BIOLOGY 336 – SECTION 101
Fundamentals of Evolutionary Biology
PRACTICE Midterm 2 - October, 2016

Name : _____ _____
FAMILY NAME FIRST NAME

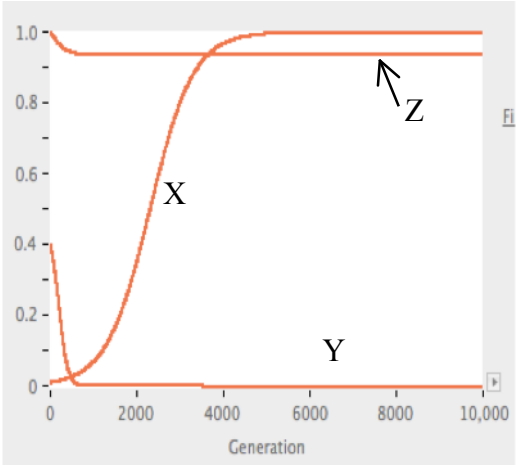
Student Number : _____

1. Answers may be in sentences or point form. The exam may be written in pen or pencil, but pencil answers will not be eligible for remarks.
2. Answer all questions in the space provided. Material written on other pages will NOT be read or marked - unless it is an exact replacement for crossed-out material to be ignored in the answer-space.
3. No student shall be permitted to enter the examination room after the expiration of one-half hour from the scheduled starting time, or to leave during the first half hour of the examination. No one may leave during the final 5 min of the 80-min exam period.
4. Students suspected of any of the following, or similar, dishonest practices shall be immediately dismissed from the examination and shall be liable to disciplinary action:
   - having at the place of writing any books, papers or memoranda, computers, sound or image players/recorders/transmitters (including telephones), or other memory aid devices, other than those authorized by the examiners;
     Y**ou may use a non-programmable calculator.**
   - speaking or communicating with other candidates; and
   - purposely exposing written papers to the view of other candidates or imaging devices.
     The plea of accident or forgetfulness shall not be received.
5. Students must hand in all examination papers; and must not take any examination material from the examination room.
6. Students must follow any additional examination rules or directions communicated by the instructor or invigilator.

I have read and fully understand these instructions, and I have checked that all pages are present.

Student signature _____

1. The graph to the right shows the change in the frequency of allele A under three scenarios (labeled X, Y and Z) that differ in various population genetic variables.



Each of the lines corresponds to a single scenario described below. Determine the scenario (a-e) that best predicts each of the lines (X,Y,Z). **Briefly explain your choice in the space provided**. (9 marks)

A. $N = 500$; $W_{AA} = 1.0005$, $W_{Aa} = 1$, $W_{aa} = 1$; $\mu=0$

B. $N = 1000000$; $W_{AA} = 1$, $W_{Aa} = 0.99$, $W_{aa} = 1.01$; $\mu=0$

C. $N = 1000000$; $W_{AA} = 0.95$, $W_{Aa} = 1$, $W_{aa} = 0.95$; $\mu=0$

D. $N = 1000000$; $W_{AA} = 1$, $W_{Aa} = 1$, $W_{aa} = 0.95$; $\mu=0.0002$

E. $N = 1000000$; $W_{AA} = 1.004$, $W_{Aa} = 1.002$, $W_{aa} = 1$; $\mu=0$

*Note that μ is the mutation rate from A to a.

Line	Best matches scenario… [(a-e) from above]	Explanation
X	E (**1 mark each**)	This line shows **directional selection** in a very large population, in which A is favored. Fixation is achieved; therefore there must be no mutation. (**2 marks each**)
Y	B	Because A is lost it could be a situation in which there is **hetoerzygote disadvantage**, and we are starting with the frequency of A **below the equilibrium**. This fits scenario B. Don't accept an answer that says W_{aa} is higher than W_{AA} , doesn't matter if you start lower than 0.5 freq, which they need to mention.
Z	D	This line shows a polymorphic equilibrium. Of the scenarios we have seen, only het advantage or mutation-selection balance allow for polymorphism. The fact that the line is close to p=1 suggests **mutation-selection balance**, but this is confirmed by noting that the particular het advantage scenario shown would lead to p-hat = 0.5. Therefore, the only possible match is (d).

2. Calculate the selection and dominance coefficients for the following set of fitnesses:

$w_{11} = 1.24$, $w_{12} = 1.18$, $w_{22} = 1$ (3 marks)

$w_{11} = 1+s$ $w_{12} = 1+hs$ $w_{22} = 1$

$s = 0.24$ $w_{12} = 1.18 = 1+h(0.24)$ $h = 0.18/0.24 = 0.75$

(**1 mark** for calculations, **1 mark each** for correct answer for s and h)

3. You have a population of flies of the following genotypes: (12 marks total)

Genotype	# individuals
F/F	11
F/S	14
S/S	5

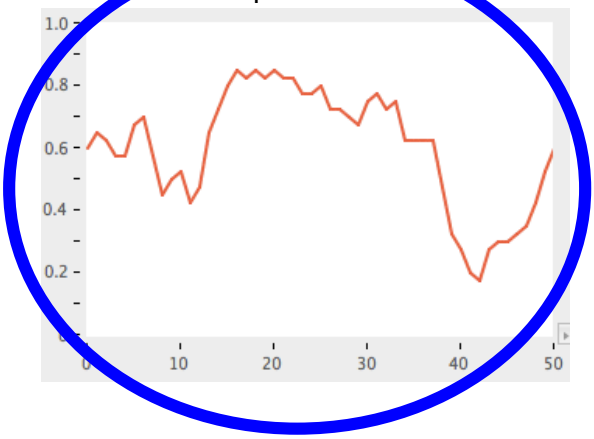
a. What are the frequencies of the F and S allele in this population? (2 marks)

f(F) = 18/30 [or 36/60, if did # F alleles rather than #individuals] = 0.6
f(S) = 1 – 0.6 = 0.4

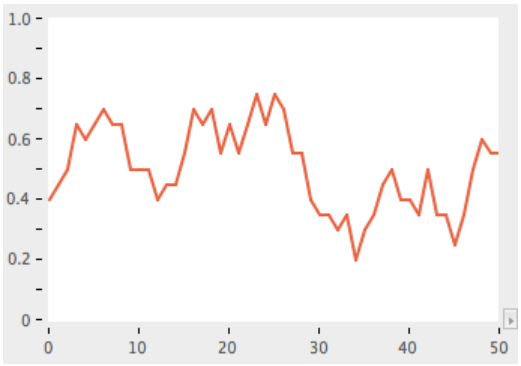
b. Let's say you maintained this fly population in a stable environment and tracked the frequency of the F allele over 50 generations. After the 50th generation, you plot a graph using your frequency data.

Which of the two graphs below represents your data? Circle your chosen graph. (2 marks)

Graph A



Graph B

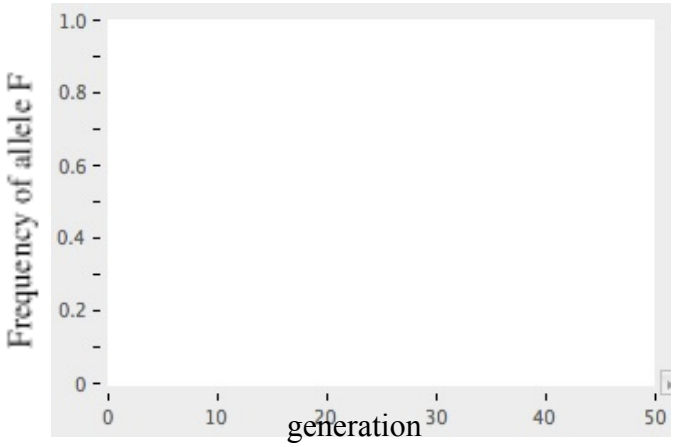


c. How can you tell that genetic drift is operating on this population? (3 marks)

Looking for students to say something like:
– The line is "jagged", suggesting sampling bias from generation to generation,
– The sampling is apparently random (i.e., genetic drift), since the frequency of F fluctuates around the starting frequency (*might also add:* end frequency is very similar to starting frequency).

d. Imagine this fly population was 100x larger (N=3000). Using the graph template below, sketch an average prediction for how the F allele frequency might possibly change. Your graph should include the ***typical*** changes you might expect to see due to drift, given a much larger population. (There are many possible graphs) (2 marks)

– GRAPH BELOW: start frequency = 0.6; line looks less "jagged" than graphs from 3b.



e. Compare your drawn graph to the graphs from 3b and describe ***why*** the features of your graph indicate the data came from a much larger population. (3 marks)

– FEATURES: The change due to genetic drift should be less than in 3b b/c pop. size larger, therefore the random fluctuation in allele F frequency should be less, therefore line on 3d graph should be less "jagged".

4. Consider the YEL locus in a local population of mice. There are two alleles at this locus, A and B. The B allele arises in the population due to mutation every generation and is lethal in homozygotes. Heterozygotes experience lower survival to reproductive age compared to individuals who do not have the B allele. (7 marks)

a. What is the relationship between alleles at the YEL locus? (1 mark)

Partial dominance

b. What is the value of the selection coefficient? (1 mark)

$s = 1$

c. At equilibrium, the A allele is present in the population at a frequency of 0.996. If the mutation rate to the B allele is 3×10^{-3}, what is the relative fitness of the heterozygous mice? Show your work. (3 marks)

A-hat = 0.996, so B-hat = 1- B = 0.004 (1 mark)

$q = \mu/hs$
$0.004 = 0.003/h$, so $h = 0.75$ (1 mark)

$w_{12} = 1-hs = 1- 0.75 = 0.25$ (1 mark)

d. In general, are most mutations in that occur in a genome expected to be deleterious? Explain your answer. (2 marks)

Most mutations are neutral (1 mark). This is because they may be synonymous or they may occur in regions of DNA that are not involved in coding for proteins. (1 mark)

5. Biologists have been studying the butterflies on the remote island of Sulawesi for the last decade. Populations of the Sulawesi blue butterfly can have one, two or three black stripes on their wings, and this trait is controlled by alleles at the striped locus. (7 marks total)

In 2005, they observed the following numbers of individuals for the three genotypes

BB (one stipe)	600
Bb (two stripes)	705
bb (three stripes)	195

a. Calculate the frequency of each allele in the population (show all of your work). (1 mark)

f(BB) = 600/1500 = 0.4 f(B) = 0.4 + 0.47/2 = 0.635 OR (600+705/2)/1500 = 0.635
f(Bb) = 705/1500 = 0.47 f(b) = 1-0.635 = 0.365
f(bb) = 195/1500 = 0.13

b. What would be the expected number of each genotype if this population was in Hardy-Weinberg equilibrium? (Show all of your work) (2 marks)

0.635*0.635 = 0.403225 * 1500 = 604.8 BB
2(0.635*0.365) = 0.46355 * 1500 = 695.3 Bb
0.365*0.365 = 0.133225 * 1500 = 199.8 bb

c. If a Chi-squared test (critical value of 3.84) gave a Chi-squared calculated value of 0.2887, would you conclude that this population is in Hardy-Weinberg equilibrium? Explain. (2 marks)

Yes, this population is in HW. The calculated value is lower than the critical value, which means that any deviations from expected genotype numbers are not statistically significant.

d. What four mechanisms of evolution could change genotype frequencies away from Hardy-Weinberg equilibrium in a population? (2 marks)

Mutation, Selection, Drift and Gene Flow/Migration (0.5 each)

6. Biologists have continued studying the butterflies on the remote island of Sulawesi. Populations of the Sulawesi blue butterfly can have one, two or three black stripes on their wings, and this trait is controlled by alleles at the striped locus. (10 marks total)

In 2010, they observed the following numbers of individuals for the three genotypes

BB (one stipe)	548
Bb (two stripe)	764
bb (three stripe)	188

a. Calculate the frequency of each allele in the population (2 marks)

f(BB) = 548/1500 = 0.365
f(Bb) = 764/1500 = 0.51
f(bb) = 188/1500 = 0.125

f(A) = 0.365 + 0.5(0.51) = 0.62
f(a) = 1-0.62 = 0.38

In 2011, there was a volcanic eruption on the island that eliminated most of the population of butterflies. In their surveys one year after the eruption, researchers surveyed the offspring of survivors of the eruption and found the following:

BB	23
Bb	33
bb	30

b. Calculate the new allele frequencies in this sample. (2 marks)

f(BB) = 23/86 = 0.27
f(Bb) = 33/86 = 0.38
f(bb) = 30/86 = 0.35

f(A) = 0.27 + 0.5(0.38) = 0.46
f(a) = 1-0.46 = 0.54

c. Briefly describe the mechanism that best accounts for the change in allele frequency. (3 marks)

Genetic drift due to a population bottleneck caused by the volcanic eruption. The size of the population was suddenly reduced and a different frequency of each genotype survived.

d. Has this population evolved? Explain your answer. (2 marks)

Yes, they did reproduce and a year later they were looking at the next generation. There was a change of allele frequencies from one generation to the next, so this would count as evolution.