for mammalian genes. Then estimate the mutation rate for mammals, assuming that the average generation time is about 1 year.

2. In mammals the rates of synonymous substitution differ between nuclear and mitochondrial genes. The rate is 4.6×10^{-9} bp substitutions per bp per year in the nucleus, and about 50×10^{-9} in the mitochondrion. What, if anything, can you infer from these data about the mutation rates in mammalian nuclei and mitochondria?

3. Two evolutionary geneticists compared the base sequences of the *gag* genes of three different viruses that cause AIDS. The results are as follows:

differences between	base pair differences per 1,500 base pairs
LAV-1a and pv.22	6
LAV-1a and ARV-2	42
pv.22 and ARV-2	45

(a) Based on these data, which is the correct phylogenetic tree for these viruses (A, B, or C)?



(b) The rate of evolution of these viruses is incredibly high, on the order of 10^{-3} substitutions per site per year. How long ago did the most distantly related of these AIDS viruses diverge?

4. Answer each of the following questions with M for Mutation rate, BS for Balancing Selection, DS for Directional Selection, D for random Drift, or I for Inbreeding.

(a) The average resistance of houseflies to the insecticide DDT increased rapidly after use of the insecticide began. Resistance is a quantitative trait involving a number of different genes. The increase in resistance is most likely due to _____.

(b) The difference in evolutionary rates between synonymous and nonsynonymous substitutions is due to differences in _____.

(c) The high frequency of the Hb^S allele for sickle cell anemia in black populations is due to _____.

5. Many animals and plants are on a list of endangered species, and these have greatly reduced population sizes. Even if they do not become extinct, there will be significant consequences for their population genetics. Circle the letters of any of the following which are likely consequences of the reduced population size:

- (a) reduced nucleotide diversity
- (b) reduced rate of molecular evolution
- (d) increased mutation rate
- (e) establishment of pure lines

6. Suppose that during the evolutionary divergence of wheat and maize from their common ancestor, both lineages had an average population size of 10^6 plants and an average mutation rate of 5×10^{-10} mutations per base pair per generation. Further imagine that in the *rbcS* gene, which codes for an enzyme called rubisco, the average fixation probability for nonsynonymous substitutions is 10^{-7} .

- (a) Write the equation for the rate of molecular evolution as a function of these parameters.
- (b) Calculate the rate of nonsynonymous substitutions that you would expect to see in these *rbcS* genes.
- (c) Calculate the rate of evolution in a pseudogene for the two species.