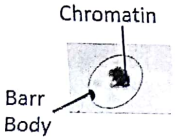
BIO 201: Genetics and Evolution
Second Mid-Semester Examination, October 11, 2018
Total Marks: 35, Time: 1 Hour
Please write genotypes/reasoning where ever necessary



1. The photograph in the margin is of a human cell nucleus stained with a suitable dye. Can you guess the sex of the individual from whom the cell is taken? Explain. (2 marks)

2. A white-eyed male fly is mated with a pink-eyed female. All the F1 offspring have wild-type red eyes. F1 individuals are mated among themselves to yield:

Females	Males
red-eyed 450	red-eyed 231
pink-eyed 155	white-eyed 301
	pink-eyed 70

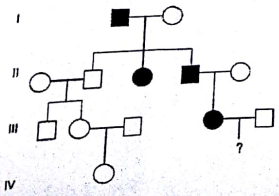
Provide a genetic explanation for the results. (4 marks)

3. Ancon (an, legs are short) and spiny legs (sple) are 10 map units apart on chromosome 3. Notchy (ny, wing tips nicked) is on the X chromosome (chromosome 1). All these alleles are recessive to their wild type counterparts. An important point to remember is that in male Drosophila, chromosomes assort independently but there is no recombination between homologus chromosomes during meiosis.
   a. Show the genotype of the parents which you will use if you were making crosses to determine the linkage arrangement of these three loci. (1 mark)
   b. Create a data set that would result from the above cross. Assume a total sample of 1000 progeny. (4 marks)
   c. How would you know that the notchy locus is on the X chromosome? (2 marks)

4. There are at least 4 closely linked genes in the histocompatibility complex in humans. Let's call them A, B, C and D loci. Each of these genes is multiallelic, having as many as 35 codominant alleles. These loci are so closely linked that recombination among them can be disregarded. An individual is tested and found to have the genotype (A1A34 B3B24 C1C23 D10D11), where A1A34 represent the two alleles at the A locus, B3B24 represent the two alleles at the B locus and so on. His wife has the genotype (A1A20 B10B11 C3C12 D9D13). Their son is (A1A34 B11B24 C1C12 D9D10). Draw a schematic of the homologus chromosomes of the parents and the son showing the alleles on each of the chromosomes. (3 marks)

5. Differentiate between Directional, Stabilising and Disruptive selection (3 marks).

6. Please consider the following pedigree for a relatively common inherited condition in which the frequency of the dominant allele is 0.23 in the population at large.



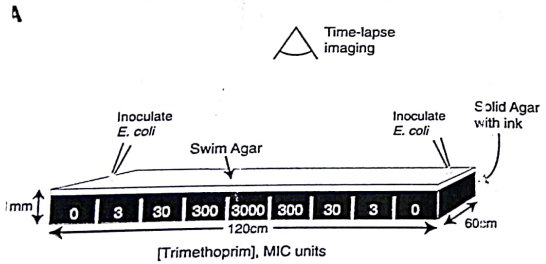
(a) Determine the mode of inheritance. Then calculate the probability that the child IV-2 inherits the condition. (2 marks)

(b) If IV-2 is unaffected and marries at random with respect to this condition, what is the probability that the couple's first child will show the trait? (4 marks)

7. Michael Baym et al. 2016 (Science; 353:1147-1151) did a beautiful experiment where they grew *E. coli* bacteria on a large agar plate which had a gradient of antibiotic (trimethoprim- TMP, see figure below). The ancestral bacteria had very low antibiotic resistance. They then took time-lapse images of the agar plate over the next 12 days (see the time-lapse movies in the paper reference given above- they are beautiful). The bacteria grew and by 12th day, had reached highest antibiotic concentration region of the agar plate. The set up and results are summarised below in the figure. The white regions in the plate represent bacteria. The black regions show no bacteria. MIC is a measure of antibiotic concentration with higher values representing higher antibiotic concentration.

a. Design an experiment (just mention the idea) to show that bacteria in the 3000 MIC region have actually evolved antibiotic resistance. (2 marks)
b. The experiment was started by inoculating the plate with six clonal (genetically identical) colonies of *E. coli* bacteria. Yet, these bacteria evolved increased antibiotic resistance. How can clonal populations evolve? (2 marks)
c. What is (are) the agent(s) of selection in this experiment? (2 marks)
d. The lines in Figure B represent ancestry. You can see that some lineages of bacteria evolved to colonise areas with higher antibiotic resistance but then died out while few lineages consistently increased in numbers. What are the potential reasons? (2 marks)
e. Suppose that the antibiotic gradient was steeper (i.e. 0, 30 and 3000 only). Would the results be any different? If yes, in what way? (2 marks)

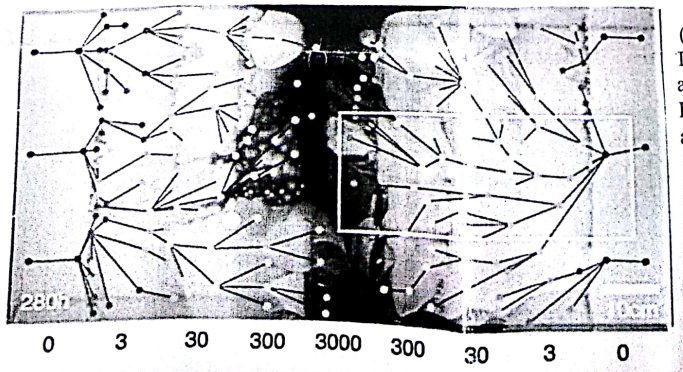
A



An experimental device for studying microbial evolution in a spatially structured environment.

(A) Setup of the four-step gradient of antibiotic trimethoprim (TMP). Antibiotic is added in sections to make an exponential gradient rising inward.

B



(B) The four-step TMP Agar-plate after 12 days. Lines indicate ancestry.