BIOL 403 EVOLUTION Exam 2 Spring 09

1 (16 pts). List four assumptions of the Random Mating (Hardy-Weinberg) Model other than random mating. For each assumption, give an example of an evolutionary model developed in lecture which relaxes or removes this assumption.

Assumption	**Model**
1. No selection	**HW model plus selection**
2. No mutation	**selection-mutation balance model drift-mutation balance**
3. No migration	**island migration model, migration-selection balance**
4. Infinite pop'n (No chance change in allele frequency)	**Genetic drift, drift-mutation balance**

2. (4 pts) Given the following genotype frequencies, calculate the frequency of the + allele (p).

	Genotype		
	+/+	+/Δ32	Δ32 /Δ32
# Obs'd	20	20	10

p = 0.6

3. (4 pts) Refer to the preceding problem. Is there significant evidence for deviation of genotype frequencies from random mating expectations?

	Exp'd #	**Obs'd #**
p^2* 50 =	**18**	**20**
2pq* 50=	**24**	**20**
q^2* 50 =	**8**	**10**

The resulting chi-square value is 1.39, N.S.

4. (4 pts) What real world population (if any) does this sample resemble with respect to the frequency of the Δ32 allele?

None; the frequency of the Δ32 allele is far higher than in any real world population

5. (8 pts) For genotypes with the following fitnesses and frequencies at birth

Genotype	A_1A_1	A_1A_2	A_2A_2
Birth Freq'cy	p^2	$2pq$	q^2
Fitness	$1-s$	1	$1-t$

Using this information, write down an expression for the average fitness of a genotype in the population, $\bar{w}$:

$\bar{w} = p^2 (1-s) + 2pq + q^2(1-t)$

$= 1 - sp^2 - tq^2$

6. Refer to the preceding problem. Write down an expression for the frequency of the A_1 allele after selection:

Frequency of A_1 after selection = $p^2(1-s)/\bar{w} + pq/\bar{w}$

7. (4 pts) Refer to the preceding problem. If s = 0.8, t =0.2 and p = freq'cy of A_1 = 0.5, calculate the average excess of the A_1 allele in this case as as $p\,w_{11} + q\,w_{12} - \bar{w}$ (where $\bar{w}$ is the average fitness of the population). Interpret your result.

Plugging in the given values of p, s and t, $\bar{w}$ = 0.75 and the average excess of A_1 is -0.15

The interpretation of this result is that the frequency of A_1 will decrease in the next generation.

8. (4 pts) Why is the change in allele frequency for a favored recessive extremely slow when the favored allele is rare?

Because most of the favored alleles occur in heterozygotes of low fitness.

9. (4 pts) Why might overdominant selection (heterozygote superiority) be regarded as a less than optimal adaptation, compared to the outcome of directional selection?

Because at equilibrium, overdominant selection necessarily produces homozygous genotypes of lower fitness.

10. (4 pts) What interesting evolutionary property do negative frequency dependent selection and overdominant selection share?

Maintenance of alternative alleles at intermediate frequency.

11. (4 pts) The frequency of individuals born with cystic fibrosis in some populations is 1 in 2500. Assuming that affected individuals do not reproduce, what other independent information do you need in order to determine whether the frequency of a recessive disease allele is consistent with a model of mutation–selection balance?

An independent estimate of the mutation rate to the disease allele.

12. (4 pts) In an island model of migration from a mainland source of infinite size, what is ultimate effect of migration on allele frequency on the island (assume the absence of other evolutionary forces)? What is the purpose of such a simple model of gene flow?

The frequency of the allele on the island will become equal to that on the mainland.

The model can be used to study the rate of change of allele frequency due to migration

13. (4 pts) For the island model of migration-selection balance considered in lecture, what is the consequence of m>>s for the evolution of allele frequency in the population? What is the implication of this result for the evolution of real world populations.

Maladaptive evolution (maintenance of an allele in the population opposed by selection).

Maladaptive evolution due to migration may limit the the ability of populations to adapt to environments at the edge of the species range.

14. (8 pts) Give a real world example of a genetic trait in a human population where there is evidence it evolved as a result of genetic drift (ie, founder effects). Why do we think that genetic drift is the evolutionary force responsible for the frequency of the trait?

Achromatopsia on Pingelap Atoll.

The frequency of this unconditionally deleterious allele is extremely high (q = 0.35). This cannot be explained by selection (which would act to eliminate it) or mutation (which is a weak evolutionary force).

Genetic drift is the most plausible explanation, given that it is known that the population was reduced to very small size following a typhoon in 1775, and that every affected individual is descended from one particular survivor.

15. (4 pts) What is the effect of genetic drift on selectively neutral genetic variation (ie, heterozygosity) in a population of constant size (assume the absence of all other evolutionary forces)?

Genetic drift reduces neutral genetic variation as measured by H by an amount 1/2N per generation.

16. (4 pts) List two predictions of the Neutral Theory of molecular evolution.

1. Molecular substitutions occur at a constant rate, equal to the neutral mutation rate

2. The substitution rate will be higher for molecular sites which are less evolutionarily constrained (and therefore have a higher neutral mutation rate)

17. (4 pts) Why is the Neutral Theory (which supposes that molecular evolution is largely due to subsitution of selectively equivalent alleles) confined to molecular evolution, rather than being applied to phenotypic evolution as well?

Because it is plausible that many changes in molecular sequences may have little or no effect on fitness (for example, synonymous changes in protein coding sequences).

18. (4 pts) What observation with respect to molecular evolution prompted the Nearly Neutral Theory? What assumption of the Neutral Theory did it alter to address this problem?

The molecular clock ticks at a constant rate per year, not per generation

The NNT proposes that substitutions are not completely neutral, unlike the Neutral Theory.

19. (4 pts) What is the expected dN/dS ratio for a gene under strong selection not to change its amino acid sequence?

dN/dS << 1

20. (4 pts) Human-chimp sequence comparisons find that only about 5% of genes show evidence of positive selection (adaptive substitutions). A comparison of two species of Drosophila found that about half the genes showed evidence of positive selection. How does the Nearly Neutral Theory account for this difference?

The NNT predicts that small populations evolve (fix substitutions) more by drift, large ones by selection. Because the fly species maintain much larger (effective) population sizes than humans or chimps, they have experienced a much larger proportion of substitutions which are adaptive as a result.

20. (4 pts) List the 4 different evolutionary forces, and characterize each one as strong or weak with respect to its ability to change allele frequencies.

Force	Strength
selection	**strong**
mutation	**weak**
migration	**strong**
genetic drift	**weak**