

**Biology 213 Fall Quarter 1998 KEY to Test 2 Dr. Bryant Page 1 of 6**

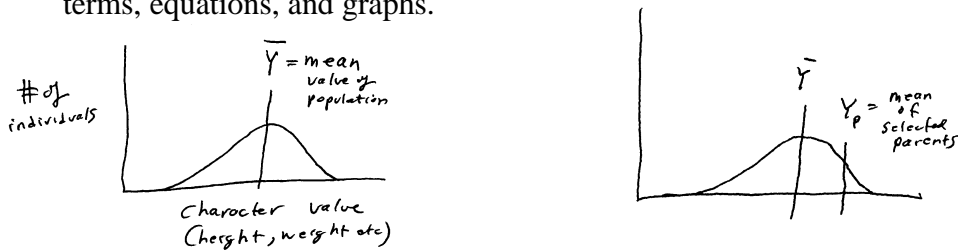
NAME: KEY

SCORE: 100 /100

Notes:

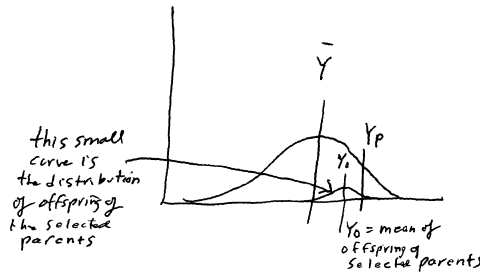
1. Make sure you have your name on the test.
2. Make sure you have the correct number of pages — check now!
3. Be sure to show ALL your work on problems — credit is given for correct steps in solving the problem.  
The correct answer without a clear showing of the derivation of the answer will receive little or no credit. If you run out of room in the space given, continue on the back of the page.
4. Maintain silence throughout the test.
5. For multiple choice questions, put the letter of the correct answer in the blank to the left of the question number. Multiple choice questions are worth 3 points each.
6. DO NOT GET UP — if you have a question, raise your hand and the instructor will come to you.
7. Read the questions carefully — misreading is a primary cause of point loss. Also be sure to answer the question that was asked.

1. (13) Using graphs of the population and the offspring of selected parents, graphically and algebraically derive the equation for heritability as done in class. Use words to explain all terms, equations, and graphs.

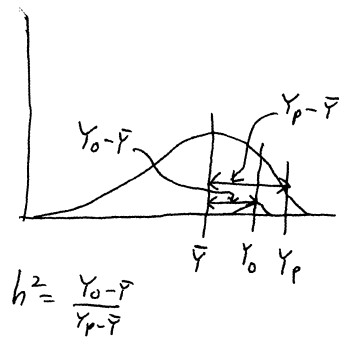


In the graph above left, the distribution of some character trait is shown for some population. The mean value of the population is denoted by  $\bar{Y}$ . We select parents who have a higher than average value for the trait; the mean value of the trait for these selected parents is called  $Y_p$ .

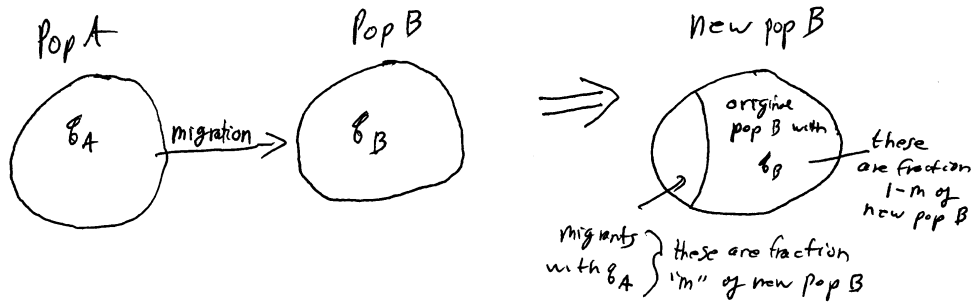
Now we breed the parents together, and look at their offspring. The offspring will vary among themselves, of course, but their mean value we denote  $Y_o$ . This is shown below:



Heritability is the proportionate distance that the mean of the offspring is from the population mean to the mean of the selected parents.



2. (13) Using graphs and equations, derive the recurrence and  $\Delta q$  equations for migration. Be sure to use words to explain all graphs, symbols, and equations.



Some of population A migrate into population B, forming new population B

In new population B, a proportion "m" come from population A, and a proportion "1-m" come from the old population B

The gene frequency of the  $A_2$  allele in new population B is the weighted average of the gene frequencies of the  $A_2$  allele in populations A and B, weighted by their proportions in new population B

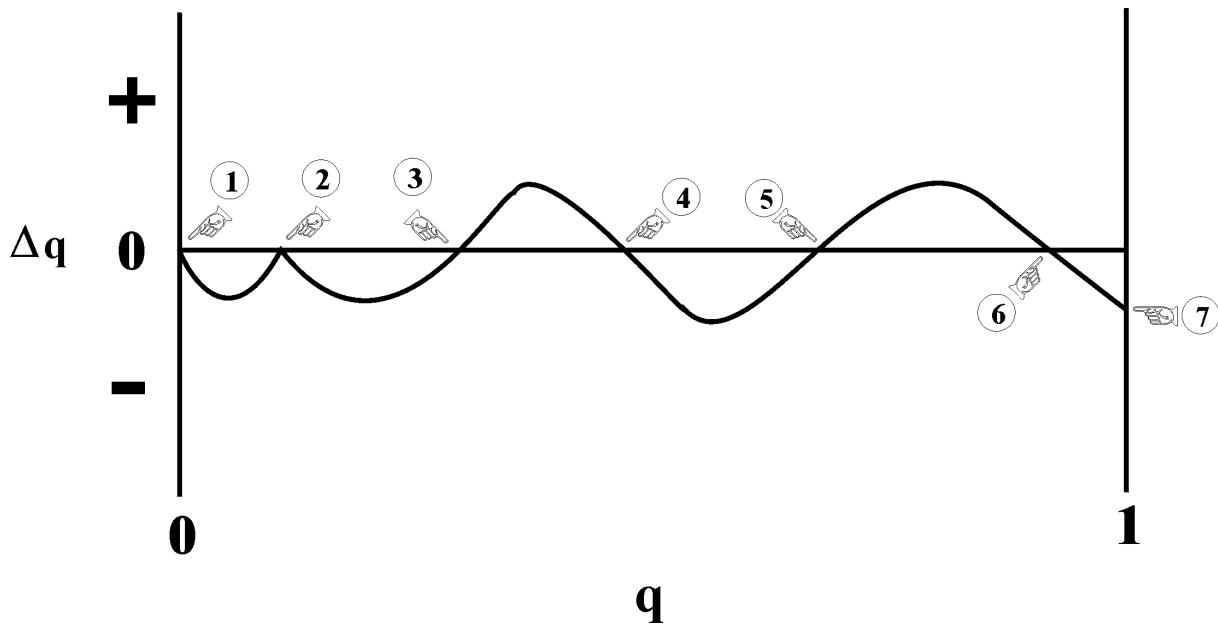
$q_A$  = frequency of  $A_2$  in population A

$q_B$  = frequency of  $A_2$  in old population B

thus,  $q'_B$ , the frequency of the  $A_2$  allele in new population B is:  $q'_B = mq_A + (1-m)q_B$

3. (13) Interpret the following  $\Delta q$  graph, by filling out the chart for each indicated point: (Each indicated point refers to a point where the  $\Delta q$  curve crosses or touches either the  $\Delta q=0$  line or the  $q=0$  or  $q=1$  axes)

Point #	Equilibrium? Yes (Y) or NO (N)	IF equilibrium, Trivial (T) or Interesting (I)?	IF equilibrium, Stable (S), Metastable (M) or Unstable (U)?	IF stable equilibrium, Globally stable (G) or Locally stable (L)?
1	Y	T	S (or M)	L
2	Y	I	M	----
3	Y	I	U	----
4	Y	I	S	L
5	Y	I	U	----
6	Y	I	S	L
7	N	----	----	----



NOW, ANSWER THE FOLLOWING:

A. WHAT IS THE DOMAIN OF ATTRACTION FOR POINT 4?

from point 3 (exclusive) to point 5 (exclusive).

B. IF A POPULATION STARTS OUT AT  $q=0.75$ , WHAT WILL BE THE (APPROXIMATE) FINAL FREQUENCY OF HETEROZYGOTES IN THE POPULATION ASSUMING THE  $\Delta q$  GRAPH DOESN'T CHANGE OVER TIME?

a. 0.01 **b. 0.2** c. 0.4 d. 0.8 e. 0.95 nearest stable equilibrium is point 6, for which  $q \sim 0.9$ . Therefore  $2pq$  would be about 0.18, so answer "b" is closest.

4. (13) Derive and solve the recurrence equation for selection against a recessive (homozygous) lethal. Let  $q$ =f(lethal allele), and start with a population of codominant genotypes in the Hardy-Weinberg proportions, as done in class. Then assign fitnesses, get the recurrence equation and then solve it. Use words to explain/define all your terms.

$A_1A_1$	$A_1A_2$	$A_2A_2$	genotypes
$p^2$	$2pq$	$q^2$	H-W proportions
1	1	0	fitnesses

$$q_1 = \frac{pq}{p^2+2pq} = \frac{pq}{p(p+2q)} = \frac{q}{p+q+q} = \frac{q}{1+q} \quad \text{derivation of recurrence equation}$$

$$q_2 = \frac{q_1}{1+q_1} = \frac{\frac{q_0}{1+q_0}}{1+\frac{q_0}{1+q_0}} = \frac{\frac{q_0}{1+q_0}}{\frac{1+q_0+q_0}{1+q_0}} = \frac{\frac{q_0}{1+q_0}}{\frac{1+2q_0}{1+q_0}} = \frac{q_0}{1+2q_0} \quad \text{working towards solution}$$

$$q_3 = \frac{q_2}{1+q_2} = \frac{\frac{q_0}{1+2q_0}}{1+\frac{q_0}{1+2q_0}} = \frac{\frac{q_0}{1+2q_0}}{\frac{1+2q_0+q_0}{1+2q_0}} = \frac{\frac{q_0}{1+2q_0}}{\frac{1+3q_0}{1+2q_0}} = \frac{q_0}{1+3q_0} \quad \text{working towards solution}$$

therefore, by mathematical induction,

$$q_n = \frac{q_0}{1+nq_0} \quad \text{solution to recurrence equation}$$

$$q_1 = \frac{q}{1+q} \text{ is the recurrence equation}$$

- \_\_g\_\_ 5. [Ch. 4.3] The increase in frequency of the melanic, relative to the light-colored, form of the moth *Biston betularia* clearly illustrates which of the following: a. genetic drift b. how natural selection causes evolutionary change c. migration d. how natural selection causes adaptation e. the effects of positive assortative mating causing an increase in the frequency of homozygosity f. both a and b above g. both b and d above h. both c and d above
- \_\_a\_\_ 6. [Ch 5.11] Which of the following is a property of a subdivided population, as opposed to a large, fused population? a. higher homozygosity b. lower homozygosity c. higher rate of selection against recessive alleles d. lower rate of selection against recessive alleles e. none of the preceding
- \_\_c\_\_ 7. [Ch 6.4 ] The rate of neutral substitution is equal to: a. the rate of selection against the neutral allele b. the inverse of the migration rate c. the rate at which neutral mutations arise d. the rate at which favorably selected mutations arise e. none of the preceding
- \_\_a\_\_ 8. [Ch. 7.1 ] The statement that "mutations that have been substituted in evolution are selectively neutral with respect to the genes they replaced" is the definition of which of the following: a. the neutral theory b. the mutation-balance theory c. the molecular clock theory d. the genetic load theory e. none of the preceding
- \_\_e\_\_ 9. [Ch. 9.8] Stabilizing selection acts to: a. increase the amount of genetic variability in a population b. increase the rate of migration c. increase the rate of mutation to neutral alleles d. increase the amount of genetic correlation in the population e. none of the preceding
- \_\_d\_\_ 10. [Ch. 10.3] Unequal crossing-over or polyploidy give rise to which of the following? a. inversions b. parasitic or "selfish" DNA c. the C-factor paradox d. gene families e. transposase
- \_\_b\_\_ 11. [Ch. 11.2 ] Which of the following is **NOT** a way in which adaptation can be studied? a. experimentally altering an organ b. increasing the rate of mutation c. comparing the observed form of an organ with a theoretical prediction d. comparing the form of an organ in many species (no "e" choice for this question)
- \_\_a\_\_ 12. [Ch. 12.6] Humans are Weismannist organisms. a. true b. false (no "c", "d" or "e" choices for this question)
- \_\_b\_\_ 13. [Ch. 13.2+6+7+8] Which of the following statements is true? a. evolution only proceeds by natural selection b. adaptation is only produced by natural selection c. adaptations are simultaneously optimal for all levels of organization in organisms d. adaptations are only selected for if they are perfect adaptations to an environmental challenge e. time-lags are important in evolution, but have no bearing on adaptation

- c 14. [Partridge video] An individual's contribution of progeny to the next generation, (relative to the contributions of other individuals in the population) is that individual's:  
a. adaptation b. success c. fitness d. normalized relative inbreeding coefficient e. none of the preceding
- c 15. [Lewontin video] What besides DNA is necessary to specify an organism? a. its RNA  
b. its proteins c. its environments d. its embryology e. none of the preceding
- d 16. [Hamilton video] To study altruism, it is necessary to: a. study adaptations b. study sexual selection c. realize that genes are generally in gene families d. realize that genes are shared by relatives e. none of the preceding
- a 17. [Virtual experiment on mutational load] In the virtual experiment on mutational load, which of the following is correct? a. low allelic mutation rates produce low values of mutational load and high allelic mutation rates produce high values of mutational load  
b. high allelic mutation rates produce low values of mutational load and low allelic mutation rates produce high values of mutational load c. high values of migration cause the highest values of mutational load d. low values of migration cause the highest values of mutational load (no "e" choice for this question)
- b 18. [Virtual experiment on gene frequency] In this experiment, which of the following produces the most rapid approach to gene frequency = 1.0? a. low values of the selection coefficient b. high values of the selection coefficient c. intermediate values of the selection coefficient d. high values of migration e. low values of migration
- a 19. [Gould & Lewontin paper] Which of the following summarizes the Gould and Lewontin paper the best? a. evolution proceeds by many mechanisms, not just adaptation caused by natural selection b. adaptation is responsible for almost every feature of organisms c. genetic drift is more important than natural selection d. evolutionary stories are the best examples of the evolutionary process e. migration between populations with similar allele frequencies will not have much effect
- a 20. [Coyne & Orr paper] Coyne and Orr found that which of the following evolves first? a. hybrid sterility in males b. hybrid sterility in females c. extreme size in hybrid males d. an increase in inversion frequency among female hybrids e. none of the preceding