

## 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.

- D. The off-diagonal elements are proportional to the rates of substitution from one amino acid to another.

	A	C	D	E	F	G	H	I	K	L	M	N	P	Q	R	S	T	V	W	Y
A	4	0	-2	-1	-2	0	-2	-1	-1	-1	-2	-1	-1	-1	-1	1	0	0	-3	-2
C		9	-3	-4	-2	-3	-3	-1	-3	-1	-1	-3	-3	-3	-3	-1	-1	-1	-2	-2
D			6	2	-3	-1	-1	-3	-1	-4	-3	1	-1	0	-2	0	-1	-3	-4	-3
		E		5	-3	-2	0	-3	1	-3	-2	0	-1	2	0	0	-1	-2	-3	-2
			F		6	-3	-1	0	-3	0	0	-3	-4	-3	-3	-2	-2	-1	1	3
				G		5	-2	-4	-2	-4	-3	0	-2	-2	-2	0	-2	-3	-2	-3
					H		8	-3	-1	-3	-2	1	-2	0	0	-1	-2	-3	-2	2
						I		4	-3	2	1	-3	-3	-3	-3	-2	-1	3	-3	-1
							K		5	-2	-1	0	-1	1	2	0	-1	-2	-3	-2
								L		4	2	-3	-3	-2	-2	-2	-1	1	-2	-1
									M		5	-2	-2	0	-1	-1	-1	1	-1	-1
										N		6	-2	0	0	1	0	-3	-4	-2
											P		7	-1	-2	-1	-1	-2	-4	-3
												Q		5	1	0	-1	-2	-2	-1
													R		5	-1	-1	-3	-3	-2
														S		4	1	-2	-3	-2
															T		5	0	-2	-2
																V		4	-3	-1
																	W		11	2
																		Y		7

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.