LABORATORY 8: POPULATION GENETICS GAME

Objectives

In this lab, you will gain familiarity with fundamental concepts in population genetics as demonstrated through a card-trading activity. You will be examining how random mating results in a binomial distribution of genotypes. Additionally, you will be looking at how deviations from an idealized ("Mendelian") population influence genotype and allele frequencies.

Preparation and Quiz

As preparation for this laboratory session, read the Practical in its entirety to become familiar with the following concepts and terms:

- Hardy-Weinberg Equilibrium (HWE)
- Allele and Genotype Frequency
- Population Selection Events
- Associative Mating
- Overdominant Selection

COVER SHEET
STUDYING INHERITANCE USING *FLY*LAB

HUMAN GENETICS – CORE-UA 303 – Professor Fitch

Name: ____ Date: ____________________

Lab Partner Name(s): ____

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Laboratory Instructor: __________________________________ Section: __________________

LAB PRACTICAL

In this lab, you and your fellow students in the class will simulate a population. We will look at how different factors affect the genotype and allele frequencies at a single locus, the "A-gene". Each individual will be diploid and thus have two copies of this gene. Either of these gene copies could be one of two alleles, 'A' or 'a'. Thus, the possible genotypes are **'AA', 'Aa' and 'aa'**. Gene copies are simulated by cards that are dealt out to population members at the start of the "game".

The simulated population is a simplified version of a real population in additional ways. For example, generations are discrete, because the next generation is made all at once and completely replaces the previous generation.

Rules of the Game

- When it is time to make a new generation, individuals pair up and randomly exchange a gene copy (a card) to simulate "mating". If there is an odd number of students, one student will abstain from the genetic exchange; however, the same student cannot abstain more than once in the game.
- The resulting genotypes constitute the new population that replaces the parental population. After each such round of mating, your TA will tabulate the genotype frequencies using the provided Excel datasheet.
- In some cases, the parental population will be subject to a selection or bottleneck event. Such events reduce the number of adults that will produce the next generation.

Analysis

The Excel spreadsheet automatically calculates things like allele frequency and genotype frequency, but students should already know how these calculations are made. (The formulas in the spreadsheet can be viewed but must not be changed!)

In this simulation, you will follow 10 generations. Some generations may approximate a "Mendelian population", resulting from random mating. Such populations are predicted to be in a HWE (binomial distribution of genotype frequencies) with no evolution (no change in allele frequency from the previous generation). Alternatively, other generations may result from deviations from ideal situations, such as assortative mating, selection and genetic drift. The goal is to determine how such factors affect genotype frequencies (by testing for HWE) and allele frequencies (by testing for evolution).

Given the Rules of the Game above, simulate the following situations, in order 1–10 below, and enter the counts of individuals with different genotypes into the Excel datasheet.

Generation 1, the original population, is formed by shuffling the allele cards and dealing two per person. Once all cards are dealt, the TA will tabulate the genotype counts. For this original population, record these observed genotype counts below:

Question 1: Copy the counts of genotypes and total number of individuals for your original population:

n(AA) = ____

n(Aa) = ____

n(aa) = ____

Total number of individuals: N = ____

The spreadsheet will calculate the observed genotype frequencies, allele frequencies, the observed and HWE-expected genotype frequencies and counts. It will also apply a chi-square test to compare the observed to expected genotype count values. The P-value is also calculated for this comparison. Allele evolution is *not* tested for this generation.

Question 2: Provide the *general formulas* for the following quantities and calculate the *values* for this original population:

observed f(AA) = ____

observed f(Aa) = ____

observed f(aa) = ____

f(A) = ____

f(a) = ____

expected f(AA) = ____

expected f(Aa) = ____

expected f(aa) = ____

expected n(AA) = ____

expected n(Aa) = ____

expected n(aa) = ____

Question 3: Why is it legitimate to test if this one generation is in HWE or not? Doesn't this require comparison with a previous generation? Why or why not?

Question 4: Why can allele evolution not be tested for this generation, even if we can test for HWE?

Generation 2 is formed by a random mating process: students randomly pair up (a student's sex identity is irrelevant here, as the simulated population is hermaphroditic) and blindly (*randomly*) give each other one of their two allele cards. The genotype counts in this generation are tabulated by the TA in the "Gen. 2" line of the spreadsheet. Again, observed and expected allele and genotype frequencies and counts are calculated automatically in the spreadsheet.

Question 5: What is the result of the HWE test and the evolution test? What can you conclude about the genotype and allele dynamics?

Generation 3 is formed after an associative mating process: students with 'A' phenotype (i.e. genotypes AA or Aa) pair up and exchange alleles; students with 'a' phenotype (i.e. 'aa' genotype) are *only allowed to exchange alleles with other 'a' phenotypes*. Genotype counts are tabulated by the TA in the "Gen. 3" line.

Question 6: What is the result of the HWE test and the evolution test? Does evolution result from non-random mating alone?

Generation 4 is formed after another random mating process. Genotype counts are tabulated by the TA in the "Gen. 4" line. *Make sure the class has truly mixed randomly*.

Generation 5 is formed by random mating after selection against 'aa'. In this case, 'aa' genotypes do not survive and do not reproduce. That is, genotype 'aa' has a much lower "fitness" than either of the other genotypes. Thus, only students with 'A' phenotypes pair up (otherwise randomly) to exchange alleles. Only the genotype counts in this generation formed by matings are tabulated by the TA in the "Gen. 5" line of the spreadsheet.

Question 7: What is the result of the HWE test and the evolution test? What is the result of selection on evolution?

Generation 6 is formed by random mating including *all individuals*. The genotype counts in this generation are tabulated by the TA in the "Gen. 6" line of the spreadsheet.

Generation 7 is formed by overdominant selection. In this case, *only heterozygotes* (genotype Aa) contribute to the next generation (randomly mating with each other). The genotype counts in this generation are tabulated by the TA in the "Gen. 7" line.

Question 8: What is the result of the HWE test and the evolution test? If overdominant selection were to continue, would you predict that evolution would continue? Why or why not?

Generation 8 is formed by random mating including *all individuals*. The genotype counts in this generation are tabulated by the TA in the "Gen. 8" line of the spreadsheet.

Generation 9 is formed by a bottleneck or founder effect, i.e. a reduction in population size. In this case, the TA randomly selects *only 5 students* to participate in producing the offspring. The genotype counts in this generation are tabulated by the TA in the "Gen. 9" line of the spreadsheet.

Question 9: What is the result of the HWE test and the evolution test? Does population size reduction necessarily cause HW "disequilibrium"? Can population size reduction result in evolution? Why or why not?

Generation 10 is formed by migration and mixing of these new migrants with the above population. In this case, *all* individuals with 'AA' and 'Aa' genotypes in the class mix with the individuals from the reduced population above and mate randomly. The genotype counts in this generation are tabulated by the TA in the "Gen. 10" line of the spreadsheet.

Question 10: What is the result of the HWE test and the evolution test? Specifically, how are these affected by migration?