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Population Genetics, ECOL 426/526 2004
Mid-Term Exam
(Total points possible for graduate students110/110; for undergraduates110/100)

1. Consider a Wright-Fisher model of random genetic drift with a single di-allelic locus (A and a) in which each subpopulation has 50 diploid individuals. At time t = 0 all subpopulations have p_0 = 0.25 and q_0 = 0.75.

a) (4 pts) What is the variance in allele frequency among subpopulations after 10 generations?

b) (4 pts) What is the average allele frequency among subpopulations after 17 generations of drift?

c) (4 pts) What proportion of subpopulations will be fixed for the A allele at time t = ∞?

2. (4 pts) Consider a sibship of four offspring from the mating Aa x Aa in which A is dominant. What is the probability of obtaining three dominant phenotypes in the sibship?

3. (4 pts) In how many generations will the expected heterozygosity be 50% of the initial value (as a consequence of drift) in a diploid randomly mating population of size 100?

4. (4 pts) What is the Poisson distribution and what is it used for? How many parameters are needed to completely define the shape of a Poisson distribution?

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5. (6 pts) Kreitman (1983) and Li and Sadler (1991) provided the first estimates of nucleotide diversity for *Drosophila melanogaster* and humans, respectively. What did they find and how did they differ? Suggest an explanation for the observed differences.

6. (4 pts) What is the effective population size of a herd of 40 cows and one bull?

7. (4 pts) If a child has an autosomal recessive disease and both parents are unaffected, what is the probability that the child's brother will be a heterozygous carrier for the disease?

8. (6 pts) A population of 100 annual plants on an isolated island is surveyed for allozyme variation. The PGI locus shows two alleles: PGI-1 and PGI-2. In the first year, the frequency of PGI-1 is 50%. In the second year, the frequency of PGI-1 is 39%. What might account for this difference? (Be explicit; you might want to contrast the possibilities using a mathematical argument).

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9. Consider the following dataset for an autosomal locus. A total of 2000 bp were sequenced in four alleles from one population and 1,995 sites were invariant. Only the 5 variable sites are shown. A dot indicates identity with the base in the first sequence. Each row depicts a different allele.

	1	2	3	4	5
Consensus	A	C	T	T	C
Allele 1	.	.	.	.	T
Allele 2	.	.	A	.	T
Allele 3	.	G	.	C	.
Allele 4	G	G	.	.	T

a) (4 pts) Calculate nucleotide diversity per site, π, for these data.

b) (4 pts) Describe, in words, what the number π represents.

c) (2 pts) π is an estimator; what parameter does it estimate?

10. (6 pts) Allozyme gels reveal a sample with 64 FF, 32 FS and 4 SS females, but there seem to be 40 FF males and 10 SS males with no heterozygotes. How would you explain these data? Suggest a test for your hypothesis.

11. (4 pts) Cystic fibrosis is an autosomal recessive disease. About 1 in 1,000 Caucasians are affected. Assuming random mating, what is the frequency of heterozygous carriers?

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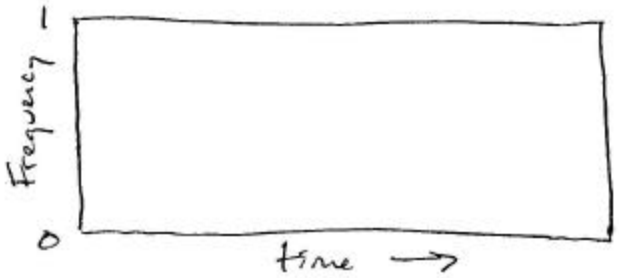
12. (6 pts) Two electrophoretic alleles, PGI-2a and PGI-2b, were observed among 57 *Oenothera biennis* in the following genotypic proportions:

35 PGI-2a/PGI-2a
19 PGI-2a/PGI-2b
3 PGI-2b/PGI-2b

Estimate the allele frequencies and their standard errors. What are the expected numbers of each genotype under random mating?

13. a. (4 pts) On the graph below, draw and label the trajectories of a beneficial dominant mutant, and a beneficial recessive mutant from time of first appearance in the population, assuming no drift. Also indicate the position of all equilibrium allele frequencies (use closed circles for stable equilibria, and open circles for unstable equilibria).



b. (4 pts) Why are these trajectories different? (Be explicit.)

c. (4 pts)Will selection alone lead to the fixation of these mutants? Why or why not? (Explain mathematically)

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14. A population of haplo-diploid insects has two alleles, A and a. The frequency of A in males is given by p_m and the frequency of this allele in females is p_f. Let $p_m = 0.6$ and $p_f = 0.4$.

a) (4 pts) Give the genotype frequencies of the offspring.

b) (4 pts) What are the allele frequencies in gametes from these offspring?

15. (4 pts) Calculate the equilibrium allele frequency with overdominance when the fitnesses of AA, Aa, and aa are 0.2, 1, and 0.6.

16. (4pts) The fitnesses of AA, Aa, and aa are 1.0, 0.9, and 0.6, and the initial frequency of A, p_o, is 0.7. What is the frequency of the A allele after two generations of selection?

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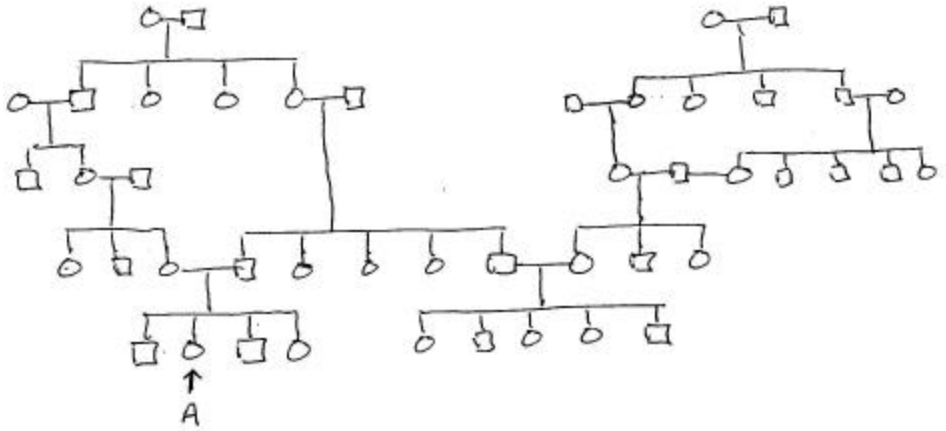
17. (4 pts) If an isolated population of annual plants decreases in heterozygosity by half every 50 years because of random genetic drift, what is its effective population size?

18. (4 pts) Calculate the inbreeding coefficient for individual A in the pedigree below. Assume F=0 for all ancestors.



19. (4 pts) A new autosomal mutation arises in a population of 1000 birds, and this mutation has no effect on fitness. What is the probability that this mutation will be fixed by drift?