- This quiz forms part of our assessment of your personal learning in this program. Your work must be done independently of others.
- Attempt all questions on this test. Do not leave answers blank. Marks will be given for partial answers, so show all your working.
- This is an open book test. You may consult your textbooks, notes, homework and workshop solutions.
- Your completed test is due at 1:00 pm on Tuesday March 11th.

---

1. The table on the right shows the frequencies of bases at corresponding sites of two 1000 site aligned sequences of DNA. Assume that S_0 refers to an ancestral sequence and S_1 refers to a descendant sequence. Based on this data:

$S_1 \backslash S_0$	A	G	C	T
A	214	35	5	6
G	39	202	9	10
C	9	7	184	40
T	8	6	32	194

   (a) What is the probability of finding an A in sequence S_0? What about in S_1?

   (b) If a site is an A in S_0, what is the probability it will mutate to a T in S_1.

   (c) If a there is a C at a site in S_1, what is the probability that it was also a C in S_0?

   (d) What is the probability that a site will change?

   (e) Would the Jukes-Cantor model be a suitable one to model the changes in base distribution demonstrated in the table? If so explain why. If not, give a better model and explain why it is better.

2. Suppose that the genetic code for creatures on Alpha Centuari is written with only two bases, namely adenine and thymine and that when these creatures replicate, the probability of an A mutating to a T is 0.3 and the probability of a T mutating to an A is 0.2.

   (a) Write down a Markov Model describing how the distribution of bases in the DNA of a species on Alpha Centuari changes over time. That is, if p is the fraction of sites with an A and q is the fraction of sites with a T, then write down a matrix model showing how p and q at time $t+1$ depend on p and q at time t.

   (b) Use your matrix model to calculate the probability that a site which has an A at $t = 0$ has a T at $t = 2$

   (c) Use your matrix model to calculate the probability that a site which has a T at $t = 0$ has an A at $t = 2$.

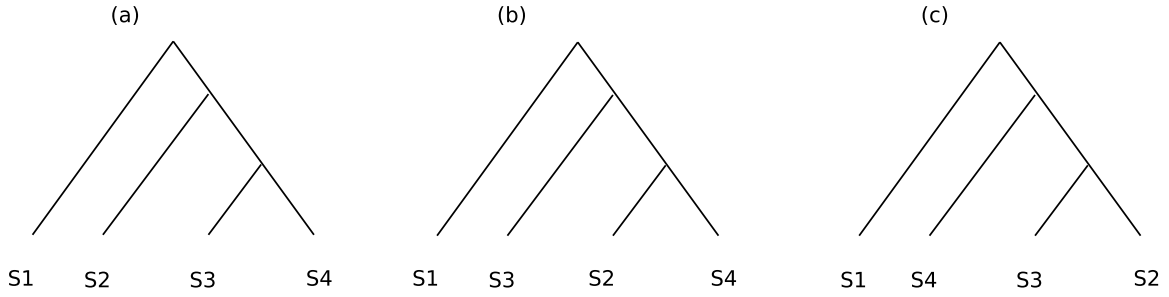
   (d) Find the eigenvalues and eigenvectors of your matrix and use these to predict the equilibrium frequencies of A and T if these rates of mutation continues.

3. What follows are four aligned sequences of DNA corresponding to related taxa:

$$S1: \ ATGACATGGAATCGCGATGG$$
$$S2: \ GAGTCATGGCATCGCGATCG$$
$$S3: \ GAGCCTTAGCATCGCGACCG$$
$$S4: \ ACGCCTTAGCATCCCGATCC$$

(a) Circle the informative sites in the above sequences.

(b) Calculate the parsimony number for each of the three trees below – using only the informative sites. Show your reasoning.



(c) Fill in the following distance table for the sequences showing the Jukes-Cantor distance between them. Make sure you show your work for at least one distance.

	S1	S2	S3	S4
S1				
S2				
S3				

(d) Use the distance table you calculated to construct a phylogenetic tree, with distances labeled, using the average distance method (UPGMA). (Note: If you could not do part (c) use the table below instead.). Does this correspond to the most parsimonious tree in part (b)?

	S1	S2	S3	S4
S1		0.3	0.7	0.5
S2			0.2	0.5
S3				0.3

4. Suppose that a couple living together both get benefit b from achieving a particular task (eg child rearing, house cleansing etc). If only one of them does the work that person incurs a cost c, while the other incurs no cost, yet each gets a benefit b (eg a clean house or a nice meal). If they do it together they each incur cost $c/2$ and both enjoy the benefit b. Consider two strategies for this game. One is work (W), the other is slack (S). The reward matrix for this game is:

	W	S
W	$b - \frac{1}{2}c$	$b - c$
S	b	0

(a) Assuming b and c are both positive, explain why W can never be an evolutionarily stable strategy.

(b) Under what circumstances is S an evolutionarily stable strategy? Explain.

(c) Under what circumstance do the working and slacking strategies coexist?

(d) Suppose we take the cost of doing the work to be 2 units. Assuming the condition in (c) holds, find an expression for the frequency of workers, x at equilibrium in terms of the benefit b.

(e) For what value of the benefit b would the population be half slackers and half workers?