Human Genetics:
Problem Set XI

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Abstract

This work contains the solutions to the problem set XI of Human Genetics 2015 course at New York University.

Question 1.

1. An STR locus on chromosome 6 has many alleles, each with a different number of CA repeats. In a particular population, the alleles have these frequencies:

allele	allele frequency
20	0.10
21	0.001
22	0.12
23	0.05
24	0.30
25	0.10
26	0.009
27	0.09
29	0.23

These frequencies describe the local gene pool for the STR locus. Assume that the population is at Hardy-Weinberg equilibrium.
a. What's the expected frequency of 25/25 homozygotes?

b. What's genotype is expected to be the most common genotype in this population?

c. What's the expected heterozygosity at this locus? (You'll want a calculator for this one.)

Solution. (a) The expected frequency of $25/25$ homozygotes is $0.1^2 = 0.01$.

(b) The most common genotype in this population will be $24/29$ heterozygote with $2 \cdot 0.30 \cdot 0.23$ chance.

(c) The expected heterozygosity at this locus, can be computed by $1 - \sum_{locus} p_{locus}^2$, where p_{locus} is the allele frequency at a particular locus. Carrying out the calculations, we obtain that the expected heterozygosity is approximately 0.812

□

Question 2.

2. Which of these loci shows greatest differentiation between populations?

Locus	Frequency of allele #1 in Abu Dhabi	Frequency of allele #1 in Sydney
A	0.4	0.6
B	0.5	0.5
C	1.0	1.0
D	0.1	0.9
E	0.1	0.1

Solution. By referring to the differentiation map, we see that the $(0.1, 0.9)$ pair of allele frequency results in the highest differentiation. Hence, the D locus shows the greatest differentiation between populations. □

Question 3.

3. A cattle breeder wants to have milk cows with higher yields. The method of artificial selection has been very effective in achieving this goal in the past, as our current industrial milk cows produce an average of 20,000 pounds of milk a year, almost triple the yield from 50 years ago. Suppose the heritability of milk yield is 0.4 and the farmer selects only cows that produce on average 21,000 pounds per year and mates them to bulls that are expected to be similarly genetically-endowed for high milk yield (this is readily determined by measuring the average milk yield of multiple daughters of a bull by different mothers). Suppose that the average milk yield of the selected class is 21,000 pounds, and the average of the whole pre-selection population is 20,000 pounds. In the next generation, after selection, what's the expected average milk yield of the breeder's cows? Show your work (*2 points).*

Solution. Observe that the selection differential is $21000 - 20000 = 1000$ and heritability is 0.4. Hence, the Breeder's equation gives that the response to selection is 400. Hence, the expected average milk yield of the breeder's cows is $21000 - 400 = 20600$. □

Question 4.

4. Why is heterozygosity lower in people with Native American ancestry than in those with East African ancestry?

Solution. The founders effect tells us that the expected heterozygosity decreases as the population is located further away from East Africa. Therefore, people with the Native American ancestry has lower heterozygosity than those with East African ancestry. □

Question 5.

5. Suppose we have allele frequencies of three loci in Gujaratis and Bengalis:

Locus	Allele	Gujarati Frequency	Bengali Frequency
1	*a*	0.4	0.5
2	*b*	0.2	0.2
3	*c*	0.5	0.4

Each locus has two alleles. For example, at locus 1, the alleles are A and a.

a. What is the probability of the genotype *aa* in a Gujarati?

b. What is the probability of genotype *aa Bb cc* in *each* population?

c. What's the most probable ancestry for an individual with genotype AA *bb cc* ?

Solution. **(a)** The probability of the genotype aa in Gujarati is $0.4^2 = 0.16$.

(b) The probability of the genotype of aa Bb cc for Gujarati is $0.4^2 \cdot 2 \cdot 0.8 \cdot 0.2 \cdot 0.5^2 \approx 0.128$. The probability of the genotype of aa Bb cc for Bengali is $0.5^2 \cdot 2 \cdot 0.2 \cdot 0.8 \cdot 0.4^2 \approx 0.128$, which equals that of Gujarati.

(c) The probability of the genotype of AA bb cc for Gujarati is $0.6^2 \cdot 0.2^2 \cdot 0.5^2 \approx 0.0023$. The probability of the genotype of AA bb cc for Bengali is $0.5^2 \cdot 0.2^2 \cdot 0.4^2 = 0.0016$. Hence, the most probable ancestry for an individual with genotype AA bb cc is Gujarati.

□