Genetics and Inheritance

Objectives
1. Students will use sampling to determine phenotypic ratios of a visible trait in corn.
2. Students will form hypotheses about genotypic and phenotypic ratios in the F2 generation by using monohybrid and dihybrid Punnett squares.
3. Students will survey themselves for heritable traits and observe dominant and recessive allele ratios.

Inherited Traits

Physical traits are observable characteristics determined by specific segments of DNA called genes. Multiple genes are grouped together to form chromosomes, which reside in the nucleus of the cell. Every cell (except eggs and sperm) in an individual's body contains two copies of each gene. This is due to the fact that both mother and father contribute a copy at the time of conception. This original genetic material is copied each time a cell divides so that all cells contain the same DNA. Genes store the information needed for the cell to assemble proteins, which eventually yield specific physical traits.

Most genes have two or more variations, called alleles. For example, the gene for hairline shape has two alleles – widow's peak or straight. An individual may inherit two identical or two different alleles from their parents. When two different alleles are present they interact in specific ways. For the traits included in this activity, the alleles interact in what is called a dominant or a recessive manner. The traits due to dominant alleles are always observed, even when a recessive allele is present. Traits due to recessive alleles are only observed when two recessive alleles are present. For example, the allele for widow's peak is dominant and the allele for straight hairline is recessive.

If an individual inherits:
- Two widow's peak alleles (both dominant), their hairline will have a peak
- One widow's peak allele (dominant) and one straight hairline allele (recessive), they will have a widow's peak
- Two straight hairline alleles (recessive), their hairline will be straight.

A widespread misconception is that traits due to dominant alleles are the most common in the population. While this is sometimes true, it is not always the case. For example, the allele for Huntington's Disease is dominant, while the allele for not developing this disorder is recessive. At most, only 1 in 20,000 people will get Huntington's; most people have two recessive, normal alleles. While a few traits are due to only one gene (and its alleles), most genetic traits are the product of interactions between several genes. When more than one gene influences a trait, the inheritance pattern is not easily predictable. The predictable patterns referred to as dominant and recessive apply only to single gene traits.

Activity I – Class Survey of Heritable Traits

Read through the list of heritable traits below. The traits listed have commonly been presented as being determined by single genes. However, it is possible that some may involve more than one gene. For each trait, determine if you have the dominant allele or the recessive allele. When finished, students will complete a chart on the board to calculate what portion of the class displays dominant and recessive forms of each trait. Use this information to complete **Table 1**.

Earlobe Attachment
If earlobes hang free, they are detached. If they attach directly to the side of the head, they are attached earlobes. Some scientists have reported that this trait is due to a single gene for which unattached earlobes is dominant and attached earlobes is recessive. Other scientists have reported that this trait is probably due to several genes. The size and appearance of the lobes are also inherited traits.

Tongue Rolling
In 1940, the famous geneticist Alfred Sturtevant noted that about 70% of people of European ancestry are able to roll up the lateral edges of the tongue, while the remaining 30% were unable to do so. Tongue rolling ability may be due to a single gene with the ability to roll the tongue a dominant trait and the lack of tongue rolling ability a recessive trait. However, there is some question about the inheritance of tongue rolling. Recent studies have shown that around 30% of identical twins do not share the trait.

Cleft Chin
This trait is reportedly due to a single gene with a cleft chin dominant and a smooth chin recessive.

Dimples
Dimples are reportedly due to a single gene with dimples dominant (people may exhibit a dimple on only one side of the face) and a lack of dimples recessive.

Handedness
Some scientists have reported that handedness is due to a single gene with right-handedness dominant and left-handedness recessive. However, other scientists have reported that the interaction of two genes is responsible for this trait.

Freckles
This trait is reportedly due to a single gene; the presence of freckles is dominant, the absence of freckles is recessive.

Naturally Curly Hair
Early geneticists reported that curly hair was dominant and straight hair was recessive. More recent studies suggest that more than one gene may be involved.

Hand Clasping
Fold your hands together by interlocking your fingers without thinking about it. Which thumb is on top – your left or your right? One study found that 55% of people place their left thumb on top (dominant), 45% place their right thumb on top (recessive), and 1% have no preference. A study of identical twins concluded that hand clasping has at least some genetic component. However, other scientists have not found evidence that genetics plays a significant role in determining this trait.

Colorblindness
Colorblindness is due to a recessive allele located on the X chromosome. Women have two X chromosomes, one of which usually carries the allele for normal color vision. Therefore, few women are colorblind. Men only have one X chromosome, so if they carry the allele for colorblindness, they will exhibit this trait. Thus, colorblindness is seen more frequently in men than in women.

Hairline Shape
Hairline shape is reportedly due to a single gene with a widow's peak dominant and a straight hairline recessive.

PTC Tasting
For some people the chemical PTC (phenylthiocarbamide) tastes very bitter. For others, it is tasteless. The ability to taste PTC shows dominant inheritance and is controlled by a gene on chromosomes 7. This gene codes for part of the bitter taste receptor in tongue cells. One of its five alleles causes a lack of ability to sense bitter tastes; the other four alleles produce intermediate to fully sensitive taste abilities. Approximately 75% of people can taste PTC while the remaining 25% cannot.

PTC-like chemicals are found in the Brassica family of vegetables, such as cabbage, brussels sprouts, and broccoli. People who can taste PTC often do not enjoy eating these vegetables, since they taste bitter to them. Non-tasters tend not to notice bitter tastes and therefore may be more likely to become addicted to nicotine, which is bitter.

Table 1. Heritable Trait Survey

Trait Type:	Are you dominant or recessive?	Portion of Class with Dominant allele	Portion of Class with Recessive allele
Earlobe Attachment			
Tongue Rolling			
Cleft Chin			
Dimples			
Handedness			
Freckles			
Curly Hair			
Hand Clasping			
Colorblindness			
Hairline Shape			
PTC Tasting			

Corn Genetics

In 1866, **Gregor Mendel** presented his findings on the inheritance of traits in garden peas. The world yawned. Today, however, his work is celebrated as the basis of modern genetics. Mendel was the first person to successfully derive the rules of genetics. He did it through careful, systematic experiments, *and* he analyzed his data mathematically. He proposed that an organism carries two "units" for each visible character but contributes only one "unit" to each of its offspring. Of course, today we know that these "units" are gene alleles, carried on two chromosomes, one inherited from each parent.

Why do we use corn? We will experiment with corn because mature corn plants produce ears that contain hundreds of seeds or kernels. Each seed/kernel is formed by the fertilization of an egg by a male gamete. Therefore, each kernel on an ear of corn can grow into a whole new plant. We count corn cobs because a single cob holds hundreds of offspring from a single parental cross.

What are we doing today? In today's exercise you will examine and count corn kernels produced from monohybrid (single gene differences) crosses. We will look at two phenotypic characters: kernel color and carbohydrate content. There are two different *alleles* for each gene: purple *vs.* yellow, and starchy (plump) *vs.* sweet (wrinkled). The results of your counting will illustrate the **Laws of Mendelian Inheritance**:

1. The Law of **Segregation**, and
2. The Law of **Independent Assortment**.

According to the law of segregation, for any particular trait, the pair of alleles of each parent separate and only one allele passes from each parent on to an offspring. According to the law of independent assortment, different pairs of alleles are passed to offspring independently of each other. The result is that new combinations of genes present in neither parent are possible. Today's exercise will demonstrate to you the two basic laws of Mendelian genetics.

Activity II – Genotypic and Phenotypic Ratios in Corn

Students should work in pairs.

1) Obtain and examine corncobs labeled **A** or **B.** The corncob bears fruit (the seeds/kernels) that are either purple or yellow in color. The color of the corn fruit is inherited in exactly the same way as the color of the flowers on Mendel's peas. The F2 generation corncob results from a cross between two heterozygous corn plants (F1). The F1 corn plants are the result of a cross between a homozygous purple fruit plant (P1) and a homozygous yellow fruit plant (P1). The allele P (purple) is dominant over the recessive allele p (yellow). The allele S (starchy & smooth) is dominant over the recessive allele s (sweet & wrinkled). Parental (P1) corn ears for each of the mutations in the experimental ears of corn are on display in the front of the room.

P1 = Parents, F1 = 1^{st} Offspring Generation, F2 = 2^{nd} Offspring Generation

2) Start HERE with "**A**" corn:
The corn A had homozygous Purple X homozygous Yellow grandparents (P1). Draw a Punnett square of the both **P1 cross** and the **F1 x F1** that was crossed with each other to produce the **F2 generation corn A** that you are examining. (*You can draw the Punnett squares where ever you have room on this page.*)

Here are the allele abbreviations to be used for the crosses:

Dominant Genes	Recessive Genes
P = Purple	**p** = yellow

Examine your F2 offspring from your F1 x F1 Punnett square:

List the **gametes** ________________________

List the **genotypes** _______________________

Describe **phenotypes** _____________________

3) Answer the questions based on your F2 offspring Punnett square:

What proportion of the fruit on your cob do you expect to be purple? ______

What proportion do you expect to be yellow? ______

4) Now, **count 100 fruits (kernels) on corn A** and record your results:

Purple _____

Yellow _____

Total 100

5) Do your results agree with the proportions you expected? ______________________

6) Start HERE with "**B**" corn:
The corn B had homozygous Starchy (smooth) X homozygous Sweet (wrinkled) grandparents (P1). Draw a Punnett square of the both **P1 cross** and the **F1 x F1** that was crossed with each other to produce the **F2 generation corn B** that you are examining. (*You can draw the Punnett squares wherever you have room on this page.*)

Here are the allele abbreviations to be used for the crosses:

Dominant Genes	Recessive Genes
S = Starchy (smooth)	**s** = sweet (wrinkled)

Examine your F2 offspring from your F1 x F1 Punnett square results:

List the **gametes** ________________________

List the **genotypes** _______________________

Describe **phenotypes** _____________________

7) Answer the questions based on your F2 offspring sPunnett square:

What proportion of the fruit on your cob do you expect to be Starchy? ______

What proportion do you expect to be sweet? ______

8) Now, **count 100 fruits (kernels) on corn B** and record your results:

Starchy _____

sweet _____

Total 100

9) Do your results agree with the proportions you expected? ___________

Questions

For each of the following questions, use the cross ***Aa X aa****. (You'll need to draw a Punnett square.)*

1. In the cross Aa X aa, what genotypes can occur in the offspring?
2. What is the probability that a given offspring will be Aa?
3. If the first offspring is aa, what are the chances that the next will also be aa?
4. What are the odds that the third will be AA?
5. Which of the above parents is homozygous?
6. Which parent displays the dominant trait?