Name: KEY

Student number:

MID-TERM BIOL 434/509: October 2014

	Points
Q1	18
Q2	12
Q3	10
Q4	18
Q5	22
Q6	15
Q7	5
Total	100

Check that your copy of the test has all 7 pages.

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. (18 *points: 5;6;1;6*) A locus has two alleles. At one point in time (call it generation 0), the allele frequency is measured to be 0.2 for one of the alleles (call it *K*). Ten generations later, the allele frequency of *K* in the same diploid population is measured again. For each generation between these two time points, the population had an effective population size equal to 20. There is no mutation or migration during these generations.

a. What is the heterozygosity at this locus in generation 0?

$$2p(1-p) = 2(0.2)(0.8) = 0.32$$

b. What is the heterozygosity in generation 10 expected to be if the allele is neutral?

$$\left(1-\frac{1}{2N_e}\right)^t H_0 = \left(1-\frac{1}{2(20)}\right)^{10}(0.32) = 0.248$$

c. In actual fact, the allele frequency was measured in generation 10, and the frequency of the *K* allele was 0.35. What is heterozygosity in generation 10?

$$2p_{10}(1-p_{10}) = 2(0.35)(0.65) = 0.455$$

d. Is this result (in part *c*) possible if the allele is neutral? Explain.

Yes, it is possible. The answer in (b) is an expectation, but drift can cause allele frequency to change up or down.

2. (12 *points*) Define the following terms, in 25 words or less.

a. *Negative frequency dependence*

Fitness of each phenotype increases as that phenotype becomes rarer.

b. *Overdominance*

The fitness of a heterozygote is greater than either homozygote.

c. *Insertion*

A mutation whereby one or more nucleotides is inserted into a DNA sequence.

3. (10 *points*) A biallelic locus experiences meiotic drive, such that in heterozygotes 80% of the gametes are *A* (rather than *a*). In a randomly mating large population with no other selection, no mutation, and no migration, the allele frequency of *A* is 0.6. What is the allele frequency expected to be in the next generation? What is the frequency of heterozygotes expected in the offspring generation?

$$p' = p^2 + 2Kpq$$

$$K = 0.8; \quad p = 0.6$$

$$p' = (0.6)^2 + 2(0.8)(0.6)(0.4) = 0.744$$

$$H = 2p'q' = 2(0.744)(1-0.744) = 0.3809$$

4. (18 *points*) A new neutral mutation b appears in an ideal population of 20 haploid individuals, which is otherwise fixed for a different allele B. Assume that there is no further mutation or migration.

a. What is the probability that this new mutation b is lost in one generation?

$$\binom{20}{0}\left(\frac{1}{20}\right)^0\left(1-\frac{1}{20}\right)^{20} = 0.35948$$

b. What is the probability that this new mutation b is lost over an infinite number of generations?

$$\Pr\{\text{fixation of neutral allele}\} = p = \frac{1}{20}$$

$$\Pr\{\text{loss}\} = 1 - \Pr\{\text{fixation}\} = 1 - \frac{1}{20} = 0.95$$

c. If the new mutation is linked to another variable allele which is favored by selection, how would that change your answer to part (b): (increase or decrease)? What is this called?

Selection for a linked allele would decrease the probability of loss; this is genetic hitchhiking.

5. (22 *points*) A population (which we will assume is very large in number) has 1% of its alleles as *g* alleles, with the rest *G*. This locus experiences selection on viability, with the probability of a zygote surviving to adulthood equal to 0.5 for *GG* individuals, 0.48 for *Gg* individuals, and 0.3 for *gg* individuals. The *G* allele mutates to *g* at rate 10^{-6} per generation, with no back mutation. There is no migration into this population.

a. (*5 points*) What is the expected allele frequency of *G* after one generation?

~~p = 0.9~~

$$p' = p \frac{(p w_{11} + (1-p) w_{12})}{p^2 w_{11} + 2p(1-p)w_{12} + (1-p)^2 w_{22}} (1-\mu)$$

$$= (0.99) \frac{0.99(0.5) + (0.01)(0.48)}{0.99^2(0.5) + 2(0.99)(0.01)(0.48) + (0.01)^2(0.3)} (1-10^{-6})$$

$$= 0.990427$$

b. (*6 points*) What is the expected frequency of *G* after a very large number of generations?

At equilibrium, q will be at mutation selection balance:

$\hat{q} = \frac{\mu}{hs}$; and G will be at $\hat{p} = 1 - \hat{q} = 1 - \frac{\mu}{hs}$

$1 - hs = \frac{0.48}{0.5}$; $hs = 0.04$; $\hat{q} = \frac{10^{-6}}{0.04} = 0.000025$

$\hat{p} = 0.999975$

c. (*5 points*) How much mutation load is caused by this locus at equilibrium?

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

d. (*6 points*) How much load is caused by this locus at the beginning generation in the scenario described above?

$$\bar{w}_{no\ mut} = 1$$

$$\bar{w}_{mut} = 0.99^2(1) + 2(0.99)(0.01)\left(\frac{0.48}{0.5}\right) + (0.01)^2\left(\frac{0.3}{0.5}\right) = 0.99168$$

$$L = \bar{w}_{no\ mut} - \bar{w}_{mut} = 0.00832$$

6. (15 *points*) A locus has heterozygosity equal to 0.7 (with Hardy Weinberg frequencies of the genotypes) in the initial generation of an experiment. This locus is observed in a diploid population of 100 individuals (each generation) with a variance in reproductive success equal to 6.

a. What can you say about how many alleles are at this locus?

number of alleles > 3

with 2 alleles, maximum heterozygosity is 0.5 (when p = ½)
with 3 alleles, maximum heterozygosity is 2/3 (when p = ⅓ for all a)

b. What is the expected probability of identity in state of randomly chosen pairs of alleles from this population 10 generations after the start described above?

$F_0 = 0.3 \qquad N_e = \frac{4(100)-2}{6+2} = 49.75$

$$1-F_{10} = \left(1-\frac{1}{2N_e}\right)^t (1-F_0)$$

$$= \left(1-\frac{1}{2(49.75)}\right)^{10} (1-0.3) = 0.6327$$

$$H_{10} = 1-F_{10} = 0.3675$$

7. (*5 points)* TRUE or FALSE: At every stable equilibrium, the marginal fitnesses of all alleles are equal.

FALSE. For example, with directional selection, two alleles never have equal fitness, even at the stable equilibrium (fixation of the best allele).