MBG-3060 Quantitative Genetics Midterm Examination

Name: Answer Key Student ID number: ______

Q1	/10
Q2	/9
Q3	/5
Q4	/6
Q5	/7
Q6	/8
Part 2	/15
Total	/60
Percent	%
(Don't write here)	

Wednesday, February 12, 2014 7:00 to 9:00 pm
ANNU various locations

Instructions: Answer **ALL** questions on the exam pages. **Be sure to write your name and student ID number on EVERY PAGE of this exam.** The marks awarded for each question are shown in parentheses ( ) in the left margin. The time limit for this examination is 2 hours - manage your time well. Formulae sheets are provided along with a Chi-square table. Help save trees by returning the formula sheets so we can use them for the final exam. For a maximum opportunity to receive partial credit, show all calculations, steps for numerical questions and **indicate all units as appropriate.**

Part 1 - Answer Each Part of Each Question, Marks Awarded as Noted in Parentheses

(10) Question 1. (3 marks for part a), c) and d), 1 mark for part b))
A zoologist is studying the Gryphon squirrels on the U of G campus. By careful observation, the zoologist detects that 16% of the population are black and the remainder are grey. The zoologist assumes the black colour is a recessive allele to the dominant grey colour and assigns the coat colour locus alleles labelled **G** (dominant allele) and **g** (recessive allele).

3 marks

a) Calculate the frequency of the grey phenotype for this coat colour locus.

Given $f(gg) = 0.16$, assume $f(gg) = q^2 \Rightarrow q = \sqrt{0.16} = 0.4$ (1)

$p = 1 - q = 1 - 0.4 = 0.6$ (1)

then $f(Grey) = p^2 + 2pq = (0.6)^2 + 2(0.6)(0.4) = 0.84$ (1)

OR

short cut $f(Black) = 1 - f(Grey) = 1 - 0.16 = 0.84$ (3)

b) What ***specific*** assumption did you make to arrive at the frequency you calculated in part a)?

→ random mating (1)

Don't need to assume Hardy-Weinberg Equilibrium

MBG-3060 Quantitative Genetics Midterm Examination

Name: ______________________________ Student ID number: ___________

(Question 1 Continues)

Coming back for another year of study, the zoologist observes that something has changed from the previous year. The 16% of black squirrels seem to be subject to predation during the winter months and the zoologist observes that the frequency of the **gg** genotype has become 9%.

c) What was the fitness of the **gg** genotype that led to the change of genotypic frequency?

$q_0 = \sqrt{0.16} = 0.4$, $q_1 = \sqrt{0.09} = 0.3$, $p_0 = 1 - q_0 = 0.6$, $p_1 = 1 - q_1 = 0.7$ (1)

$p_1 = \frac{p_0}{1 - sq_0^2}$ (1) $\Rightarrow 0.7 = \frac{0.6}{1 - s(0.16)} \Rightarrow 0.7 - 0.112s = 0.6 \Rightarrow 0.112s = 0.1, s = 0.8929$

fitness $= 1 - s = 1 - 0.8929 = 0.1071$ (1)

−1 for stopping at s = 0.8929

d) If the predators become very efficient and in subsequent years the zoologist observes **all** of the **gg** individuals are removed by predators each generation, how many generations does it take for the percentage of individuals born with the black coat colour to go from 9% to less than 1%.

$q_0 = \sqrt{0.09} = 0.3$ $q_n = \sqrt{0.01} = 0.1$ (1)

$n = \frac{1}{q_n} - \frac{1}{q_0}$ (1) $= \frac{1}{0.1} - \frac{1}{0.3} = 6.67 = 7$ generations (1)

−1 for not rounding

−½ for no units

(9) Question 2. (4 marks for each of parts a) and c) , one mark for part b)).

Given two loci (**A** and **B**) with 2 alleles each (**A** or **a**, **B** or **b**) and f(**A**) = 0.9, f(**B**) = 0.7.

a) Calculate the frequency of the **AB** and **aB** gametes produced by individuals with an **AB** // **ab** genotype if d = +0.03. *4 marks*

$f(AB) = f(A) \cdot f(B) + d$ (1) $= 0.9(0.7) + 0.03 = 0.66$ (1)

$f(aB) = f(a) \cdot f(B) - d$ (1) $= 0.1(0.7) - 0.03 = 0.04$ (1)

if wrong sign in equation deduct 1 per equation

b) What is the linkage phase?

Coupling (1)

Name: ________________________________ Student ID number: ___________

(Question 2 Continued)

4 marks

c) If the recombination rate is 1 individual per 150 individuals, how much does the frequency of the **Ab** gamete produced by individuals with the same genotype as part a) change after one round of random mating?

$c = 1/150 = 0.0067$ (1)

$f(Ab)_1 = f(Ab)_0 + cd_0$

change $= +cd_0 = 0.0067(0.03) = 0.0002$ (1) (1) (1)

-1 if they calculated the new f(Ab) instead of just the change

(5) Question 3. (4 marks for part a), 1 marks for part b)

A horse breeder is worried about a recessive **autosomal** allele causing a condition like haemophilia that is non-fatal. The frequency of the homozygous recessive genotype in this particular breed is 1%. This breeder is interested in a prominent stallion (male) as a possible mate for her prize mare (female) and wonders if the stallion is a carrier of the recessive allele. This particular stallion has had 8 foals (babies) so far, from matings at random in the population and none have been affected.

a) What is the probability that the stallion would be detected as a carrier with this many foals?

$P(\text{detect}) = 1 - [f(BB) + \frac{3}{4}f(Bb) + \frac{1}{2}f(bb)]^n$ (1)

$f(bb) = 0.01 \Rightarrow f(b) = q = \sqrt{0.01} = 0.1 \Rightarrow f(B) = p = 1 - q = 0.9$ (1)

$f(BB) = (0.9)^2 = 0.81 \quad f(Bb) = 2(0.9)(0.1) = 0.18$ (1)

$P(\text{detect}) = 1 - [0.81 + \frac{3}{4}(0.18) + \frac{1}{2}(0.01)]^8 = 1 - (0.95)^8 = 0.3366$ (1)

b) What is the single best thing the stallion's owner could do to increase the probability of detecting that the stallion is a carrier of the recessive allele?

Mate to all homozygous recessive mares (1)

MBG-3060 Quantitative Genetics Midterm Examination

Name: ______________________________ Student ID number: __________

(6) Question 4.

Researchers have identified a non-lethal dwarfism condition in the Dexter breed of beef cattle. It is an autosomal recessive and the "normal" allele is **D** and the dwarf allele is **d.** Of the 100 Dexter cattle sampled in the study, 20 had the **dd** genotype and 40 had the **DD** genotype. What was the effective number of individuals randomly mating that produced this sample of 100 cattle?

$n = 100 \quad f(dd) = \frac{20}{100} = 0.2 = Q, \; f(DD) = \frac{40}{100} = 0.4 = P$ (1)

$H = 1 - P - Q = 0.4$ (1)

$f(D) = P + \frac{1}{2}H = 0.4 + \frac{1}{2}(0.4) = 0.6$

$f(DD) = p^2 + \sigma_p^2$ (1) $\Rightarrow 0.4 = (0.6)^2 + \sigma_p^2 \Rightarrow \sigma_p^2 = 0.4 - 0.36 = 0.04$ (1)

$\sigma_p^2 = \frac{pq}{2N_e}$ (1) $\Rightarrow \frac{0.6(0.4)}{2N_e} = 0.04 \Rightarrow 0.24 = 0.08 N_e \Rightarrow N_e = 3$ (1)

(7) Question 5 (part a) 4 marks, part b) 3 marks)

In a wild population of groundhogs, there is a recessive albino allele (**a**) which produces a white albino ground hog. The dominant allele (**A**) produces a normal, brown groundhog. In search of a replacement for Wiarton Willy (a famous albino groundhog), a wildlife biologist has observed that **4%** of the groundhogs in this unusual population are born albino. The biologist also observes that the young albino ground hogs have become easy prey for a group of Redtail Hawks that have developed a taste for groundhog and **none** of the albinos survive to reproduce. Assume that this groundhog population is large, has been randomly mating and is in Hardy-Weinberg equilibrium.

4 marks

a) With the hawks preying on them, what will be the proportion of albino groundhogs born in the next generation?

$f(aa) = 0.04$ assume $q = \sqrt{0.04} = 0.2, \; p = 1 - q = 0.8$ (1)

equivalent to lethal recessive

$q_1 = \frac{q_0}{1 + q_0}$ (1) $= \frac{0.2}{1 + 0.2} = 0.8333\dot{3}$ (1)

$f(aa)$ in next generation $= q_1^2 = (1 - 0.8333\dot{3})^2 = 0.0278$ (1)

Name: ______________________________ Student ID number: ___________

Question 5 continued 3 marks

b) What will be the frequency of the albino allele in the 5[th] generation, if the hawk population continues to prey on the albino groundhogs?

$$p_n = \frac{1+(n-1)q_0}{1+nq_0} \text{ (1)} \Rightarrow p_5 = \frac{1+(5-1)(0.2)}{1+5(0.2)} = \frac{1+4(0.2)}{1+5(0.2)} = \frac{1.8}{2} = 0.9 \text{ (1)}$$

$$q_5 = 1 - p_5 = 1 - 0.9 = 0.1 \text{ (1)}$$

(8) Question 6. (both parts 4 marks each)

Two populations of tropical fish live in separate aquariums in a marine theme park. The colour of these fish has been transgenically manipulated with the green fluorescent protein locus with alleles **G** and **g**. The **GG** genotype glows green, the **Gg** genotype glows yellow and the **gg** genotype is normal silver. In tank A, the allele frequencies are: f(**G**) = **0.8**, f(**g**) = **0.2**. In tank B, the population allele frequencies are: f(**G**) = **0.5**, f(**g**) = **0.5**. There are **100** fish in tank A and **100** fish in tank B. The fish have an annual reproductive cycle. A new employee filling in during summer vacation messes up the filter pumps and pumps **20** fish from tank B to tank A.

a) What is the frequency of the **g** allele in the combined tank A population after the pump mix-up?

Tank A $p_1 = 0.8$ $q_1 = 0.2$ $n = 100$

Tank B $p_2 = 0.5$ $q_2 = 0.5$

$$m = \frac{20}{100+20} = 0.1667 \text{ (1)}$$

$$p_1' = m(p_2 - p_1) + p_1 \text{ (1)} = 0.1667(0.5-0.8) + 0.8 = 0.75 \text{ (1)}$$

$$f(g) = q_1' = 1 - p_1' = 0.25 \text{ (1)}$$

b) The mixup is never tracked to that same employee and they are once again on duty each of the **next** 2 summers. The hapless employee manages to make the same mistake each summer. What is the frequency of the glowing green phenotype in the resulting population in tank A assuming random mating?

Assume m stays constant, k = 3

$$(1-m)^k = \frac{{}_kP_1 - P_2}{{}_0P_1 - P_2} \text{ (1)} \Rightarrow (1-0.1667)^3 = \frac{{}_3P_1 - 0.5}{0.8 - 0.5} \text{ (1)} \Rightarrow 0.5786 = \frac{{}_3P_1 - 0.5}{0.3}$$

$$\Rightarrow 0.5786(0.3) + 0.5 = {}_3P_1 = 0.6736 \text{ (1)}$$

$$f(\text{glowing green}) = f(GG) = {}_3P_1^2 = 0.4537 \text{ (1)}$$

Some may use ${}_0P_1 = 0.75$ and $k = 2$ ⇒ that is okay

if $k=2$ and ${}_0P_1 = 0.8$ then −1

Some may calculate m each time and do 3 generations - that is OK too

MBG-3060 Quantitative Genetics Midterm Examination

Name: ______________________________ Student ID number: ___________

Part 2 - Short Answer Questions

Each correct answer is awarded one (1) mark. Each question can be answered with a brief sentence, quick calculation or by circling the correct answer.

2.1 Which genotype(s) listed below has a gametic output that is altered by linkage disequilibrium (circle all that apply) Ab//aB or AB//Ab or AB//ab

½ each

2.2 For a single locus with two alleles, what is the highest frequency the heterozygous genotype can achieve if mating is random and nothing is altering allele frequencies?

$H_{max} = 0.5$

2.3 What is the most informative genotype to use in matings for detecting a carrier of an embryonically lethal allele? no aa born so use Aa (heterozygote)

2.4 Suppose we have 2 loci, **G** and **H**, with alleles **G** and **g, H** and **h**. Which of the equations below is correct for calculating the observed frequency of the **gH** gamete type when given the expected frequency of that gamete type and the coefficient of linkage disequilibrium? (circle the correct one)

$t_O = t_E - d$ **OR** $s_O = s_E + d$ **OR** $s_O = s_E - d$ **OR** $t_O = t_E + d$

2.5 Given a locus with two alleles, **A** and **a.** If selection against the **AA** genotype is equal to half the selection against the **aa** genotype and both those genotypes have less than full fitness, what is the frequency of the **a** allele at equilibrium?

$s_1 = \frac{1}{2} s_2$

$$f(a)_E = q_E = \frac{s_1}{s_1 + s_2} = \frac{\frac{1}{2} s_2}{\frac{1}{2} s_2 + s_2} = \frac{\frac{1}{2} s_2}{1\frac{1}{2} s_2} = 0.333\dot{3}$$

2.6 A locus where the phenotype of the heterozygote is exactly between both of the phenotypes of the homozygotes is said to exhibit:

codominance **complete dominance** **over dominance** (circle one)

2.7 If a population is in Hardy-Weinberg equilibrium, H is always more than 50% of the population.

TRUE or **FALSE**

2.8 If the population size is 20 random mating individuals and there is no selection, mutation or migration can alleles still be fixed over many generations? (circle one)

YES – (genetic drift)

MBG-3060 Quantitative Genetics Midterm Examination

Name: ______________________________ Student ID number: ____________

YES or NO

2.9 Epistasis is defined as one locus affecting more that one trait
TRUE or **FALSE**

2.10 If the effective population size is 30 what is the rate of inbreeding per generation?

$$\Delta F = \frac{1}{2N_e} = \frac{1}{2(30)} = 0.0167$$

2.11 If mutation balances selection in a large, random mating population without migration, alleles could still be lost from the population? **TRUE** or **FALSE**

2.12 If ΔF is 0.01, and $F_0 = 0$, how many generations of random mating does it take for F to reach or exceed 7%?

$$F_t = 1-(1-\Delta F)^t \Rightarrow 0.07 = 1-(1-0.01)^t \Rightarrow (0.99)^t = 0.93$$

$$\Rightarrow t = \frac{\log(0.93)}{\log(0.99)} = 7.22 = 8 \text{ generations}$$

−½ not rounded

2.13 Pleiotropy is defined as alleles at one locus affecting the expression of alleles at another locus
TRUE or **FALSE**

2.14 **d** decreases more rapidly when loci are linked as opposed to unlinked
TRUE or **FALSE**

2.15 If a locus with two alleles of equal frequency is subject to 25% selection against the homozygous recessive genotype, what proportion of the population survives?

$$\text{Survivors} = p^2 + 2pq + 0.25(q^2) = (0.5)^2 + 2(0.5)(0.5) + 0.75(0.5)^2$$

$$= 0.9375$$

Bonus (to a maximum of 60 points): You might be expecting a bonus question about the names of our animals but my spies tell me with an exam coming up there is chatter about the names of our pets even in the Library! So, since you're ready for a bonus like that . . . where did we get Ginny from?

Dog Guides Canada – failed guide dog

Total of the exam is 60 points. The maximum you can get is 60 points, even with the bonus.