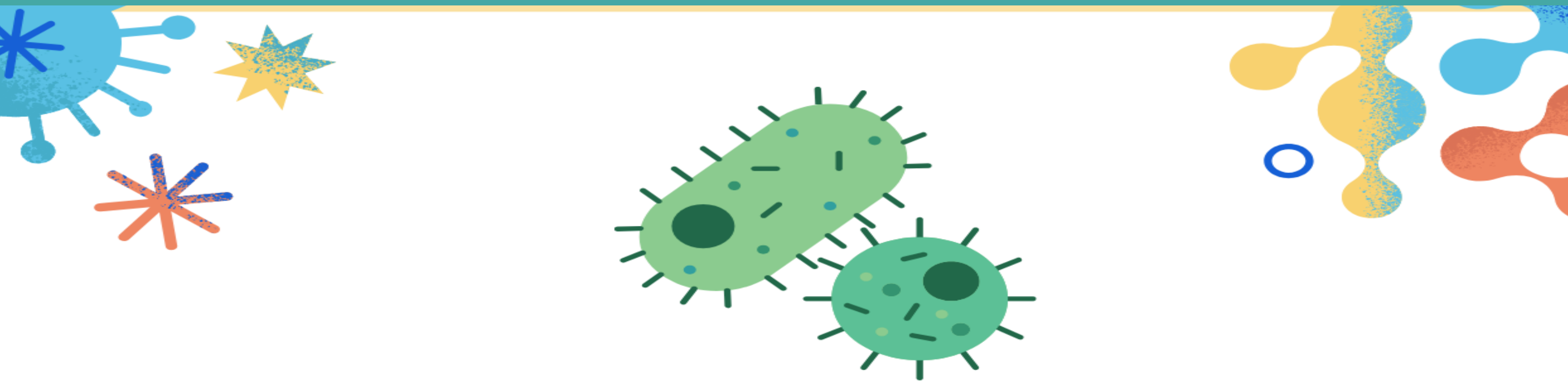
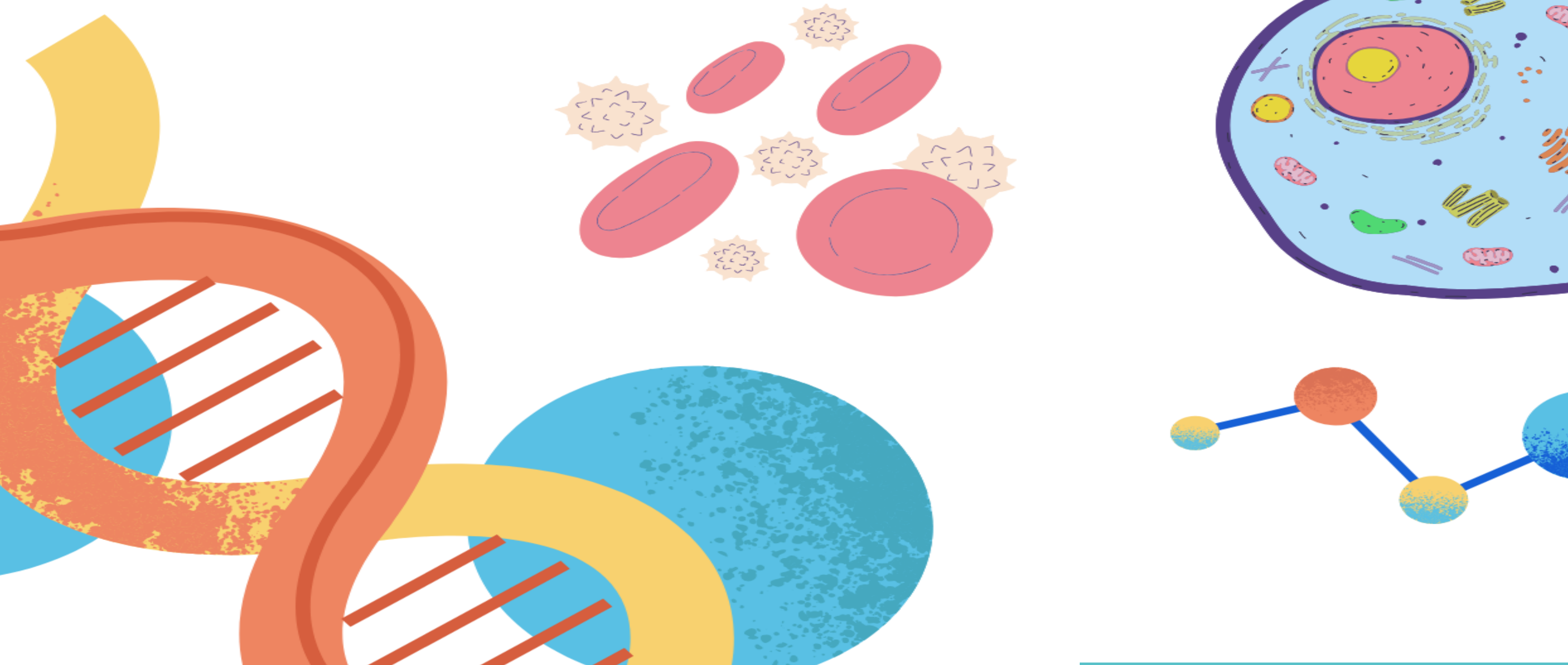


MENDELIAN GENETICS



Learning Competency/ies: Predict the phenotypic and genotypic expression of the following sample pattern of inheritance (S8LT -IVF-18)

LESSON 4: PATTERNS OF MENDELIAN GENETICS

Vocabulary Words:

Genetics - a branch of science dealing with the study of heredity and variation.

Heredity - is the transmission of traits from one generation to the next generation.

Genes - is the basic physical and functional unit of heredity. Genes are made up of DNA.

Alleles - is two contrasting traits. If the two alleles are the same, the individual is homozygous for that allele. If the alleles are different, the individual is heterozygous.

Hybrids/Heterozygous - a combination of two contrasting traits with a symbol of the capital and small letter (Xx, Yy, Rr). Homozygous - pure breeding traits and is the symbol with a capital letter (XX, YY, RR).

Dominant traits - traits that are masked/hidden and will not appear in the F1 generation during the cross.

Recessive traits - is the transmission of traits from one generation to the next generation.

Phenotype - a physical expression of the traits.

Genotype - a genotypic expression of the traits.

F1 generation - first parental generation.

F2 generation - second parental generation.

Punnet Square - a tool discovered by Reginald Punnet that was used to determine the possible combination of genes.

MENDEL'S DISCOVERY OF THE PRINCIPLE OF HEREDITY

The concept of a gene was first put forth in the late 19th century when an Augustinian monk **GREGOR JOHANN MENDEL** performed a series of breeding experiments involving a garden pea plant (Pisum sativum) using a garden in the monastery. Mendel was interested in investigating how individual traits were inherited. He wanted to find out whether both parents contribute equally to the traits of the offspring. He also wanted to know if the traits present in the offspring were produced by the blending of the traits of the parents.

MENDEL'S EXPERIMENT

Gregor Mendel did study the changes in traits of pea plants. He developed the fundamental laws of heredity. He used to study genetics in garden peas (Pisum sativum) as they are easily planted, and their pollination is easily managed. He controlled pollination by manually extracting pollen between plants. He developed true-breeding plants by self-pollination. He is known as the father of Genetics.

First: Production of pure-breeding strains of pea plants

Mendel allowed his pea plants for many generations until he gathered all the offspring that had the same features as the parents, generation after generation. The result of the cross is shown in Table 1.

Table 1: The Results of Mendel's crosses between pure-breeding pea plants

Traits	Parent 1 (P1)	First Filial Generation (F1)
Flower Position	Axial X Terminal	All Axial
Seed Shape	Round X Wrinkled	All Round
Seed Color	Green X Yellow	All Green
Seed Coat Color	Colored X White	All Colored
Pod Shape	Inflated X Constricted	All Inflated
Pod Color	Green X Yellow	All Green
Stem Length	Long X Short	All Long

Second: The crossing of two different varieties of pure-breeding strains.

When he had pure-breeding plants, Mendel began cross-pollinating peas with contrasting traits. The pure-breeding pea constituted the **parental or P1 generation.** All offspring of these crosses resembled one another. For example, when he crossed pea plants that produced purple-colored flowers with pea plants that produced white-colored flowers all the resulting offspring had purple-colored flowers. He labeled the first set of offspring **as the F1 generation of the first filial generation.**

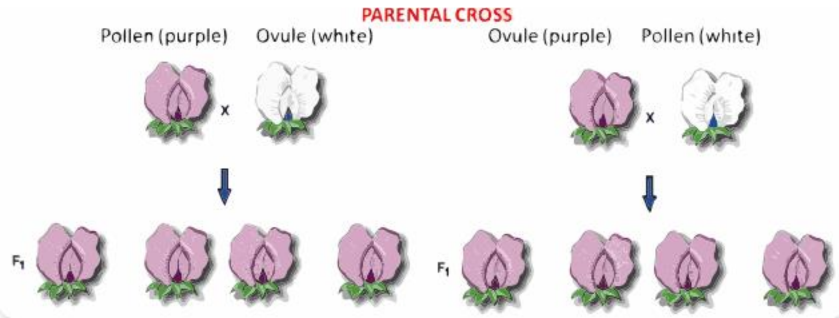


Figure 1: Cross between two different pure-breeding traits

Table 2: Results of Mendel's crosses between hybrid plants

TRAITS	F1/Hybrid	F2 Generation Produced by Self-Pollinating F1 Hybrids		Observe Ratio
Flower Position	Axial	Axial (651)	Terminal (207)	3.14:1
Seed Shape	Round	Round (5474)	Wrinkled (1850)	2.96:1
Seed Color	Yellow	Yellow (6022)	Green (2001)	3.01:1
Seed Coat Color	Colored	Colored (705)	White (224)	3.15:1
Pod Shape	Inflated	Inflated (882)	Constricted (299)	2.95:1
Pod Color	Green	Green (428)	Yellow (152)	2.82:1
Stem Length	Long	Long (787)	Short (277)	2.84:1

The offspring of the parental cross is called the first filial (F1) generation. In Mendel’s experiment, the F1 generation they called hybrids because they resulted from a cross between two pure breeding with contrasting traits. (See Figure 1). The third column shows the number of plants (offspring) resulting from the crosses. For instance, F1 plants were allowed to self-pollinate Mendel got 5474 plants for round seeds and 1850 for wrinkled seeds. The fourth column of the Table shows that in the F2 generation, the ratio of the plants with the dominant character to the plants with the recessive character.is almost 3:1 ratio.

Third: The crossing of the F1 generation

Finally, he pollinated the F1 generation. **He called this the P2 or second parental generation.** He gathered and planted seeds and when they germinated and produced flowers, **he noticed that 75% of the garden peas had purple-colored flowers and 25% had white-colored flowers.** He labeled this second set of offspring as the F2 or second filial generation. **The white flower did not appear in the F1 but appeared in the F2 in a ratio of 3:1 (See Table 2).**

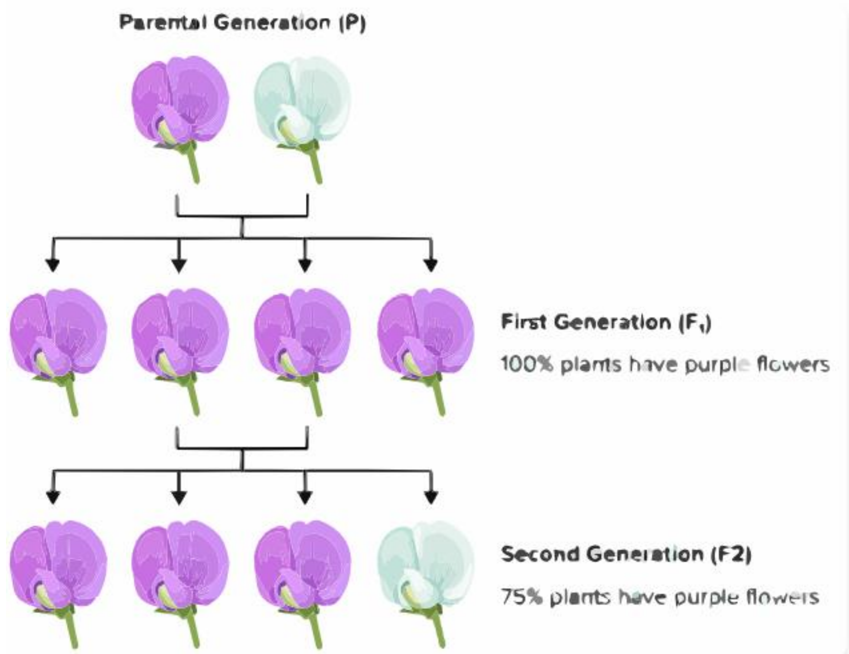


Figure 2: Cross between the offspring of F1 generation

MENDELIAN PRINCIPLES OF GENETICS

Gregor Mendel from the result of his experiment hypothesized that there each of the F1 plants must have contained **two determiners**, one for round seed and wrinkled seed. The determiner for round seed masked the determiner for wrinkled seed. This **unit of determiner** now called **genes**. Since there are **two alternative expressions of a trait** (round and wrinkled) he also hypothesized that traits were regulated by a **pair of "factors" now called alleles**. With these findings, Gregor Mendel was able to formulate the three principles of heredity.

Gregor Mendel conceived the idea of heredity units, which he called hereditary "factors". Mendel found that there are alternative forms of factors currently called genes that account for variations in inherited characteristics.

1. Law of Dominance - states that in every organism, there is a pair of factors or genes that control the appearance of a particular trait. One of the pair of genes/alleles may hide or prevent the appearance of the other. One allele is a dominant trait, while the other is a recessive trait. The dominant traits hide or mask the appearance of the recessive trait. The dominant trait is represented by a big letter and a small letter for the recessive trait. (See Table 3).

Example:

R for round seed (dominant trait), r for wrinkled seed (recessive trait)

G for the green pod (dominant trait), g for the yellow pod (recessive trait).

Table 3. Dominant and Recessive traits in Pisum sativum (Garden Pea)

Character Studied	**Dominant**	**Recessive**
Flower Position	Axial (AA)	Terminal (aa)
Seed shape	Round (RR)	Wrinkled (rr)
Seed color	Yellow (YY)	Green (yy)
Seed coat color	Colored (CC)	White (cc)
Pod shape	Inflated (II)	Constricted (ii)
Pod color	Green (GG)	Yellow (gg)
Stem length	Long (SS)	Short (ss)

Note that in a particular trait, the same letter will be used for both the dominant and recessive traits. Since genes are in pairs, the **pure-breeding** green seed peas will be represented with letters **GG** and the pure-breeding yellow seed peas gg. There are pairs of alleles that are **identical and are called homozygous or homozygote** while the pair of alleles that are **not identical are called heterozygous or heterozygote**. Each one of us has genes or alleles that are either homozygous or heterozygous.

Example:

RR - homozygous genes for round seed

Rr - heterozygous genes round seed

The pair of genes or alleles is the **genetic makeup** for a particular trait of an organism called **genotype** while the **phenotype** is the **observable trait, or the visible trait** of an organism based on the genotype (See Table 4).

Table 4: Genotype and Phenotype of Pea Plant

Genotype	Description of the Alleles of Genes	Phenotype
RR	Homozygous dominant for round seeds	Round Seed
Rr	Heterozygous genes round seeds	Round seed

2. Law of Segregation - – states the pair of genes segregate or separate from each other during gamete formation. Gregor Mendel argued that for any trait, an organism must inherit one factor from the sperm and one factor from the egg. Thus, a new organism receives one factor for each trait from each parent. (See Figures 3, 6, 7).

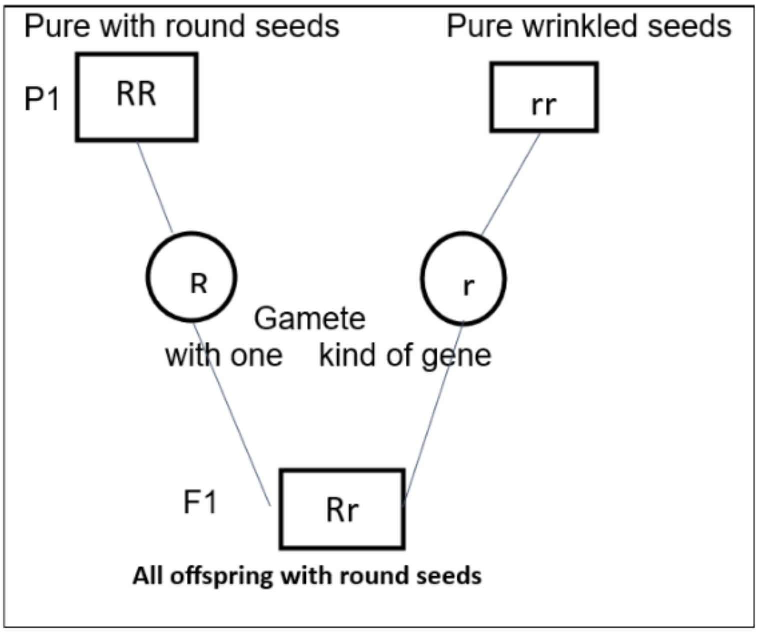


Figure 3: Cross between one trait showing the Law of Segregation

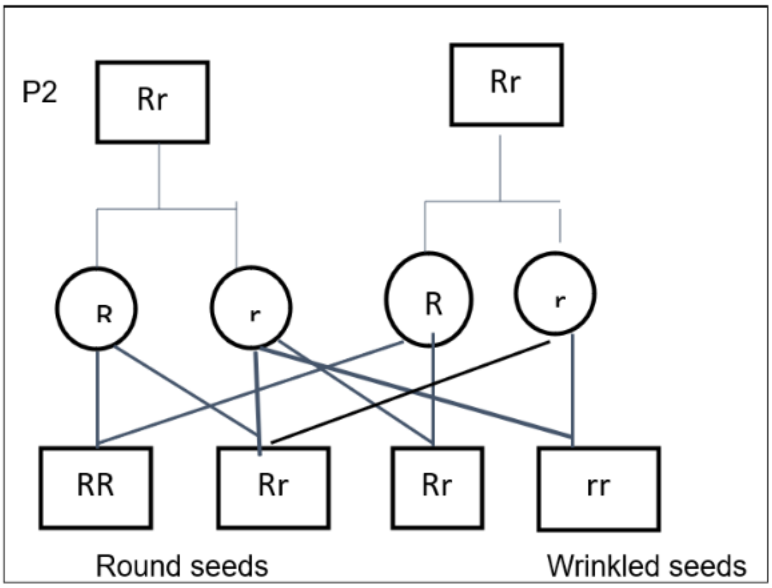


Figure 4: The result of crossing pure-breeding round and wrinkled seed

3. Law of Independent Assortment - states that the distribution or assortment of one pair of factors is independent of the distribution of the other pair. Traits are inherited independent of each other. The law applies to genes that are found on separate chromosomes. Thus, one pair of genes is not affected by the other pair.

Dihybrid Cross

Aside from Gregor Mendel's study on the inheritance of one pair of genes or alleles, he also studied the inheritance of two pairs of genes or alleles. A cross that involves two pairs of genes or alleles is called a dihybrid cross. An easy way to do the dihybrid cross is through the use of **Punnett square.**

Example:

RRYY (Round, Yellow Seed) X **rryy** (Wrinkled, Green Seed)

Punnett Square

Reginald C. Punnett devised the Punnett square. This is a simple way to determine the possible combinations of genes in a given cross. It can help you predict easily the outcome of a given cross.

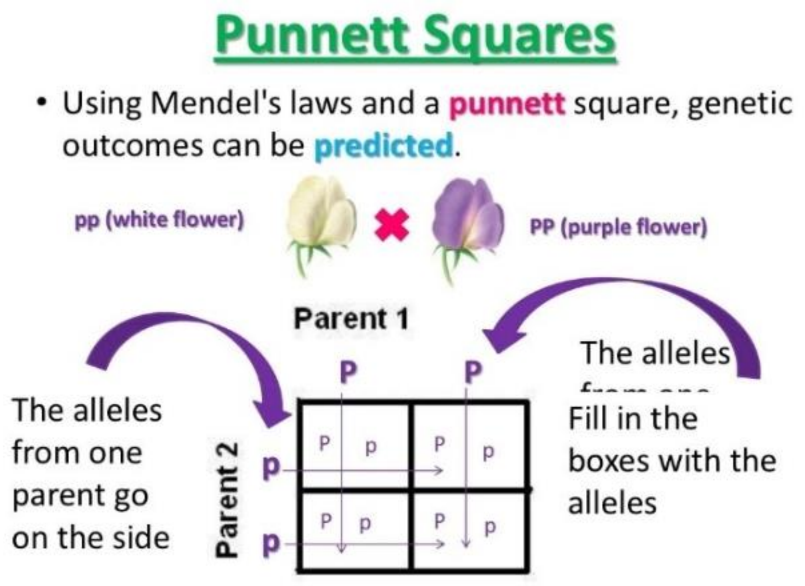


Figure 5: Showing how to use the Punnet Square with Monohybrid cross

How to Make a Punnett Square

1. Make a square and divide it into 4 boxes for a monohybrid cross and 16 boxes for a dihybrid cross.
2. The letters of the possible genes for a trait from the female (♀) are written down on the left side.
3. The letters of the possible genes for the same trait from the male (♂) are written across the top of the square.
4. Place the phenotype of the offspring in the square.

Example Illustration

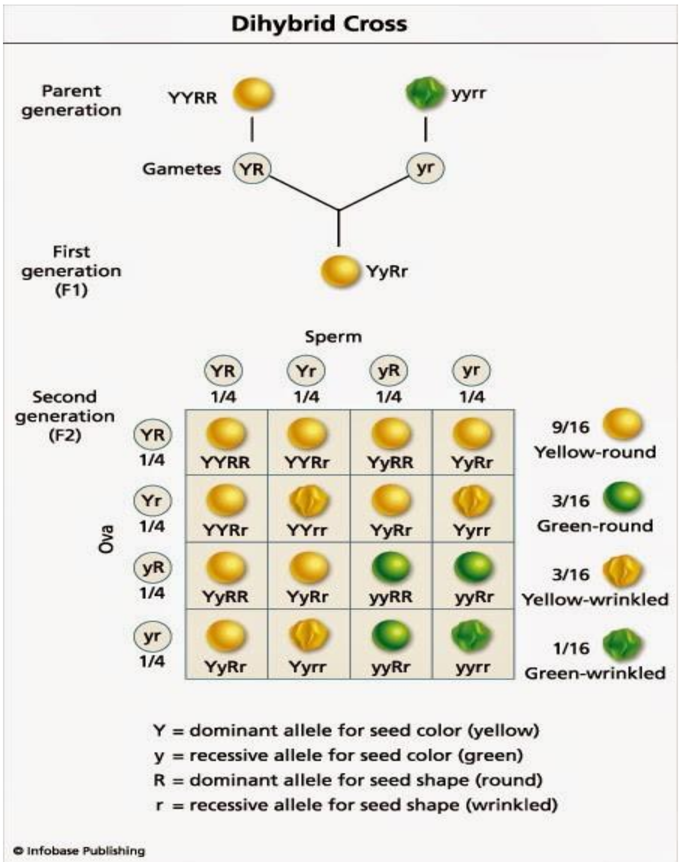
A - Axial **Aa X Aa**
a - Terminal

5. Lastly, interpret the result.

Result of the sample illustration:

- There are 4 offspring produced from crossing both hybrid axial flowers: Aa x Aa.
- Their genotypes are:
  - 1 AA - homozygous axial flower
  - 2 Aa - heterozygous axial flowers
  - 1 aa - homozygous terminal flower
- The genotypic ratio: 1:2:1
- Their phenotypes are:
  - 3 axial flowers, 1 terminal flower
- The phenotypic ratio: 3:1

Example 1: Dihybrid Cross using the Punnett Square:



Result:

There are 16 offspring from the cross of both hybrid/heterozygous round, yellow-seed pea plants.

- The **Genotypes**:
    - 1 RRYy - homozygous round, yellow seed
    - 2 RRYy - homozygous round, heterozygous yellow seed
    - 1 RRyy - homozygous round, green seed
    - 2 RrYY - heterozygous round, homozygous yellow seed
    - 4 RrYy - heterozygous round, yellow seed
    - 2 Rryy - heterozygous round, green seed
    - 1 rrYY - homozygous wrinkled, yellow seed
    - 2 rrYy - homozygous wrinkled, heterozygous yellow seed
    - 1 rryy - homozygous wrinkled, green seed

Genotypic ratio: **1:2:1:2:4:2:1:2:1**

Figure 6: Showing the Dihybrid Cross

The Phenotype:

- 9 round yellow
- 3 wrinkled yellow
- 3 round green
- 1 wrinkled green

Phenotypic ratio: **9:3:3:1**

II. PERFORMANCE TASK

Worksheet 1: What Am I?

Direction: Identify whether Genotype: Homozygous Dominant or Recessive, Genotype or Phenotype the following items. Write your answer in the blank provided.

A. Homozygous Dominant or Recessive/ Heterozygous	B. Phenotype vs. Genotype
1. YY ______________________	1. Tall ____________________
2. yyss ____________________	2. RRss ____________________
3. RrYY ____________________	3. Long and axial ____________
4. SSss ____________________	4. CC ______________________
5. ttRy ____________________	5. short and green __________

C. For each of the genotype below, determine what phenotype were possible to produce.

Yellow (YY) Flower are dominant to white (yy)	**Brown eyes are dominant to blue**
YY ________________________	BB ___________________________
Yy ________________________	Bb ___________________________
Yy ________________________	bb ___________________________
Round seeds are dominant to wrinkled	**Curly are recessive to straight hairZS**
RR ______________________	CC ______________________
Rr ______________________	Cc ______________________
Rr ______________________	cc ______________________

For each of the phenotype below, write the genotype (remember that capital letter for the dominant trait.

Long hair is dominant to short hair	Fair complexion is dominant over brown
Short ________________________	Fair ___________________________
Long _________________________	Fair ___________________________
Long _________________________	Brown __________________________

Worksheet 2: Complete "D"

Direction: Let D =dominant allele and d =recessive while DD, Dd, and dd represent the homozygous dominant, heterozygous dominant, and homozygous recessive phenotype. For each type of cross, determine the genotypic and phenotypic ratios, respectively. The first cross is already done for you.

CROSS	Genotypic Ratio	Phenotypic Ratio
1. DD X DD	100% DD	100% dominant
2. DD X Dd		
3. DD x dd		
4. Dd X Dd		
5. Dd X dd		
6. dd x dd		

Worksheet 3: SOLVING PROBLEM: Monohybrid Cross Using the Punnett Square

Directions: Read the situation and answer the questions that follow.
Write your answers on a separate sheet of paper.

Situation:

A homozygous red Santan flower (RR) is crossed with a homozygous pink Santan flower (rr).

Tasks:

1. Show the given cross using the Punnett square.
2. Write the genotypes and phenotypes of the resulting offspring.

	R	R
r		
r		

Genotype:

Phenotype

Situation:

A purple (P) gene for flower is dominant and is crossed over the white flower (p). Determine the genotypic and phenotypic ratio of the offspring. Use a punnet square to solve the problem.

Tasks:

1. Show the given cross using the Punnett square.
2. Write the genotypes and phenotypes of the resulting offspring.

Genotype:

Phenotype

Situation:

A homozygous Curly hair (C) is crossed with a recessive straight hair (c).

Tasks:

1. Show the given cross using the Punnett square.
2. Write the genotypes and phenotypes of the resulting offspring.

Genotype:

Phenotype

Worksheet 4: Dihybrid Cross Using the Punnett Square

Directions: Show the dihybrid cross of both hybrid/heterozygous tall, green mango (TtGg) by filling up the blank boxes in the Punnett square and answering the questions that follow.

	T G	T g	t G	t g
T G				
T g				
t G				
t g				

Questions:

1. Count the number of:

Tall green Mango: ___________

Short yellow Mango: ___________

Tall yellow Mango: ___________

Short green Mango: ___________

2. Write the phenotypic ratio.

Phenotypic ratio: ___________

Worksheet 5: Dihybrid Cross Using the Punnett Square

Directions: Given the cross RrYy x RrYy

R- round

R -wrinkled

Y- yellow

y- green

Questions:

1. Count the number of:

Round yellow seeds: ____________

Round green seeds: ____________

Wrinkled yellow seeds: ____________

Wrinkled green seeds: ____________

2. What proportion of the offspring will have the following genotype: RY, Ry, rY, ry?

3. How many kinds of genotypes will the offspring have?

III. WRITTEN WORKS: (ASSESSMENT)

Direction: Read and understand each question, then choose the correct answer. Write the letter of your choice on a box before each number.

1. What does the word “inherit” mean?

   A. The passage of the heredity material DNA to offspring.
   B. To pass characteristics through the transmission of heredity material known as DNA
   C. To receive a characteristic through the transfusion of heredity material, known as DNA
   D. To receive characteristics through the transfusion of heredity material, known as DNA

2. Which does not describe Gregor Mendel?

   A. An Austrian Monk
   C. Father of Genetics
   B. Author of Punnet Square
   D. Proponent of Law of Dominance

3. Which pair of letters represents a pure line dominant trait?

   A. CC B. Ee C. Gg D. tt

4. Purebred Organisms, also called __________.

   A. Homozygous
   C. Dominant
   C. Heterozygous
   D. Recessive heterozygous

5. Describe someone who is heterozygous for a trait.

   A. Two of the same alleles for a particular trait
   B. Two different alleles for a particular trait
   C. One of the same alleles for a particular trait
   D. One different allele for a particular trait

6. A plant with a flower position (aa) is crossed with a heterozygous plant. What percentage of their offspring have axial flower position?

   A. 25% B. 50% C. 75% D. 100%

7. If a constricted pod pea plant is crossed with one that is heterozygous how many of its offspring will also be constricted pod?

   A. 1:1 B. 2:2 C. 1:3 D. 1:4

8. How would you differentiate genotype from phenotype?

   A. Genotype are the genetic makeup while phenotypes are physical traits.
   B. Genotypes are physical traits while phenotypes are the genetic makeup.
   B. Genotypes are physical character traits
   D. Phenotypes are the genetic traits.

9. Which refers to the offspring resulting from cross-between parents with two contrasting traits?

   A. Hybrids
   C. Multiple Allele
   B. Crossbred
   D. Purebred

10. Which of the following statements is true regarding the “law of segregation**”?**

   A. Law of segregation is the law of purity of genes
   B. Alleles separate from each other during gametogenesis
   C. Segregation of factors is due to the segregation of chromosomes during meiosis
   D. All of the above

Identification: Write the correct term to describe each statement.

1. The Law of _______ states that one member of the pair of factors or genes may mask or hide the appearance of the other genes

2. Similar alleles are called _______ while dissimilar alleles are called heterozygous.

3. The Law of _______ states that during gamete formation, the all pairs of genes for all traits of an organism separate from each other.

4. The Law of _______ states that the distribution of one pair of genes is independent of the distribution of the other pair.

5. The _______ is a diagram that allows us to determine the possible combinations of genes in a given cross.