

NAME _____

POPULATION GENETICS AND MICROEVOLUTIONARY THEORY
MIDTERM EXAMINATION

The following table may be useful in answering one or more of the questions. Use it as needed:

Probability	Chi-Square Test Statistic Value			
	df = 1	df = 2	df = 3	df=4
0.10	2.706	4.605	6.251	7.779
0.05	3.841	5.991	7.815	9.488
0.01	6.635	9.210	11.345	13.277

1. Briefly define (5 points each):

a) Interval Mapping

b) Tree Scanning

c) Environmental deviation

2. A sample of individuals is surveyed tested at an autosomal locus with two alleles as follows:

Genotype	<i>AA</i>	<i>Aa</i>	<i>aa</i>	Total
Number	22	36	42	100

a. (1 point) Characterize this sample by its genotypic frequencies.

b. (2 points) Characterize the gene pool by the allele frequencies for *A* and *a*.

c. (4 points) Test the goodness of fit of this population to the Hardy-Weinberg expectations.

d. (4 points) Estimate the correlation of uniting gametes in this sample and list three distinct explanations to explain its value.

3. a. (4 points) Suppose a deme is scored for 3 randomly chosen loci. The genotypic frequency results are as follows:

locus i	A_iA_i	A_ia_i	a_ia_i
1	.09	.42	.49
2	.36	.48	.16
3	.111	.378	.511

What do you conclude about this population's system of mating (assume no selection or drift)?

b. (4 points) Same question as (a), but now assume the results were:

locus i	A_iA_i	A_ia_i	a_ia_i
1	.05	.50	.45
2	.2025	.5950	.2025
3	.45	.50	.05

4. (4 points) Linkage disequilibrium is monitored between two loci, each with two alleles, in an infinite-sized population, with no natural selection occurring. The statistic D is observed over several generations:

Generation	1	2	3	4
D	0.10	0.13	0.17	0.20

Suppose the genotype frequencies at each of the two loci involved in the linkage disequilibrium are determined, and f is calculated for each locus. Do you expect these f 's to be positive, negative, or zero?

5. 100 isolated populations are established, each with an initial allele frequency of 0.2 for the A allele at an autosomal locus, and each with a constant variance effective size of 25 and each randomly mating.

a) (2 points) How many of these populations are expected to become fixed for the A allele under neutrality?

b) (2 points) The system of mating is now changed such that $f = -0.1$. How many of these populations are now expected to become fixed for the A allele under neutrality?

c) (2 points) The variance effective size of each population is increased to 2 billion. How many of these populations are now expected to become fixed for the A allele?

6. a) (4 points) A deme of inbreeding effective size 20 has an initial $\bar{F}(0)=0.1$. What is $\bar{F}(1)$ and $\bar{F}(2)$?

6. b) (4 points) A deme of inbreeding effective size 100 has an initial $\bar{F}(0)=0.1$. What is $\bar{F}(1)$ and $\bar{F}(2)$?

7. a) (2 points) A neutral pseudogene has a nucleotide mutation rate of 10^{-9} . What is the rate of nucleotide substitution in this pseudogene in a population with variance effective size 100?

b) (2 points) Suppose now the variance effective size is changed to 1,000,000. What is the rate of nucleotide substitution?

c) (2 points) Suppose now that nucleotide mutation rate is 10^{-8} and the variance effective size is 1000. What is the rate of nucleotide substitution?

8. The times (in years) to the most recent common ancestor (TMRCA) for several X-linked loci were determined as follows:

Locus	1	2	3	4	5	6	7	8	9	10
TMRCA	90,000	120,000	100,000	80,000	110,000	75,000	105,000	125,000	95,000	100,000

a) (5 points) Given that there is one generation per year, what is the long term inbreeding effective size of this population?

b) (3 points) What is the expected coalescence time for an autosomal locus in this population?

c) (4 points) Assuming that the reproductive properties of both sexes are identical and that the sex ratio is 50:50, what is the expected coalescence time for mitochondrial DNA and for the Y chromosome?

9. (5 points) What is the expected value of a Molecule Genetic Distance? Briefly define all terms used.

10. (5 points) The expected heterozygosity at a neutral locus is determined to be 0.6. What is the probability that two randomly chosen copies of this gene will experience coalescence before mutation given that coalescence or mutation has occurred?

11. (8 points) Two populations exchange gametes at a rate of 0.005 every generation. Given that the two populations were initially fixed for different alleles at an autosomal locus, what is the expected difference (assuming neutrality and infinite population size in each deme) in the allele frequency between the demes at generation 10 and at generation 100? What are the expected differences in allele frequency at equilibrium?

12. Population 1 has a frequency of the A allele of 0.3 at an autosomal locus, and population 2 has a frequency of 0.7 for A . Both populations have the same number of individuals.

a) (6 points) What is f_{st} ?

b) (6 points) Each population is determined to have a size of 100 ideal individuals (e.g., self-compatible, randomly mating hermaphrodites, etc.). What is the variance effective size of the total population consisting of these two demes (assume there are no other demes)?