EXERCISE 10

Genetics

LEARNING OBJECTIVES

- Explain the genetic concepts of dominance and recessiveness.
- Efficiently use of the Punnett square
- Determine the outcome of monohybrid and dihybrid crosses.
- Calculate expected phenotypic and genotypic ratios given the genotype of two parents.
- Recognize that some human characteristics are inherited in a simple Mendelian fashion and others are not.
- Determine the outcome of genetic crosses involving the following principles: incomplete dominance/co-dominance, multiple alleles, sex linkage

INTRODUCTION

Genetics is the science of heredity, which explains how characteristics are passed from parents to their offspring. Much of our early understanding of genetics was due to the experiments of Gregor Mendel done in the late 19th century. Mendel was able to discover some of basic generalizations of the laws of inheritance from experiments on pea plants. These principles can be applied to may sexually reproducing organisms. However, genetics is a very complex science and while some of these generalizations apply to the inheritance of some human characteristics, many human characteristics are passed on using genetic mechanisms that were not evident to Mendel. In this lab, we will look at Mendelian genetics and also some ways in which a few human characteristics are inherited.

Before you come to lab, make sure you know the definitions of the following terms.

Homologous chromosomes	
Gene	
Allele	
Homozygous	
Heterozygous	
Dominant	

Recessive	
Genotype	
Phenotype	
Monohybrid	
Dihybrid	
Incomplete dominance	
Codominance	
Multiple alleles	
Sex linkage	

The Punnett Square

In order to understand how alleles are passed on from parent to offspring, a Punnett square is often used. A Punnett square shows the possible combination of alleles that can result when male and female gametes are crossed. The first part of this lab will give you practice with both **monohybrid** and **dihybird** crosses.

In order to complete a Punnett square, the alleles from one parent are listed on the top of the Punnett square, and the alleles from the other parent are listed along the side.

It does not matter which parent is listed along the top, and which is listed along the side.

SIMPLE DOMINANCE

Monohybrid Crosses

Exercise 1

With simple dominance, alleles that completely mask the alternate form of the gene are said to be **dominant**. In other words, dominant alleles are fully expressed whenever they are present. Dominant individuals could have either an AA genotype (homozygous dominant) or an Aa(heterozygous). The recessive allele "a" would be hidden whenever it was combined with

"A". Thus, **recessive** phenotypes will only show up when individuals are homozygous recessive (aa).
In onion sweet taste is dominant over bitter taste. Using the letter T, t, for taste, complete the following crosses, and fill in the phenotype ratios of the offspring.

1. Homozygous Dominant X Homozygous Recessive

Phenotype Ratio of Offspring

2. Heterozygous X Homozygous Recessive

Phenotype Ratio of Offspring

3. Homozygous Recessive X Homozygous Recessive

Phenotype Ratio of Offspring

4. Heterozygous X Heterozygous

Phenotype Ratio of Offspring

Questions:
1. In which of the above crosses will all of the offspring express the dominant phenotype and be heterozygous? _____
2. In which of the above crosses will all of the offspring express the recessive phenotype and be homozygous? _____

3. In pea plants purple (P) is dominant to white (p). If you see a purple-flowered plant, what are its possible genotypes? _____
4. Describe the experiment you would do to determine the correct genotype of the purple plants.

Exercise 2

Note: The kernels on this ear of corn are either dark or light in color. Both parents of this ear of corn only possessed dark-colored kernels.

1. What are the phenotypes of the kernels on your ear of corn?

   Phenotype #1 _____

   Phenotype #2 _____

2. Observe five rows of kernels. Record the number of each phenotype.

   Phenotype #1 _____

   Phenotype #2 _____

3. What is the approximate phenotypic ratio of this ear of corn? _____ : _____

4. Which allele is dominant? _____

5. Which allele is recessive? _____

6. What are the most probable genotypes and phenotypes of the parent kernels?

	Phenotype	Genotype
Parent #1	_____	_____
Parent #2	_____	_____

7. How many alleles influence this phenotype? _____

Exercise 3

Repeat the previous exercise using the new ears of corn that you are given.

1. Observe five rows of kernels. Record the number of each phenotype.

   Phenotype #1 _____

   Phenotype #2 _____

2. What is the approximate phenotypic ratio of this ear of corn? _____ : _____

3. What are the most probable genotypes and phenotypes of the parent kernels?

	Phenotype	Genotype
Parent #1	_____	_____
Parent #2	_____	_____

Exercise 4: Dihybrid cross

A dihybrid cross involves two characteristics located on different chromosomes. Recall Mendel's law of independent assortment which states that alleles of any pair of genes segregate from each other independently of members of any other gene pair.

In guinea pigs, the allele for black coat color is dominant over the allele for brown and short hair is dominant over long. If coat color is represented by B, b and hair length by H, h, the genotype of a double heterozygous pig will the BbHh. Either of the pair of alleles B and b can end up in a gamete with either of the pair H and h, so the possible combinations of theses alleles in the gametes will be: BH, Bh, bH, and bh.

What is the genotype of the following guinea pigs:

True breeding black short-haired pig _____

True breeding brown long-haired pig _____

Heterozygous black pig with long hair _____

Heterozygous short-haired pig with brown fur _____

(a) A double heterozygous black short-haired pig was mated with a heterozygous black pig with long hair.

Genotype of heterozygous black short-haired pig	Possible Gametes
Genotype of Heterozygous black pig with long hair	Possible Gametes

Use the Punnett square below to work out the genotypes of the offspring of the above cross.

(b) State the phenotypes of the offspring and give the ratio.

_____

_____

Exercise 5: Dihybrid cross (Corn)

Observe the kernels on this ear of corn carefully. Each kernel displays two different phenotypic characteristics and there are four different phenotypic combinations.

1. What are the two phenotypic characteristics that the kernels display?

   Phenotype 1 _____ and _____

   Phenotype 2 _____ and _____

   Phenotype 3 _____ and _____

   Phenotype 4 _____ and _____

2. Observe five rows of kernels. Record the number of each phenotype. Record your results on the board and pool the class results.

   Phenotype 1 _____

   Phenotype 2 _____

   Phenotype 3 _____

   Phenotype 4 _____

3. What is the approximate phenotypic ratio of this ear of corn? _____

4. Which alleles are dominant? _____ and _____

5. Which alleles are recessive? _____ and _____

6. What are the most probable genotypes and phenotypes of the parent kernels?

	Genotype	Phenotype
Parent 1	_____/_____	_____
Parent 2	_____/_____	_____

Exercise 6: Human Genetics

Most human phenotypes like height, hair color, and stature are complex and influenced by several genes. A few characteristics, however, are controlled by only a single pair of genes and follow the rules of Mendelian inheritance. In this exercise, you will attempt to determine your genotype for a number of these traits. If you demonstrate the dominant form of the gene, you could be homozygous dominant or heterozygous for that trait. Determining your actual genotype could involve developing family history or pedigree for that trait. Note that a phenotype that is dominant will not necessarily be the most abundant one in a population.

1. Tongue Rolling: The ability to roll your tongue into a U-shape is dominant to the inability to roll the tongue.

2. Widow's Peak: A widow's peak is a distinct V-shaped point in the frontal hairline. The presence of a widow's peak is dominant to a straight hairline.

3. Earlobe Attachment: Ear lobes may either be free hanging or attached to the side of the head. To have free-hanging earlobes is dominant to having attached earlobes.

4. Hitchhiker's Thumb: The ability to hyperextend or bend the end digit of the thumb backward past a 45° angle. The presence of a hitchhiker's thumb is recessive to the inability to hyperextend the end of the thumb.

5. Mid-digital hair: The presence of hair (any amount) on the second (middle) digit of the fingers is dominant to the absence of hair.

6. Freckles: The presence of freckles is dominant to their absence.

7. Dimples: The presence of dimples is dominant to their absence.

8. Thumb Overlap: When folding your hands together, to fold the left thumb over the right is dominant to folding the right thumb over the left.

IMPORTANT NOTE: Wear gloves when handling PTC paper and dispose of PTC paper and gloves in biohazard buckets.

9. PTC Tasting: The ability to taste PTC (phenylthiocarbaminde) is dominant to the inability to taste. Tasters will detect a bitter flavor.

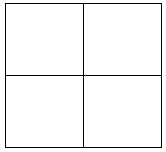
Trait	**My Phenotype**	**My Possible Genotype**	**CLASS TOTALS**
Tongue Rolling	Roller or Nonroller	TT Tt or tt	Dominant: Recessive:
2nd finger shorter than 4th	Present or Absent	MM or Mm or mm	Dominant Recessive
Widow's Peak	Peak Present or Straight	WW Ww or ww	Dominant: Recessive:
Earlobe Attachment	Free or Attached	FF Ff or ff	Dominant: Recessive:
Hitchhiker's Thumb (Last segment can be bent back 60°)	Present or Absent	HH Hh or hh	Dominant: Recessive:
Mid-digital Hair	Present or Absent	HH Hh or hh	Dominant: Recessive:
Freckles (face)	Present or Absent	FF Ff or ff	Dominant: Recessive:
Dimples	Present or Absent	DD Dd or dd	Dominant: Recessive:
Thumb Overlap	Left or Right	TT Tt or tt	Dominant: Recessive:
Right-handedness	Present	LL orLl or ll	Dominant Recessive
PTC Tasting	Taster or	TT Tt or	Dominant:

	Nontaster	tt	Recessive:

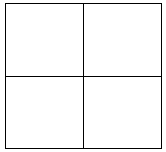
Exercise 7: Incomplete Dominance

In simple dominance that we have been investigating so far, the dominant allele is always expressed when it is present where homozygous or heterozygous. In **incomplete dominance,** there are two alleles for a trait, and neither one is truly dominant over the other. With incomplete dominance, the phenotype of the heterozygote is unlike either of the homozygotes and expresses an intermediate of both alleles a sort of blending of both phenotypes. A common example of this is flower color in petunias. Petunias with red flowers have the genotype R^1R^1. Petunias with white flowers have a genotype R^2R^2. A flower that is heterozygous (R^1R^2) is pink.

If a red-flowered plant is crossed with a white-flowered plant, what is the phenotype and genotype ratios of the F_1 offspring?



If two of the F_1 generation were crossed, what would be the genotype and phenotype ratios of the F_2?



Exercise 8: Co-dominance

In other cases, when neither allele is dominant, there is not really a blending to give an intermediate phonotype but both alleles are fully expressed. This is known as co-dominance. One of the best examples of co-dominance is demonstrated in the coat color of short-horned cattle. Those individuals with reddish-grey (roan) coats are heterozygous R^1R^2, and are the result from a mating between a red (R^1R^1) shorthorn and a white (R^2R^2) shorthorn. Roan cattle do not have roan-colored hairs. Instead, they have both red- and white-colored hairs mixed together, which at a distance appears to be roan.

What if a roan short-horn cow is mated with a white bull. What will be the genotypic and phenotypic ratios in the F_1 generation?

List the parental genotypes of crosses that would produce at least some…

White offspring: _____, _____, _____

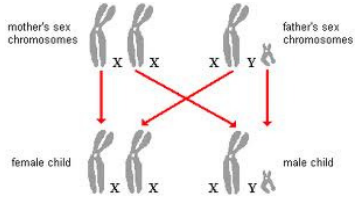
Roan offspring: _____, _____,

_____, _____

Exercise 9: Sex Linked

The sex (gender) of humans and other primates is determined by a special pair of "sex chromosomes," the X and Y chromosomes. An individual with two X chromosomes if female, while one X and one Y is male. The genes occurring on the sex chromosomes are called sex-linked genes. Most sex-linked traits are X-linked. That is, they occur on the X chromosome.

The Y chromosome is much smaller than its homologue, the X chromosome. Consequently, some genes present on the X are absent on the Y chromosome. This allows for sex-linked traits to be more common in males. Males have only a single copy of the X chromosome. Having only a single copy of the X chromosome allows for the alleles on that X chromosome to be fully expressed. Females, with two X chromosomes, can be carriers (heterozygous) for a recessive trait, but not exhibit the condition.



Color-blindness is a recessive X-linked human trait. If a color-blind man (X^rY) fathers children of a woman with the genotype X^RX^R, what percentage of the sons would be color-blind?

A man has a sex-linked form of pattern baldness. From which parent did he receive this condition? Explain your answer.

a. mom b. dad c. no way to tell d. both

A girl is color-blind. From which parent did she receive this condition? Explain your answer.

a. mom b. dad c. no way to tell d. both parents

Exercise 10: Multiple Alleles and co-dominance

Many human traits are controlled by two alleles (i.e., the ability to roll the tongue (T) or the inability to roll the tongue (t). Some characteristics are controlled by more than two versions of a gene. These are called **multiple allele**s. The most well-known of these characteristics is blood type in humans. The protein "I" on a red blood cell comes in two different forms, type A and type B. The alleles that code for A and B proteins are co-dominant. Some individuals have cells that lack this protein altogether. They have type O blood, which is a recessive condition. Thus, from three alleles, I^A, I^B, and i, we have a four possible phenotypes of blood: Type A, Type B, Type O, and Type AB.

Phenotype	Possible Genotype
Type A	AA or AO
Type B	BB or BO
Type O	OO
Type AB	AB

Is it possible for parents both with type AB blood to have a child that is type O? Why or why not?

In a case of disputed paternity, a child is type O, the mother is type A. Could an individual of the following blood types be the father?

AB _____

B _____

A _____

O _____

Genetics Review Questions

You must indicate what the letter symbols you use mean and you must include the Punnett square in all answers where appropriate.

1. In Labrador retrievers (a breed of dog) black coat color is dominant to brown.

   (a) What would be the genotype of a heterozygous black dog?

   (b) If a homozygous black dog is crossed with a brown dog, what will be the phenotypic ratio of the offspring?

   (c) If two black dogs from (b) above were crossed, what phenotypic ratio would you expect in the offspring?

   (d) If a heterozygous black dog is crossed with a brown dog, what phenotypic ratio would result?

2. In humans normal skin pigmentation is dominant to albinism (lack of the pigment melanin in the skin). Explain how two normal pigmented parents can produce an albino child.

3. In pea plants round seed shape is dominant to wrinkled and yellow seed color is dominant to green. Give the genotypes of the following:

   (a) True breeding round yellow seed plants

   (b) Plants with green wrinkled seeds

   (c) Plants whose seeds are wrinkled and which are heterozygous for yellow seed color.

(d) Plants whose seeds are green and which are heterozygous for round seed color

(e) Suppose a plant with green wrinkled seeds is crossed a double heterozygous plant with round yellow seeds.

(i) State the gametes a green wrinkled plant would produce.

(ii) State the ***genotype*** and gametes the double heterozygous would produce.

(iii) What phenotypes would this cross produce and in what ratios?

4. In cattle, red coat is incompletely dominant over white coat color. The intermediate type is called roan, which is a mixture of red and white hair. Give the genotypes and phenotypes (and their proportions) of a cross between two roan animals.

5. If a child is blood type O, and the mother is B, could an individual of the following blood types be the father? Explain your answer.

(a) AB

(b) B

6. Red-green color blindness is a recessive X-linked trait. A woman with normal vision whose father was color blind, married a color blind man.

(a) What are the phenotypes of their sons and daughters?

(b) Explain why the sons of a man with normal vision will not all necessarily have normal vision.