Chapter 4  SELF-TEST Molecular evolution

This test covers material in Chapters 3 and 4.

1. The rate of substitutions in a certain region of DNA of length 1000 bases is estimated as $10^{-9}$ per base per year. If two species diverged approximately 10 million years ago, the fraction of sites that differ between them should be approximately

   • A. 1%
   • B. 2%
   • C. 20%
   • D. 75%

2. For the same sequences as above, which of these statements is true?

   • A. The probability that the two sequences will not differ at all is greater than 50%.
   • B. The probability that the two sequences will not differ at all is less than 1 in a million.
   • C. If there were considerable variation in the substitution rate between sites, the fraction of sites that differ would be greater than if all sites changed at the average rate.
   • D. The two sequences should be almost completely randomised with respect to each other after 100 million years.

3. It is expected that synonymous sites change more rapidly than non-synonymous sites because

   • A. The fraction of transversions is larger at synonymous sites.
   • B. Stabilizing selection reduces the rate of substitutions at non-synonymous sites.
   • C. The mutation rate at synonymous sites is higher.
   • D. Natural selection favours new variants arising at synonymous sites.
4. A population of fixed size, $N$, is evolving according to the coalescent theory, with no selection acting. Let $T$ be the time since the last common ancestor of two individuals that are chosen randomly from the population. Which of the following is true?

- A. The mean value of $T$ is dependent on the product of the mutation rate, $u$, and the population size, $N$.
- B. $T$ has a Normal distribution, with a mean value equal to $N$ generations.
- C. $T$ will always be very close to $N$ generations when $N$ is very large.
- D. $T$ depends on the particular positions of the branches in the tree, and therefore fluctuates greatly from one population to another.

5. It is believed that all present-day copies of human mitochondrial DNA descended from a single person, ‘Eve’, living in Africa around 200,000 years ago. Which of the following is true?

- A. Differences in mitochondrial DNA sequences between different African populations are larger than differences between non-African populations.
- B. There are no fossil human remains prior to 200,000 years ago.
- C. Mitochondrial sequences in present day African populations have changed less since the time of Eve than have the sequences in non-African populations.
- D. Mitochondrial sequences in present day African populations have changed more since the time of Eve than have the sequences in non-African populations.

6. A new mutant allele has just arisen in a population. Which statement is true?

- A. If the mutant is neutral with respect to the original allele, there is a 50% probability that the mutant allele will replace the original allele.
- B. It is very likely to disappear in a few generations due to random drift.
- C. It will only become fixed in the population if there is a strong selective advantage.
- D. If the mutant allele reaches a frequency of 50%, it will almost always go on to fixation.
7. If two sequences evolve according to the Jukes-Cantor model, and they are observed to differ at 20% of sites, which of the following is true?
   - A. The Jukes-Cantor distance is 0.18.
   - B. The Jukes-Cantor distance is 0.20.
   - C. The Jukes-Cantor distance is 0.23.
   - D. The Jukes-Cantor distance cannot be calculated without further information.

8. Which of the following statements is correct?
   - A. A reversible rate matrix is a symmetrical matrix.
   - B. A reversible rate matrix is only used for calculations with rooted trees.
   - C. A reversible rate matrix can be used to describe DNA but not protein evolution.
   - D. A reversible rate matrix assumes frequencies of different nucleotides are constant in time.

9. Which of the following statements is correct?
   - A. The PAM250 log-odds matrix applies to sequences that are more distant from one another than the PAM100 matrix.
   - B. The BLOSUM85 log-odds matrix applies to sequences that are more distant from one another than the BLOSUM62 matrix.
   - C. The BLOSUM85 log-odds matrix applies to sequences that are more distant from one another than the PAM250 matrix.
   - D. All three of the above.

10. Which of the following statements concerning the BLOSUM62 matrix below is correct?
    - A. Alanine is aligned with arginine more often than expected by chance.
    - B. Alanine never changes to cysteine.
    - C. Tryptophan evolves the slowest.
11. The scores in BLOSUM62 are measured in half bits. The score of D against E is 2. Therefore:

- A. D is aligned with E twice as often as expected by chance.
- B. D is aligned with E four times as often as expected by chance.
- C. D is aligned with E \( \ln 2 \) times as often as expected by chance.
- D. D is aligned with E \( e^2 \) times as often as expected by chance.