

Investigations: Bean Bunnies

AP Biology

INTRODUCTION

Evolution, on a genetic level, is a change in the frequency of alleles in a population over a period of time. Breeders of rabbits have long been familiar with a variety of genetic traits that affect the survival of rabbits in the wild, as well as in breeding populations. One such trait is furless rabbits (naked bunnies). This trait was first discovered in England by W.E. Castle in 1933. The furless rabbit is rarely found in the wild because the cold English winters act as a **selective pressure** against this particular phenotype (physical characteristic). A selective pressure is a phenomenon that alters behavior and fitness of organisms in an environment. There are two types of selective pressure: biotic and abiotic. Biotic selective pressures can be things like predators, parasites or competing organisms. Abiotic selective pressures can be things like soil composition, water availability, air quality or even changes in climate.



In this lab, the dominant allele for normal fur is represented by F and the recessive allele for no fur is represented by f . Bunnies that inherit two F alleles or one F and one f allele have fur (FF or Ff genotypes), while bunnies that inherit two f alleles have no fur (ff genotype). In this activity you will model evolution by natural selection of the allele frequency of two alleles in a population of organisms. You will also calculate the allele frequency of the alleles for each generation and then graph the frequency of the two alleles over 10 generations. You will then repeat the experiment given a selective pressure, which could be biotic or abiotic.

MATERIALS

Brown paper bag 50 red beans 50 white beans 3 cups Marker

SAFETY CONSIDERATIONS

Do not eat any part of the lab.

PROCEDURE: PART ONE

1. Consider the research question: ***How does natural selection affect gene frequency over several generations?*** This is the question we will seek to answer through data collection today. Write this question in your BILL.
2. Using what you've learned about natural selection so far, devise a testable hypothesis for your experiment. A testable hypothesis does not begin with "If...then..." A hypothesis is a tentative, testable statement based on observation and prior knowledge. It is **NOT** a prediction. You will also formulate a prediction regarding how you think natural selection will affect the gene frequency in a population. State what you would predict about the frequency of F alleles and f alleles in the population of rabbits after 10 generations, where ff bunnies are selected against and do not survive.
3. The red beans represent the F allele for fur, and the white beans represent the f allele for no fur. The paper bag represents the English countryside, where the rabbits randomly mate.
4. Using the marker, label one cup FF for the homozygous dominant genotype. Label a second cup Ff for the heterozygous condition. Label the third cup ff for those rabbits with the homozygous recessive genotype.
5. Place the 50 red and 50 white beans (alleles) in the paper bag and shake up (mate) the rabbits.
6. Without looking at the beans, select two at a time; place the "rabbit," or bean pair, into the appropriate cup: FF , Ff , or ff . For example, if you draw out one white bean and one red bean place both beans into the Ff cup. Continue drawing out pairs until all beans have been placed in the appropriate cup. To determine the number of individual rabbits produced for each phenotype count the total number of beans in the appropriate cup and divide this number by two since an individual is represented by a pair of beans. Record your results in the data table.
7. The ff bunnies are born furless. The cold weather kills them before they reach reproductive age, so they can't pass on their genes. Place the beans from the ff container aside before beginning the next round. You will not count these beans in the "Number of f Alleles" column.
8. Count the F and f alleles (beans) that were placed in each of the "furred rabbit" (FF and Ff) dishes in the first round and record the number in the data table under the columns labeled "Number of F Alleles" and "Number of f Alleles." Total the number of F alleles and f alleles for the first generation and record this number in the column labeled "Total Number of Alleles."
9. Place the alleles of the surviving rabbits (FF and Ff cups) back into the countryside (paper bag) and mate them again to get the next generation.
10. Repeat steps six through nine to obtain generations two through ten. Make sure to take turns so that each partner has a chance to select the beans and record the results.
11. Determine the allele frequency of F and f for each generation and record them in the chart in the columns labeled "Allele Frequency F " and "Allele Frequency f ." To find the allele frequency of F , divide the number of F by the total number of alleles, and to find the allele frequency of f , divide the number of f by the total number of alleles. Express your results in decimal form. The sum of the frequency of F and f should equal one for each generation.
12. Your teacher will set up a Google Form for you to collect class data in, and you will use this data as a comparison with your individual data set.
13. Examine your data and **state a claim** that answers the original research question. You will then use the data that you collected to provide evidence for the claim you state.
14. Using Excel, produce a graph that displays the frequencies of the F allele and the f allele. You will need to set this graph up as a scatterplot. Remember that allele frequencies are expressed as a value

from 0 to 1, so your values will need to be in decimal form. Plot all frequencies on one graph. Your teacher can help you with making graphs in Excel if you do not know how.

15. You will also plot the class totals on the same graph. Be sure your graph legend indicates which data belong to the class set and which data belong to your individual group.

PROCEDURE: PART TWO

1. Now consider the research question: ***How does the presence of a specific selective pressure affect gene frequency over several generations?*** Write this question in your BILL.
2. Again, you'll devise a testable hypothesis for your experiment. Remember that a testable hypothesis does not begin with "If...then..." A hypothesis is a tentative, testable statement based on observation and prior knowledge. It is **NOT** a prediction. You will also formulate a prediction regarding how you think the presence of the selective pressure will affect the gene frequency in a population. State what you would predict about the frequency of F alleles and f alleles in the population of rabbits after 10 generations, for one of the following situations (your teacher will assign you one of the selective pressure situations):
 - a. The homozygous dominant genotype (FF bunnies) is selected against as it is lethal.
 - b. The climate of the English countryside becomes warmer over several generations and bunnies with no fur are selected for. Bunnies with fur are selected against.
 - c. Only bunnies that have the heterozygous genotype (Ff bunnies) survive each generation.
3. You will repeat Steps 3-10 from Part One of the lab, but making sure you are accounting for the selective pressure your group has been assigned instead of killing off the ff bunnies. So if you were assigned Pressure A, you must remove any bunnies that were of the FF genotype from the population before your bunnies breed again.
4. Using the second data chart provided, determine the gene frequency of F and f for each generation and record them in the chart in the columns labeled "Gene Frequency F " and "Gene Frequency f ." To find the gene frequency of F , divide the number of F by the total number of alleles, and to find the gene frequency of f , divide the number of f by the total number of alleles. Express your results in decimal form. The sum of the frequency of F and f should equal one for each generation.
5. Your teacher will set up a Google Form for you to collect class data in, and you will use this data as a comparison with your individual data set for the selective pressure situation you were assigned.
6. Examine your data and **state a claim** that answers the original research question. You will then use the data that you collected to provide evidence for the claim you state.
7. Using Excel, produce a graph that displays the frequencies of the F allele and the f allele. You will need to set this graph up as a scatterplot. Remember that allele frequencies are expressed as a value from 0 to 1, so your values will need to be in decimal form. Plot all frequencies on one graph. Your teacher can help you with making graphs in Excel if you do not know how.
8. You will also plot the class totals on the same graph. Be sure your graph legend indicates which data belong to the class set and which data belong to your individual group.

DELIVERABLE:

You and your partner will create a Science Writing Heuristics (SWH) and submit it via google classroom.