

NAME: _____ **KEY** _____

SCORE: _____/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.
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) A population consists of 75 A_1A_1 , 150 A_1A_2 and 300 A_2A_2 individuals.

- a. Test this population for Hardy-Weinberg genotype frequencies.
- b. Use 3.84 as the critical value for your test.
- c. IF the population is NOT, in H-W, COULD it be because of the Wahlund effect? Why or why not. Your answer must be one of the following: a. not applicable - population IS in the H-W frequencies b. No, it couldn't be Wahlund effect because ... (you need to explain why) c. Yes, it could be Wahlund effect because ... (you need to explain why)

$$75 + 150 + 300 = 525 = N \quad p = \frac{75 + \frac{150}{2}}{525} = 0.2857 \quad q = 1 - p = 0.7143$$

$$p^2N = (.2857)^2 \times 525 = 42.85$$

$$2pqN = 2 \times 0.2857 \times 0.7143 \times 525 = 214.27$$

$$q^2N = .7143^2 \times 525 = 267.87$$

	A_1A_1	A_1A_2	A_2A_2
observed	75	150	300
expected	42.85	214.27	267.87
$\frac{(o-e)^2}{e}$	24.12	19.28	3.85

$$\chi^2 = 24.12 + 19.28 + 3.85 = 47.25$$

(with 3-2=1 d. f.) Critical value = 3.84. critical value (47.25 >>> 3.84), so NOT in H-W

YES, it could be Wahlund effect, because there is an excess of homozygotes (observed homozygotes are bigger than expected homozygotes).

2. (13) Derive **and solve** the recurrence equation for selection against a recessive lethal.

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

$$q_1 = \frac{pq}{p^2+2pq} = \frac{pq}{p(p+2q)} = \frac{q}{p+q+q} = \frac{q}{1+q}$$

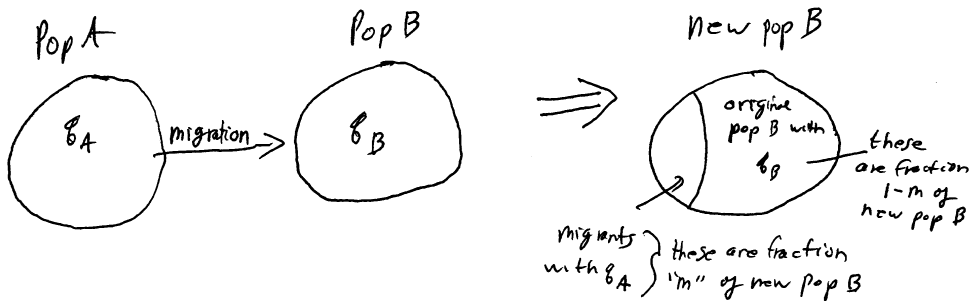
$$q_2 = \frac{q_1}{1+q_1} = \frac{\frac{q_0}{1+q_0}}{1+\frac{q_0}{1+q_0}} = \frac{\frac{q_0}{1+q_0}}{\frac{1+q_0+q_0}{1+q_0}} = \frac{\frac{q_0}{1+q_0}}{\frac{1+2q_0}{1+q_0}} = \frac{q_0}{1+2q_0}$$

$$q_3 = \frac{q_2}{1+q_2} = \frac{\frac{q_0}{1+2q_0}}{1+\frac{q_0}{1+2q_0}} = \frac{\frac{q_0}{1+2q_0}}{\frac{1+2q_0+q_0}{1+2q_0}} = \frac{\frac{q_0}{1+2q_0}}{\frac{1+3q_0}{1+2q_0}} = \frac{q_0}{1+3q_0}$$

therefore, by mathematical induction,

$$q_n = \frac{q_0}{1+nq_0}$$

3. (13) Graphically and algebraically derive the recurrence equation for migration. You do NOT have to derive the Δq equation.



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: $q'_B = mq_A + (1-m)q_B$

4. (13) Write a paragraph on the evolution of sex, covering at least the following: (1) why does sex exist, (2) why the sexes differ, (3) what sex ratio is selected for, and (4) how sex has an automatic 50% disadvantage compared to asexual reproduction. (You may also explain how the sexes differ, why females are generally choosier, criteria of female choice, what kinds of mating systems tend to produce large males and why, deviations from the normal sex-ratio, etc. for more credit). 9 points will be given for correctly covering the 4 minimal topics requested; up to an additional 5 points will be given for additional correct information on the topic of the evolution of sex).

- a. why sex:: evolution goes faster in sexual populations with reasonably high rate of favorable mutations, may be selected by host-parasite or predator-prey interactions.
- b. why 2 sexes: due to the advantages in producing either larger gametes or more gametes. There are rarely any other choices to gain an advantage.
- c. how sexes differ: females produce fewer larger gametes, males produce more smaller gametes
- d. a 50:50 sex ratio is selected for (most of the time) at the time of mean reproduction of the species
- e. sex a 50% disadvantage: each females produces two offspring, then dies:

Generation	Asexual Population	Sexual Population
1	100 females	100 females, 100 males
2	200 females	100 females, 100 males
3	400 females	100 females, 100 males

note that after 3 generations, the asexual population is at 400, the sexual at 200 total individuals

- f. females choosier: fewer gametes produced, thus each is a higher proportion of lifetime reproductive effort, and each is more valuable to a female than a sperm is to a male.
- g. criteria of female choice:
 - 1. sexy son: females choose most "attractive" mates so their sons will also be attractive to females and thus have lots of grandoffspring
 - 2. handicap: females choose males with large apparent handicap: such a male must be highly fit to survive even with such a big handicap.
 - 3. females may chose the most healthy, unparasitized males, since those males carry genes which will produce healthy offspring

- a 5. [Ch. 4.4] If, for many generations, individuals who are taller than average in a population survive and reproduce better than individuals at or below average, and height is heritable, we would have: a. directional selection for height in this population b. stabilizing selection for height in this population c. disruptive selection for height in this population d. selection for a trivial stable equilibrium in this population e. heterosis
- b 6. [Ch 5.4] The rate of change of gene frequency in real cases of natural selection can be used to infer: a. geographic patterns of fitness b. the fitnesses of the genotypes c. the Hardy-Weinberg Law d. whether selection-mutation balance is present e. whether or not the Wahlund effect may be present
- c 7. [Ch 6.5] What is the eventual fate of a small population? a. it will stay in the H-W equilibrium for all loci forever b. for most loci, the population will end up with $p = q = 0.5$ (all alleles at equal frequency) c. it will become homozygous at all loci d. loci will achieve a mutation-selection balance e. none of the preceding
- d 8. [Ch. 9. 5] The evolutionary response of a character to selection is measured by which of the following? a. quantitative variation b. degree of polymorphism c. pleiotropy d. heritability e. additive genetic epistasis
- e 9. [Ch. 10.8] Much of the nuclear genome of organisms consists of various classes of non coding DNA of which of the following types: a. Z-DNA b. mitochondrial DNA c. both a and b d. chxDNA e. repetitive DNA
- a 10. [Ch. 11.4] Provided that the rate of (favorable) mutation is high enough, which of the following will happen? a. sexual populations will evolve faster than asexual populations b. sexual populations will evolve at the same rate as asexual populations c. sexual populations will evolve more slowly than asexual populations d. one cannot tell anything about the comparative rate of evolution in sexual and asexual populations e. none of the preceding
- b 11. [Ch. 12. 8] Group selection is thought to be a generally: a. strong force in evolution b. weak force in evolution c. strong force in plants, but a weak force in animals d. strong force in animals, but weak force in plants e. none of the preceding
- c 12. [Ch. 13.8] Imperfect adaptations are due to all EXCEPT which of the following: a. genetic constraints b. developmental constraints c. selection d. historical constraints e. trade-offs among competing demands
- d 13. [Partridge video] At least part of the constancy of the molecular clock is explained by which of the following: a. selection occurring at a constant rate over short periods of time b. mutation c. migration and selection opposing one another d. neutral alleles evolving by genetic drift e. a mutation-selection balance

- e 14. [Lewontin video] The red color that blood has is due to which of the following:
a. selection for red as a warning signal b. migration-selection balance
c. mutation-selection balance d. migration e. a byproduct of selection for hemoglobin, which just happens to be red
- a 15. [Hamilton video] One of the purposes of male sexual display in animals may be to:
a. display an organ that is ideal for revealing disease (or lack thereof) b. show off for other males c. conquer other males d. gain territory e. provide natural selection an opportunity to work
- b 16. [Virtual experiment on Genetic Drift] In the virtual experiment on Genetic Drift, for which of the following population sizes did the allele frequency go to 1 or 0 (that is, go to fixation) most rapidly? a. large population sizes b. small population sizes
c. intermediate population sizes (no choices d or e for this question)
- c 17. [Virtual experiment on sexual reproduction] What happens to populations as the percentage of sexually reproducing individuals is increased? a. the population mean fitness stays at 50%, but is achieved faster b. the final population mean fitness is lower and achieved more slowly c. the final population mean fitness is higher and achieved faster
d. the population mean fitness stays at 50%, but is achieved more slowly e. the eventual population size is increased, but there is no effect on population mean fitness
- d 18. [Gould & Lewontin paper] The main theme of the Gould and Lewontin paper is that:
a. Spandrels are epiphenomena of architectural constraint b. adaptation is generally the explanation for every feature of living organisms c. adaptation has happened rarely in the living world d. the uncritical use of adaptation to explain every feature of organisms is wrong e. translocation heterozygotes show adaptations which tend to overcome their inherent semi-sterility
- e 19. [Coyne & Orr paper] In the Coyne and Orr paper, evidence is provided for which of the following: a. the sequence of chromosome changes in the Hawaiian *Drosophila*
b. the inviability of cross-over gametes in inversion heterozygotes c. semi-sterility of translocation heterozygotes d. full sterility of translocation heterozygotes
e. reinforcement, which is prezygotic mating discrimination among closely related species