# Mendelian Genetics in Corn Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Blk \_\_\_\_ # \_\_\_\_



*Mendelian traits* refer to phenotypical features whose pattern of inheritance follows Mendel’s theories about the inheritance of traits. Corn — a diploid organism — has been widely used to study and illustrate mendelian traits. In corn, the dominant gene R, determines the presence of colored aleurone. Individuals possessing one copy of the gene will exhibit *purple* kernels. Recessive phenotypes result in *yellow* kernels. Also in corn, a dominant gene produces the phenotype *smooth.* Smooth kernels appear hard and starchy. The recessive phenotype produces *wrinkled* kernels, which are shrunken in appearance.

In this lab, we will examine the mode of inheritance of these two genes by looking at the progeny (offspring) of a fertilization event between a male corn flower and a female corn flower. Each kernel is the progeny of one of such fertilization events. By counting the different kernel types, we should be able to determine their pattern of inheritance.

***A Brief List of Genetic Terms***

**Phenotype** is the observable character of a cell or an organism; the observable manifestation of a gene combination.

**Genotype** is the specific set of genes carried by an individual cell or organism.

In **homozygous dominant genotypes** both genes (in diploid organisms) for a trait are the same and are dominant. This individual would exhibit the **dominant phenotype.**

In **heterozygous phenotypes** the diploid organism has one dominant and one recessive gene. This individual would exhibit the **dominant phenotype.**

In **homozygous recessive phenotypes** both genes (in diploid organisms) are recessive. This individual would exhibit the **recessive phenotype.**

**Dominant** is a gene that is always phenotypically expressed —it is observable— if it is present. Dominant genes are written with an upper case letter.

**Recessive** is a gene that is only phenotypically expressed when the dominant gene is not present. Recessive genes are written with a lower case letter.

**Monohybrid cross** is a genetic cross in which only one trait is considered.

**Dihybrid cross** is a genetic cross in which two traits are studied.

**Gametes** are sex cells. Gametes are haploid, thus a gamete has only one gene for a single trait.

# PROCEDURE

## Monohybrid Crosses in Corn Kernels

***Generations***

**P,** parental generation (the parents)

**F1,** first filial generation (the kids)

**F2,** second filial generation (the kids of the kids)

1. Find a Corn Cross card showing the **Parental (P) Cross** and the **F1 generation**. Remember that each kernel represents an individual from the progeny of a single fertilization event. This F1 generation was obtained by crossing the following parents:

*Purple* (*RR*), S*mooth* (*SS*) **x** *yellow* (*rr*), *wrinkled* (*ss*)

1. Observe the F1 ear an and answer the following questions:

Which of the two colors would assume to be dominant? (check one)

* 1. *Purple*
	2. *yellow*

 Which of these alleles would you assume to be dominant? (check one)

* 1. *Smooth*
	2. *wrinkled*

1. We will use the following symbols for the ears of corn:

 *R* = *Purple*  *S* = *Smooth*

 *r* = *yellow*  *s* = *wrinkled*

### Exercise #1: F1 generation – Monohybrid Cross. We’ll focus on only one of the traits for this exercise.

1. Parents with the following genotypes were crossed: *RR* **x** *rr (refer to the card)*

1. Make a Punnett Square using these parents. Identify the possible types of offspring (**F1 generation**), and answer the following questions:

|  |  |
| --- | --- |
|   |   |
|   |   |

 How many of the F1 offspring are expected to be purple? \_\_\_\_\_

 How many of the F1 offspring are expected to be yellow? \_\_\_\_\_

 What is the F1 genotypic ratio? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

The F1 generation are all (check one)

* 1. Homozygous dominant
	2. Heterozygous
	3. Homozygous recessive

### Exercise #1: F2 generation

1. Two F1 parents are crossed: What are their genotypes? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |  |
| --- | --- |
|   |   |
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1. Make a Punnett Square using those F1 parents and determine the possible types of offspring (F2 generation).

1. Based on your Punnett Square, complete the sentences below:
	1. The F2 phenotypic ratio should be \_\_\_\_\_\_\_ *Purple*: \_\_\_\_\_ *yellow*

* 1. The F2 genotypic ratio should be \_\_\_\_\_\_ *RR* : \_\_\_\_\_ *Rr* : \_\_\_\_\_ *rr*

1. Find the ears of corn (in plastic wrap- do NOT remove!) marked **F2 generation**. Count the number of *purple* and the number of *yellow* kernels of corn in at least **four (4) complete rows** on your F2 ear of corn. Work with your lab partner and record the number below. You can use the non-permanent markers to mark each individual as you count. \*Be sure to wipe the marker off when finished.

 **Observed data**:

*Purple* kernels \_\_\_\_\_\_\_\_

*yellow* kernels \_\_\_\_\_\_\_\_

1. Write your numbers on Table 10.1, and on the board. Copy the numbers from the other groups onto Table 10.1. Calculate the phenotypic ratio of kernel color of the progeny of this observed data in this particular cross.

|  |  |  |
| --- | --- | --- |
| **Group**  | ***# Purple* kernels**  | ***# yellow* kernels**  |
| **1**  |   |   |
| **2**  |   |   |
| **3**  |   |   |
| **4**  |   |   |
| **5**  |   |   |
| **6**  |   |   |
| **7**  |   |   |
| **8**  |   |   |
| **9**  |   |   |
| **10**  |   |   |
| **11**  |   |   |
| **12**  |   |   |
| **Total #**  |   |   |
| **Phenotypic Ratio**  |   |   |

**Table 10.1.** Class data of kernel color in monohybrid cross

 6. Based on your expected predictions from the Punnett Square, the ratio of F2 phenotypes should have been **\_\_\_\_*Purple* : \_\_\_\_*yellow.***

1. What ratio did the class actually get from the observed data? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. If we had counted 5 times as many corn kernels, would we have been closer to the predicted ratio? \_\_\_\_\_\_\_\_\_\_.

Explain below:

### Exercise #2: Monohybrid Test Cross

Whether a dominant phenotype is the result of a heterozygous or a homozygous gene combination is practically impossible to determine just by simple observation. For example, in corn a purple kernel can be produced by either the *RR* or the *Rr* genotype. Recessive phenotypes are the only phenotypes that reveal the underlying gene combination. Yellow corn kernels can only be produced by the homozygous recessive genotype *rr*. Test crosses are intended to unravel the gene combination of dominant phenotypes.

1. We will determine the genotype of the parent with the dominant phenotype by looking at the phenotypes of the offspring of particular crosses. By following the next steps, we will learn the rationale behind a test cross and the information it can provide. Please write your answers in the spaces provided below:

Write the 2 possible genotypes of your *Purple* parent:

* 1. \_\_\_\_\_\_\_\_\_\_; this genotype is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* 1. \_\_\_\_\_\_\_\_\_\_; this genotype is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 Write the genotypes of your *yellow* parent:

If \_\_\_\_\_\_\_\_\_\_ is this genotype the phenotype is \_\_\_\_\_\_\_\_\_\_

1. Make Punnett Squares to determine the offspring (F1) of the two possible test crosses.

\_\_\_\_\_\_\_\_\_ **x** \_\_\_\_\_\_\_\_\_\_

|  |  |
| --- | --- |
|   |   |
|   |   |

 **OR**

 \_\_\_\_\_\_\_\_\_ **x** \_\_\_\_\_\_\_\_\_\_

|  |  |
| --- | --- |
|  |  |
|  |  |

3. What is the purpose of using the recessive phenotype (*rr*) in both crosses? **Explain:**

 4. Observe the F1 offspring on the card. Approximately, how many offspring are there? \_\_\_\_\_\_\_\_\_\_\_. List all phenotypes observed: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

 Explain the results based on the test cross Punnett Squares and probabilities.

## Dihybrid Crosses in Corn Kernels

A dihybrid cross is a cross involving two traits. In the following exercises, we will be examining the inheritance of both kernel color and endosperm texture in corn.

### Exercise #1: F1 generation

1. Refer to your card. Parents (P1) with the following homozygous genotypes for both traits were crossed in order to produce F1 offspring.

 *RRSS*  **x**  *rrss*

(*Purple, Smooth*) **x** (*yellow, wrinkled*)

**What types of gametes can each parent produce?**

*RRSS will produce:* \_\_\_\_\_\_\_\_\_\_

*rrss will produce: \_\_\_\_\_\_\_\_\_\_*

***Make a Punnett Square below of the F1 generation. Give genotypic and phenotypic ratios.***

***Suppose 2 individuals from the F1 generation are crossed. What gametes are possible for diploid individuals in the F1? \*Assume the alleles for both traits are on different (non-homologous) chromosomes and draw the possible ways they could independently assort. Show all possible gametes:***

***Cross two F1 individuals using a Punnett square, below. Determine the possible types of offspring (F2). Answer the following questions:***

|  |  |  |  |
| --- | --- | --- | --- |
|     |     |     |     |
|   |   |   |   |
|   |   |   |   |
|   |   |   |   |

How many F2 individuals are *Purple, Smooth*? \_\_\_\_\_\_\_\_\_\_ How many F2 individuals are *Purple*, *wrinkled*? \_\_\_\_\_\_\_\_\_\_ How many F2 are *yellow, Smooth*? \_\_\_\_\_\_\_\_\_\_

How many F2 are *yellow, wrinkled*? \_\_\_\_\_\_\_\_\_\_

What is the F2 phenotypic ratio of this dihybrid cross involving two parents heterozygous for both traits?

 \_\_\_\_\_ : \_\_\_\_\_ : \_\_\_\_\_ : \_\_\_\_\_

1. Find the ear of corn marked **Dihybrid Cross.**  With your lab partner, count and record the number and types of kernels in at least four (4) complete rows.

 *Purple, Smooth* kernels \_\_\_\_\_\_\_\_\_\_

 *Purple, wrinkled* kernels \_\_\_\_\_\_\_\_\_\_ *yellow, Smooth* kernels \_\_\_\_\_\_\_\_\_\_ *yellow, wrinkled* kernels \_\_\_\_\_\_\_\_\_\_

3. Write your numbers on Table 10.3, and on the board. Copy the numbers from the other groups on Table 10.3. Calculate the F2 phenotypic ratio.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Group**  | ***# Purple, Smooth* kernels**  | ***# Purple, wrinkled* kernels**  | ***# yellow, Smooth* kernels**  | ***# yellow, wrinkled* kernels**  |
| **1**  |  |  |  |  |
| **2**  |  |  |  |  |
| **3**  |  |  |  |  |
| **4**  |  |  |  |  |
| **5**  |  |  |  |  |
| **6**  |  |  |  |  |
| **7**  |  |  |  |  |
| **8**  |  |  |  |  |
| **9**  |  |  |  |  |
| **10**  |  |  |  |  |
| **11**  |  |  |  |  |
| **12**  |  |  |  |  |
| **Total #**  |  |  |  |  |
| **Phenotypic Ratio**  |  |  |  |  |

**Table 10.3.** Class data of kernel color and texture in dihybrid cross

Is the F2 phenotypic ratio similar to the expected ratio of 9:3:3:1? \_\_\_\_\_\_\_\_\_\_

Does this appear to be a Mendelian trait or non-Mendelian? Explain your answer below.



## Genetic Variation in Humans

Variation in human traits falls into two categories: *continuous* and *discontinuous.* A trait shows c*ontinuous variation* if it varies in a continuous fashion, from one extreme to another. Weight, hair color, and height are three traits that fall into this category. Traits that show *discontinuous variation* can be divided into two or more distinct categories with little intergrading between them. They are usually the expression of a single pair of genes. Several variations of this type will be illustrated in this lab exercise.

Determine your phenotype (and genotype, if possible) for as many of the human traits listed below. Record results on the board for the following traits:

1. Ability to taste PTC
2. Double-jointed thumbs.
3. Mid-digital hair.
4. Tongue rolling
5. Free or attached ear lobes
6. Widow’s Peak

***Human Genetic Traits***

1. *Ability to Taste PTC (Phenyl thiocarbamide)*

 You will be supplied with a small piece of filter paper that has been impregnated with a PTC solution. Place this paper on the tip of your tongue; if you do not obtain a characteristic and distinctive taste, chew the paper. Generally, if you are a taster, you will immediately be able to taste a very bitter taste. Even though it has been recently demonstrated complex inheritance of this trait, the ability to taste PTC is apparently controlled by a dominant gene. A taster could be either **homozygous** or **heterozygous**, while a non-taster would be **homozygous recessive**

 Taster: ***TT*** or ***Tt*** Non-Taster: ***tt***

1. *Double-jointed Thumbs*

The condition of having loose ligaments, which permits unusual movement of the thumbs, even permitting them to be bent almost completely back to the wrist and be “thrown out of joint”, is due to the presence of a dominant gene. Its **recessive allele** results in tighter ligaments and more limited thumb movement.

Double-Jointed Thumbs: ***DD*** or ***Dd***  Tight Thumbs:  ***dd***

1. *Mid-digital Hair*

The complete absence of hairs (not even one!) on the middle segment of your digits is a phenotypically recessive trait. The presence of more or fewer hairs on one or more of the middle segments may be controlled by a series of alleles, each dominant to its recessive partner. We will lump all of these together as one pair of genes.

 Mid-digital Hair present: ***MM*** or ***Mm***

 Mid-digital Hair absent ***mm***

1. *Tongue-rolling*

The majority of Americans can roll up the side margins of their tongues, so that the tongue becomes U-shaped. Tongue-rollers have one copy of the dominant gene.

 Tongue Roller: ***UU*** or ***Uu*** Non-Tongue Roller: ***uu***

1. *Ear Lobes*

Ear lobes may be attached, which means they form nearly a straight line where they intersect the side of the head, or they may be free, which means they are pendulous, or hanging down. Have your lab partner examining you, and pass judgment on your ear lobes.

 Free Ear Lobes: ***EE*** or ***Ee***  Attached Ear Lobes: ***ee***

1. *Tongue Folding*

The ability to fold the tip of the tongue upward and backward, without touching the upper teeth or the roof of the mouth is quite rare and is inherited as a phenotypically dominant trait.

 Tongue Folder: ***FF*** or ***Ff***  Non-Folder: ***ff***

1. *Darwin’s Ear Point*

The presence of a conspicuous point at the upper rim of the outer ear is inherited as a phenotypically dominant gene. It is a rare trait in the human population. It is possible that the point on only one of the two ears is the expression of the heterozygous genotype.

 Two Ear Points: ***EE***  One Ear Point: ***Ee***  No Ear Point: ***ee***

1. *Widow’s Peak*

Individuals whose hairline dips downward in front are said to have a “widow’s peak.” It is a phenotypically dominant trait.

 Widow’s Peak Present:  ***WW*** or ***Ww***  No Widow’s Peak: ***ww***

1. *Dimpled Cheeks*

The presence of dimples in the cheeks is inherited as a phenotypically dominant trait. The traits show considerable variability, with dimples sometimes in both cheeks, sometimes in only one cheek, and occasionally even two dimples in the same cheek.

Dimples: ***DD*** or ***Dd*** No Dimples: ***dd***

1. *Crooked Little Finger*

If the tip of your little finger leans toward your ring finger when extended, you have this phenotypically dominant trait.

 Crooked Little Finger: ***CC*** or ***Cc***  Straight Little Finger: ***cc***

1. *Relative Finger Length*

An interesting sex-influenced (not sex-linked) trait relates to the relative lengths of the index and ring finger. In males, the allele for a short index finger (S) is dominant. In females, it is recessive. In rare cases each hand may be different. If one or both index fingers are greater than or equal to the length of the ring finger, the **recessive genotype** is present in **males**, and the **dominant gene** present in **females**.

1. *Hitchhiker Thumb (Thumb Hyperextension)*

Although considerable variation exists in the trait, we will consider those individuals who cannot extend their thumbs backward to approximately 45° to be carrying the dominant gene, *H*. **Homozygous recessive** individuals (*hh*) can bend their thumbs at least 45°, if not farther.

Hitchhikers Thumb: ***hh*** No Hitchhikers Thumb: ***HH*** or ***Hh***

1. *Long Palmar Muscle*

Turn your arms so both palms face upward and tightly clench your left and right fist. Look at your wrists. If you see three tendons, then that arm has a long palmar muscle. If you have a long palmar muscle in both arms, you are **homozygous recessive** for that trait and your genotype is ***pp***. If you lack a long palmar muscle in either arm, your genotype is ***PP***. Presence of the trait in only one arm suggests that you are **heterozygous** for the trait, and your genotype is ***Pp***. This trait is an example of *incomplete dominance*.

1. *Interlacing Fingers*

 *Clasp your hands together.*

 Left thumb over right is phenotypically dominant.

 Right thumb over left is phenotypically recessive.

**Data and Questions**:

1. Make a chart below with your data for each of the above traits. If genotype is uncertain, use a question mark for second allele.

|  |  |  |  |
| --- | --- | --- | --- |
| Trait | Phenotype | Genotype | Dominant or Recessive? |
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2. If time allows, make a chart of the class data. **If it does not, you still must answer the 3 questions at the end of this lab.**



1. Does having a dominant allele for a trait indicate that more individuals in a population express the resulting phenotype? Justify your answer.

2. Explain how independent assortment affects phenotypic probability in offspring.

3. Explain how genes on the same chromosome might affect Mendelian ratios if they were close together and linked.