This test is due on Wednesday, July 18th at 9:00 am. You may refer to your notes and textbooks, but you must not consult with other people.

1. Ol' Macdonald had a farm. And on this farm he had only rabbits, R and sheep S. The rabbits and sheep are allowed to roam and eat the grass on the farm, which is their only food source. Ol' MacDonald models the annual change in rabbit and sheep population with the following equations.

$$\begin{aligned} \Delta R &= 0.5R\left(1-\frac{R}{25}\right) - 0.3RS \\ \Delta S &= 0.2S\left(1-\frac{S}{10}\right) - 0.1RS \end{aligned}$$

   (a) Explain what each term in the above equations represents with reference to the growth and death of sheep and rabbit populations, and the interaction between sheep and rabbits.

   (b) Assuming the initial population of rabbits is 10 and the initial number of sheep is 8, find the expected number of rabbits after one year.

   (c) Find all the equilibrium points for the above system and plot them on the phase plane, with R on the horizontal axis and S on the vertical axis.

   (d) On the phase plane above plot the R and S Nullclines.

2. The following table shows the frequencies of bases at corresponding sites of two 1000 site sequences of DNA from different taxa.

$S_1 \backslash S_0$	A	G	C	T
A	212	36	6	5
G	41	204	9	8
C	7	4	181	40
T	10	6	34	197

   (a) What is the probability of a mutation? What is the probability that there is a transition at a site? What is the probability that there is a transversion?

   (b) Use the appropriate probability above to find the Jukes Cantor distance between these two sequences.

   (c) Use the appropriate probabilities above to find the Kimura 2-parameter distance between these two sequences.

   (d) Why are your two answers different. Under what circumstances would you expect the two models to give the same answer?

3. Given the five aligned sequences corresponding to five different taxa

$$
\begin{aligned}
S1: &\ GCGCGTTACC \\
S2: &\ GCGACTTAGG \\
S3: &\ GATGTGTTCC \\
S4: &\ TATGCCTCCC \\
S5: &\ TACGCCGCCC
\end{aligned}
$$

(a) Circle all the informative sites

(b) Of the informative sites, how many give distinct information about the parsimony of a tree?

(c) Determine which of the trees below is most parsimonious.

(d) How many more trees would you have to check to be sure that you had found the lowest parsimony number?