(32) + Self

Name:

Student number: Key

MID-TERM BIOL 434/509: October 2017

	Points
Q1	15
Q2	10
Q3	15
Q4	16
Q5	12
Q6	20
Q7	12
Total	100

Check that your copy of the test has all 8 pages, including this one.

The following are UBC's rules governing formal examinations:

1) Each candidate must be prepared to produce, upon request, a Library/AMS card for identification.
2) Candidates are not permitted to ask questions of the invigilators, except in cases of supposed errors or ambiguities in examination questions.
3) No candidate 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.
4) Candidates suspected of any of the following, or similar, dishonest practices shall be immediately dismissed from the examination and shall be liable to disciplinary action.
    a) Having at the place of writing any books, papers or memoranda, calculators, computers, audio or video cassette players or other memory aid devices, other than those authorized by the examiners.
    b) Speaking or communicating with other candidates.
    c) Purposely exposing written papers to the view of other candidates. The plea of accident or forgetfulness shall not be received.
5) Candidates must not destroy or mutilate any examination material; must hand in all examination papers; and must not take any examination material from the examination room without permission of the invigilator.

1. (15 *points: 5 each*) A small population (of 6 diploid individuals) has an allele frequency of 0.8 for the *B* allele at neutral locus. The population meets the assumptions of an ideal population, and there is no migration into the population. Assume that mutation is too weak to affect the calculations below.

a. What is probability that allele frequency of *B* is 0.5 in the next generation?

$Pr[6] = \binom{12}{6}(0.8)^6(0.2)^6$

Answer: 0.0155

b. What is probability of fixation of *B*?

Answer: 0.8

c. What is the expected heterozygosity in the next generation?

$\left(1-\frac{1}{2(6)}\right)\left(2 \times 0.8 \times 0.2\right) =$

$\left(1-\frac{1}{2N_e}\right)\left(H_0\right)$

Answer: $0.29\bar{3}$

2. (10 *points*) A locus has mutation rate of 10^{-6} per coding region. Assume that all beneficial alleles at this locus have a homozygous fitness that is 1.01 times as great as the currently common genotype, with a dominance coefficient of 0.5. The population size is 1000 with an effective population size of 800. What is the rate at which beneficial mutations are expected to fix per generation in this population?

s = Heterozygous fitness benefit = 0.005

Answer:
0.000016

Pr[fixation of new mutation] $= 2s\frac{N_e}{N}$

$= 2(0.005)\frac{800}{1000} = 0.008$

Number of new beneficial mutations per generation $= 2N\mu$

RATE OF FIXATION = Pr[fixation] × Number of mutations

$= 0.008 \times 2 \times 1000 \times 10^{-6} =$

0.000016

3. (15 *points: 5 each*) The probability of survival from offspring to adult is 0.49, 0.70, and 0.63 for genotypes *DD*, *Dd*, and *dd*, respectively. Assume that there is no migration or mutation, and that the population size is infinitely large. In one generation, the allele frequency of *D* is 0.4.

a. What would be the expected allele frequency of *D* in the next generation?

$$p_D' = \frac{p_D(p_D(0.49) + p_d(0.70))}{p_D^2(0.49) + 2p_Dp_d(0.7) + p_d^2(0.63)}$$

$$= \frac{0.4(0.4(0.49) + (0.6)(0.7))}{0.4^2(0.49) + 2(0.4)(0.6)(0.7) + (0.6)^2(0.63)} = \frac{0.2464}{0.6412}$$

Answer: 0.384

b. What would be the expected allele frequency of *D* at equilibrium?

	DD	Dd	dd
fitness	0.49	0.7	0.63
relative fitness	0.7	1	0.9
	$1-s$	1	$1-t$
	$s=0.3$		$t=0.1$

$$\hat{p} = \frac{t}{s+t} = 0.25$$

Answer: 0.25

c. Why are $p = 0$ and $p = 1$ unstable equilibria in this system?

Because selection causes allele frequency to move away from p=0 or p=1 after a small perturbation away from these equilibria.

Answer:

$10cM \cong 10\%$ recombination

4. (16 *points: 4 each*) Two loci A and B are 10 centiMorgans apart on an autosomal chromosome. Initially, the gamete frequencies in a population are 40% *AB*, 20% *Ab*, 10% *aB*, and 30% *ab*.

a. What is D in this initial generation?

$D = (0.4 \times 0.3) - (0.2)(0.1)$

$=$

Answer: 0.1

b. What would D be after 3 generations?

$D_3 = (1-r)^3 D_0$

$= (1-0.1)^3 (0.1)$

Answer: 0.0729

c. Assuming no mutation, migration or selection in an infinitely large population, what would D be at equilibrium?

Answer: 0

d. Why is it important that this specified that the locus was on an autosomal chromosome? How would the answer to **b** be different if the locus was on a sex chromosome?

Because there is no recombination in one sex for sex chromosomes.

b would be different because recombination would proceed only half as fast.

5. (12 *points: 6 each*) What is mutation load for a locus for which the mutation rate to the deleterious allele is 10^{-6} and the fitness of the three genotype are 1 : 0.99 : 0.92? What is equilibrium allele frequency of the more fit allele?

q

$$\text{Load} = 2\mu = 2 \times 10^{-6}$$

Answers :
Load: 2×10^{-6}
Equilibrium ***p*****:** 0.9999

$$\hat{q} = \frac{\mu}{hs} = \frac{10^{-6}}{0.01} = 10^{-4}$$

$$\hat{p} = 1 - \hat{q} = 0.9999$$

6. (20 *points: 5 each*) Let us compare two similar scenarios. Both start with an allele *A* fixed in a population. Both have 1 copy of a new allele introduced by mutation. The only difference between these scenarios is the fitness of the genotypes, as given in the following table:

Scenario	Fitness of *AA*	Fitness of *Aa*	Fitness of *aa*
1	5.0	5.3	7.0
2	1.1	1.2	1.15

a. Which scenario will have a greater increase in frequency of the *a* allele in the first several generations?

Relative fitnesses:

Scenario 1: $\frac{5.0}{5.0}$ $\frac{5.3}{5.0}$ $\frac{7.0}{5.0}$

1   1.06   1.4

Scenario 2: $\frac{1.1}{1.1}$ $\frac{1.2}{1.1}$ $\frac{1.15}{1.1}$

1   1.091   1.045

Relative fitness of heterozygote is higher in Scenario 2, therefore selection will be faster for Scenario 2.

Answer:

Scenario 2

b. Which is most likely to reach fixation for the *a* allele first, and why?

Scenario 2 has overdominance, and so is unlikely to fix quickly. Scenario 1 will fix first.

c. What is the expected (stable) equilibrium frequency for each scenario?

Scenario 2

fitness   1.1   1.2   1.15

relative fitness $\frac{1.1}{1.2}$ 1 $\frac{1.15}{1.2}$

$0.91\overline{6}$ $0.958\overline{3}$

$s = 0.08\overline{3}$ $t = 0.041\overline{7}$ $\hat{p} = \frac{t}{s+t} = \frac{1}{3}$

Answer:

Scenario 1: $p = 0$

Scenario 2: $\hat{p} = \frac{1}{3}$

d. (*continued from previous page*) For scenario 1, what is the marginal relative fitness of each of the two alleles, when the allele frequency of *A* is *p*?

Answer:

$w_A = p(1) + (1-p)(1.06)$

$w_a = p(1.06) + (1-p)(1.4)$

7. (12 *points*) Describe two kinds of selection that can maintain genetic variation in the absence of mutation or migration.

The two best answers based on what we learned so far:

negative frequency-dependent selection

overdominance