

Genetics & Inheritance Lab Pre-Lab Exercise

Name _____

1. Define the following terms:

a. Genetic trait:

b. Gene:

c. Allele:

d. Genotype:

e. Phenotype:

f. Homozygous

g. Heterozygous

h. Dominant:

i. Recessive:

2. Describe how you will "mate" in Part II of the exercise.

Genetics & Inheritance Lab

Work in groups of two

This lab is designed to demonstrate **genetics**, or the study of how heritable characteristics are passed from generation to generation. Genetic traits are determined by **genes**, or small segments of DNA carried on chromosomes that determine physical characteristics. This exercise demonstrates how different alleles of the same gene segregate and reassort (separate and come together) in a population.

Summary of Activities

1. Demonstrate some of Mendel's principles of genetics by simulating different types of mating crosses.
2. Examine at the effect of natural selection on the frequency of alleles in a population.
3. Observe some single-gene genetic traits in humans.

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I. Human Genetic Traits

Some human traits exhibit the simple dominant and recessive behavior of a monohybrid cross similar to Mendel's peas. However, the expression of many other human traits, like skin color or height, is much more complex and the genetics cannot be easily studied. We will look at a few easily observed human genetic traits to illustrate the simple dominant-recessive relationship between alleles in humans.

Gene frequencies for a population will not necessarily show the same dominant/recessive ratios that you see for the offspring of a specific mating pair. When we calculate gene frequency, it is unlikely that we will have a 3:1 ratio of dominant traits to recessive traits. In our case, it is probably due more to small sample size than anything else. If you had a large immediate family to survey, these should segregate in a more classically Mendelian fashion.

1. Mark your appropriate phenotype for each trait on the chart.
 2. Record the data for the class.
- A. **Mid-digital Hair:** The presence of hair on the middle joint of the finger is a dominant trait. Hair may not be present on all of your fingers, but if you have hair on even one finger, you are dominant.

- B. **Tongue Rolling:** The ability to roll the tongue upward from the sides is a dominant trait. For some reason, people who exhibit this trait seem to think it is a desirable thing to do. As far as anyone knows, tongue rolling has no obvious anatomical or physiological advantage or disadvantage.
- C. **Widow's Peak:** A distinctive downward point of the frontal hairline is a dominant trait known as a widow's peak. If you have a straight hairline, you are recessive for this trait.
- D. **Free Earlobes:** Free earlobes are dominant over attached earlobes. Read the introduction to Chapter 9 for an explanation of how this trait is produced during fetal development.
- E. **Eye Color:** Brown pigmented irises are dominant. The absence of brown pigment results in blue eyes, which is recessive. Hazel or green eye color is the result of a second gene that produces a yellow pigment. Hazel eyes have both brown and yellow iris pigment, while green eyes have both the recessive blue iris and dominant yellow pigment. For our purposes, assess only the presence of absence of brown pigment.
- F. **Facial Dimples:** Dimples, or indentations, at the corner of the mouth are a dominant trait.
- G. **PTC Tasting:** The ability to taste the chemical phenylthiocarbamide, or PTC, is a dominant trait. Place a piece of PTC paper on the back of your tongue. If you can detect this chemical, it will have a bitter taste. If the paper does not taste nasty to you, then you are recessive for this trait.
- H. **Hitchhiker's Thumb:** The ability to bend the thumb backward at least 45° is a dominant trait. The proper term for this is distal hyperextensibility.

- I. **Relative Length of the Big Toe:** If your big toe is shorter than your second toe, you are dominant for this trait.
- J. **Palmaris Longus Muscle:** The presence of this muscle is a dominant genetic trait. If you have this muscle you will have three wrist tendons. To determine this, clench your fist tightly and flex your hand toward you. If you can see or feel three tendons in your wrist, you have the long palmar muscle and are dominant. If you have only two tendons, then you are recessive for this trait.

II. Mendelian Genetics: Monohybrid Crosses

A monohybrid cross is the genetic transmission of a single trait. For this exercise, each person will receive colored beads that represent different alleles of a gene. Red will represent the allele for the dominant characteristic (designated in writing as "A"), while yellow will represent the allele for the recessive characteristic (written as "a"). The combination of two beads determines the **genotype**. Since gametes contain only one copy of each gene, a single bead also represents a gamete.

You will "mate" (exchange gametes) with your lab partner and determine the genotypes and phenotypes of the offspring that result from each mating, or "cross".

A. F₁ Generation:

- For the first mating you will have a homozygous genotype. One lab partner will use two red beads, representing the dominant genotype. The other lab partner will use two yellow beads, representing the recessive genotype.
- Mate with your lab partner by shaking your beads in your cupped hands and selecting one without looking. Pair it with your partner's randomly chosen allele; these two beads represent the two alleles carried by your offspring. Record the genotype of your offspring in Table 1 of the attached data sheet.
- Mate with your lab partner 9 more times to produce a total of 10 offspring. Record the genotype of each offspring in Table 1.
- Report your results to the class and determine the class total for each genotype.

B. F₂ Generation:

This mating involves self-fertilization of the first generation produced by the first cross.

- Each person will now have the genotype of the F₁ offspring.
- Mate with your lab partner 10 times to produce ten offspring. Record the genotypes of your offspring in Table 1.
- Report your results to the class and determine the class total for each genotype.

III. The Gene Pool: Allele Frequency

Allele frequency refers to how often a particular allele appears in a population. Evolution can be defined as a change in the frequency of alleles over time. The allele frequency for a given trait changes over time in response to changes in the environment. At the beginning of the quarter you saw how natural selection influenced changes in the frequency of a particular phenotype. This exercise will illustrate how natural selection influences genotype.

A. How To Calculate Allele Frequency

Think of a population as a pool of genes instead of individuals, as though each of the individuals pulled out his or her genes and threw them in a big pot.

Suppose we have a population of 100 individuals:

- 25 of which are "AA"
- 50 of which are "Aa"
- 25 of which are "aa"

This population contains 200 total alleles, because 100 individuals with 2 alleles each = 200 alleles total.

Counting up all the "A's" in the population, we find there are 100 because:

$$\begin{array}{r}
 2 \times 25 = \quad 50 \text{ "AA"} \\
 + \quad 1 \times 50 = \quad 50 \text{ "Aa"} \\
 \hline
 100 \text{ "A" genes}
 \end{array}$$

Allele frequency of "A" is $100/200 = 0.5$
(or 50%).

Similarly, the allele frequency for "a" in this population is 0.5 (or 50%).

B. Selection against the aa genotype

We have just seen how two alleles of the same gene can be passed on if both genes have an equal chance of surviving. Now we will demonstrate what happens to allele frequency when there is a **selective disadvantage** to a particular genotype. In particular, genotype "aa" causes a fatal disease which results in death during childhood.

1. Everyone will begin with a heterozygous genotype. (Everyone is healthy, but carries a recessive gene for the disease.) Record your initial genotype on the first line of Table 3.
2. Instead of mating with your lab partner, roam around the room and find another person in the class AT RANDOM (without respect to charm, appearance, or even gender) to mate with. Mate twice. These two offspring will replace you and your partner in the next generation. If one offspring has the genotype is "aa", it dies. One of you cannot reproduce again. If both offspring are "aa", then neither of you can reproduce again. Record your offspring's genotype in Table 3.

Stop at this point until everyone in the class has finished mating.

3. You will now assume the identity of your offspring and take on its genotype. Remember, if you were aa, you cannot mate again. If you are "AA" or "Aa", replace your beads with the appropriate colors.
4. **Find a new partner** to mate with and produce two offspring. Record the genotypes. Again, if you produce an "aa" offspring, you cannot mate in the next generation.
5. Repeat the mating four more until a total of **six generations** have been completed.
6. Report your results to the class and record the class results in Table 4. Calculate the allele frequencies for each generation based on the class results.

Genetics & Inheritance Lab
Data Sheets

Name _____

I. Human Genetic Traits. Table 1: The dominant trait is the first listed of each pair.

Trait	Your Phenotype	Class Data
Mid-digital Hair		
No Mid-digital Hair		
Tongue Rolling		
No Tongue Rolling		
Widow's Peak		
Straight Hairline		
Free Earlobes		
Attached Earlobes		
Brown Eye Color		
Blue Eye Color		
Dimples		
No Dimples		
PTC Taster		
Non-Taster		
Hitchhiker's Thumb		
Straight Thumb		
Longer Second Toe		
Longer Big Toe		
Palmaris Longus Muscle		
Two Wrist Tendons		

II. Monohybrid Cross:

Make a hatch mark to keep count of each genotype that is produced during your matings.

Table 2

Genotype of Mating Pair: AA X aa	Number of Offspring		
	Homozygous Dominant (AA)	Heterozygous (Aa)	Homozygous Recessive (aa)
No. of <u>your</u> F1 offspring:			
No. of <u>your</u> F2 offspring:			
Total No. of <u>class</u> F1 offspring:			
Total No. of <u>class</u> F2 offspring:			

Your genotypic ratio:

Class's genotypic ratio:

III. Natural Selection Against the Recessive Phenotype

Table 3: Your Individual Genotypes

	Your Genotype
Original Genotype	
Genotype of 1st Generation	
Genotype of 2nd Generation	
Genotype of 3rd Generation	
Genotype of 4th Generation	
Genotype of 5th Generation	
Genotype of 6th Generation	

Table 4: Class Genotypes

	No. of people with genotypes:			No. of Individual Alleles		Allele Frequency	
	AA	Aa	aa	A	a	A	a
Original Genotype							
Genotype of 1st Generation							
Genotype of 2nd Generation							
Genotype of 3rd Generation							
Genotype of 4th Generation							
Genotype of 5th Generation							
Genotype of 6th Generation							

Genetics & Inheritance Lab Lab Report

1) (2 pts) Hand in all data tables

I. Human Genetic Traits

- 2) Is it always the case that more people in a population will have the dominant trait over the recessive trait? Why or why not? Use your data to support your answer.
- 3) How closely did your individual data match the class data?

II. Mendelian Genetics: Monohybrid Crosses

- 4) Why did all the F1 individuals look the same?
- 5) What happened to the recessive trait from parental → F1 → F2 generations?
- 6) How close were your group's F2 generation data and the class data to the expected ratio? What could you have done to make these data more accurate?

III. The Gene Pool: Allele Frequency

- 7) How does the frequency for each *allele* and each *genotype* change over the generations?
- 8) Explain the effect that natural selection appears to have on allele frequency in a population.
- 9) Why doesn't selection against aa individuals lead to the complete loss of the "a" allele from the population?