BSC 2011 POPULATION GENETICS

1. A survey of the peppered moth (Biston betularia) population of London gives the following result:

dark (melanic) morphs = 827 light morphs = 353

Given the M (melanic) is dominant to m (light), and assuming that the population is in Hardy-Weinberg equilibrium, answer the questions below:

(a) What is the frequency of the melanic allele in the population?

(b) What percentage of the moths will be melanic in the next generation?

2. A small pond northeast of Tallahassee is being used for a breeding experiment to develop golden carp. The single locus controlling the golden pigment has two codominant alleles, G and g, with phenotypes as follows:

GG = golden Gg = bronze gg = brown

After a number of generations of breeding, the researcher finds that this population has reached genetic equilibrium, and she can count the following individuals in the pond:

golden =
$$147$$

bronze = 125
brown = 28

(a) What is the frequency of the G allele in the population?

During one winter the pond is almost completely frozen, and all but 10 of the fish die. Of the 10 remaining, 6 are bronze and 4 are brown.

(b) What is the frequency of the G allele in this smaller population?

(c) Does this qualify as an evolutionary change?

(d) If so, what is the mechanism of evolution involved?

3. A large, human population is analyzed for A, B, AB, and O blood types. All blood types are present in the population, and the alleles are in genetic equilibrium. The frequencies of the alleles are shown to be

$$p(I^A) = 0.3$$
 $q(I^B) = 0.1$ $r(i) = 0.6$

(a) What will be the most common blood type in the population?

(b) What percentage of the Type B persons will be heterozygous?

(c) What will be the frequency with which two Type AB persons will mate in this population, assuming mating is random with regard to blood type?

(d) In this population, how often would you expect to find a family in which the father is Type A and the mother is Type B?

4. You observe the following distribution of autosomal genotypes in a population in Hardy-Weinberg equilibrium:

MM = 42.3% Mm = 45.4% mm = 12.3%

- (a) What are the frequencies of the M and m alleles?
- (b) What proportion of the matings in this population will occur

between a homozygous dominant and a heterozygous individual?

5. In the American Black population, the frequency of the recessive Hbs allele (which causes sickle cell anemia) is 0.05; in the African Black population, it shows a frequency of 0.20. Assuming Hardy-Weinberg assumptions are met:

- (a) What fraction of the American Black population is heterozygous for this allele (sickle trait)?
- (b) What fraction of the African Black population is heterozygous for this allele (sickle trait)?
- (c) If matings are random, what is the probability that two heterozygous American Blacks will mate and produce a child with sickle-cell anemia?
- (d) How much greater is that probability for two heterozygous African Blacks?

6. Using the allelic frequencies below for A, B, and O blood antigens, and assuming Hardy-Weinberg equilibrium, answer the questions that follow:

	β	lΒ	i
Caucasian	0.26	0.07	0.67
Black	0.14	0.12	0.74
Asian	0.20	0.26	0.54

(a) What proportion of the Asian population will have Type AB blood?

- (b) What proportion of the Black population will have Type AB blood?
- (c) What proportions of the Caucasian and of the Asian populations will have Type B blood?

7. In an area near Birmingham, England, Kettlewell observed that 87% of the <u>Biston</u> <u>betularia</u> were melanic. What fraction of the melanic moths were heterozygous if the population was at Hardy-Weinberg equilibrium? The allele for melanism (M) shows simple dominance to the allele for light color (m).

8. Phenylketonuria (PKU) results in a form of mental retardation that is caused by an autosomal recessive allele.

- (a) If 1 in 10,000 newborn Caucasians have PKU, what fraction of the Caucasian population is a carrier for the trait (assuming a Hardy-Weinberg equilibrium)?
- (b) In part (a) you were told to assume that the prerequisites of a Hardy-Weinberg equilibrium were met. Do you think it is likely that this assumption is correct? If not, which Hardy-Weinberg prerequisites are probably not met in this case?
- (c) Based upon your answer to part (b), how will the carrier frequency be affected over several generations? Explain your answer.
- (d) PKU can now be prevented by regulation of the diet of a person with this trait. How will this fact affect your answer to part (c)?

9. In many American Indian groups, the I^B allele is extremely rare. A sample of 600 Papago Indians in Arizona shows that 37 were blood type A and 563 were type O.

(a) What are the best estimates of the frequencies of the I^A , I^B , and i alleles in this population?

(b) What are the genotype frequencies predicted by the Hardy-Weinberg model?

10. An electrophoretic study of the enzyme alkaline phosphatase in a population of stone crabs shows this enzyme is controlled by a single gene locus with two alleles, A and a. Further analysis reveals that the frequency of A = 0.5. Analysis of a sample collected later reveals the frequencies of the three possible genotypes to be AA=.33, Aa = .33, aa = .33.

(a) Is this population in Hardy-Weinberg equilibrium? How can you tell?

(b) Describe two mechanisms that might account for this situation

ANSWERS (Beware of rounding error)

2.

4.

1. a) 0.7 b) 91%

- a) 0.7
- b) 0.3
- c) yes
- d) genetic drift (bottleneck)

a) p(M) = 0.65; q(m) = 0.35

- 3. a) Type A
 - b) 92%
 - c) 0.0036
 - d) 5.85% or 0.0585
 - a) 9.5% b) 32% c) 0.002 d) 11.1 times more probable (0.0256 vs. 0.0023)
- b)0.385
- 6. a) 10.4%
 b) 3.4%
 c) 9.9% Asian, 34.8% Caucasian

7. 0.53

5

- 8. a) 0.02
 b) The assumption of equal survival and reproduction is probably wrong in this case.
 c) The frequency of the PKU allele should decline as homozygous recessives are removed from the population.
 d)The decline will stop if there is no selection against PKU sufferers.
- 9. a) $p(I^B) = 0.000$, $p(I^A) = 0.03$, p(i) = 0.97b) $iI^A = 0.058$, $I^A I^A = 0.0009$, ii = 0.941
- 10. a) No, we don't see the genotype frequencies predicted by Hardy-Weinberg

b) Possibly non-random mating, migration, chance, selection against the heterozygote. (Probably not mutation)