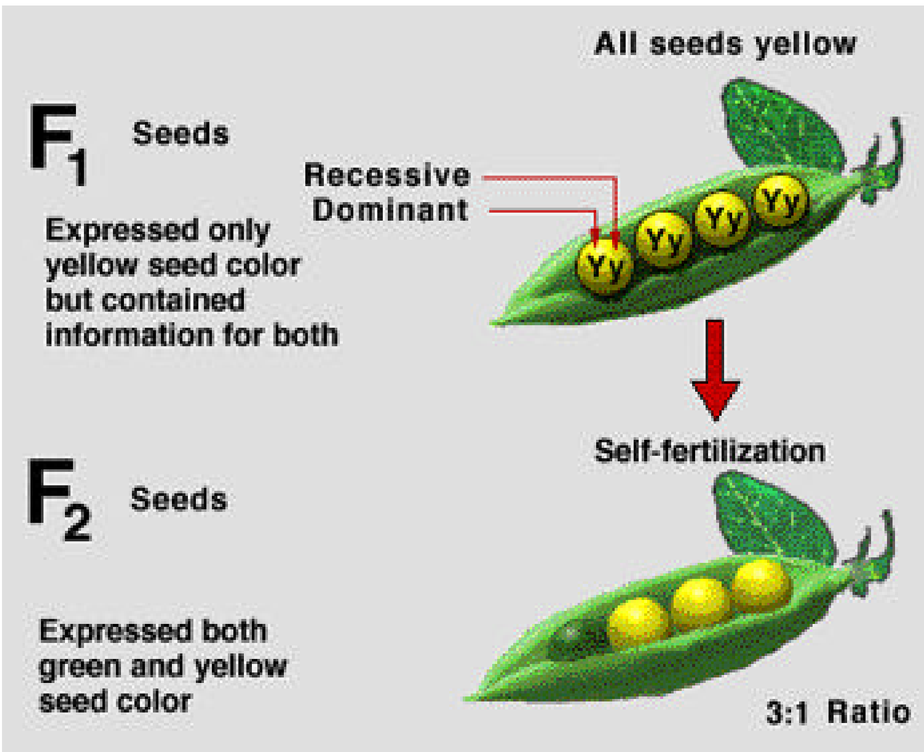
Interactive Biology Multimedia Courseware



# Mendel's Principles of Heredity
## Program Supplement



## Mendel's Principles of Heredity
## TEACHING OBJECTIVES

The following subject areas are illustrated throughout the Interactive Biology Multimedia Courseware program, *Mendel's Principles of Heredity.* Ideally, these areas would be augmented with additional course work outside of this program. *(Click on a subject to jump ahead.)*

- **A historical look at the life of Gregor Mendel.**
- **An overview of Mendel's experiments, including an introduction to the concepts of pure breeding plants, self-fertilization, cross-fertilization, parental generation (P), and first filial generation ($F_1$).**
- **A detailed look at Mendel's experiments, including an introduction to the concepts of dominant and recessive traits, the 3:1 ratio, and Mendel's Law of Dominance.**
- **A look at the experiments and reasoning leading up to the formation of Mendel's Law of Segregation.**
- **A look at the modern terminology behind Mendel's Law of Segregation, including homozygote, heterozygote, gene, allele, genotype, and phenotype.**
- **An examination of Mendel's dihybrid crosses and the 9:3:3:1 ratios that confirmed his Law of Independent Assortment.**

## Study Guide #1
## GREGOR MENDEL

Have you ever wondered why children resemble their parents, or why siblings resemble each other? Why do certain traits, such as red hair, run in families?

Today, we know that heredity is responsible for the specific characteristics possessed by offspring. For hundreds of years, man has used a basic understanding of hereditary influences to selectively breed certain traits into livestock. For instance, cows that produced the most milk would be selectively bred to ensure that the next generation of cows would also produce large amounts of milk.

Although man was able to take advantage of his rudimentary knowledge of heredity, the underlying principles involved were not understood for many years. It was not until the mid-1800's that these principles were investigated and understood by Gregor Mendel, a European monk who became known as the Father of Genetics.

Mendel was born in a small town in what is now the Czech Republic. His family was poor and, with little money to spare on education, Mendel chose to join a Gregorian monastery that was involved in scientific research. Here, he was given the opportunity to study such subjects as physics, chemistry, botany, plant physiology, and mathematics.

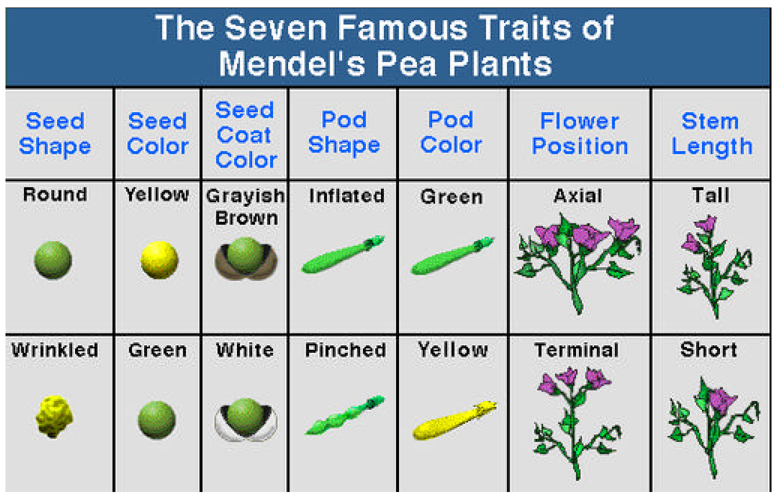

After completing his formal education, Mendel began a series of experiments in the garden of his monastery. These experiments were conducted on pea plants, and would lead him to a basic understanding of the mechanisms of heredity.

## Study Guide #2
## OVERVIEW OF MENDEL'S EXPERIMENTS

Mendel's meticulously controlled experiments were conducted on pure breeding pea plants. This means that a trait seen in the parents will always be seen in their offspring. For instance, if the parent plants have round, yellow seeds, then all of their offspring will have round, yellow seeds as well.

Mendel was able to follow traits between generations because pea plants are capable of self-fertilization. This means their flowers have both male and female reproductive parts and are therefore able to produce both male and female gametes. These gametes are able to come together and form a new, viable pea plant. In this process, also known as self-pollination in plants, the offspring of pure breeding plants will look like the parent plant.

In addition to letting plants self fertilize, Mendel was able to cross breed certain plants. He accomplished this by cutting off the male parts, or stamens, in order to prevent these plants from self-fertilizing. Next, he would pollinate that plant with pollen provided from the stamen of another plant with different traits. The resulting seeds were then planted to see what traits would be expressed, or seen, in the next generation.



The Seven Famous Traits of Mendel's Pea Plants

| Seed Shape | Seed Color | Seed Coat Color | Pod Shape | Pod Color | Flower Position | Stem Length |
|---|---|---|---|---|---|---|
| Round | Yellow | Grayish Brown | Inflated | Green | Axial | Tall |
| Wrinkled | Green | White | Pinched | Yellow | Terminal | Short |

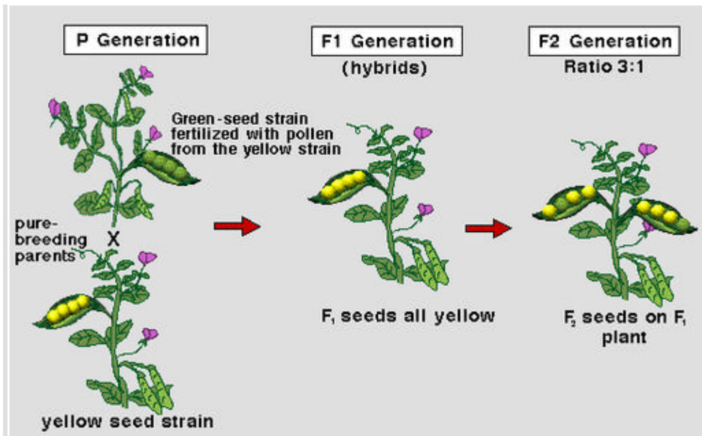
In his experiments, Mendel was careful to choose only traits that were easily detected in mature plants. These seven traits were seed shape, seed color, seed coat color, pod shape, pod color, flower position, and stem length.

Mendel began his studies by crossing two pure breeding plants with opposite traits. For example, in an experiment involving the inheritance of seed color, Mendel would cross a pure breeding yellow seed strain with a pure breeding green seed strain and observe the seed color in the offspring. The plants in this first cross were known as the "P", for parental, generation. The generation of plants that arose from this breeding is known as the "$F_1$" generation. F stands for filial, which means offspring.

After conducting much selected breeding and using his background in mathematics, Mendel was able to see order in the inheritance patterns that emerged. In the next study guide, we will explore these crossings in detail.

## Study Guide #3
## MENDEL'S LAW OF DOMINANCE

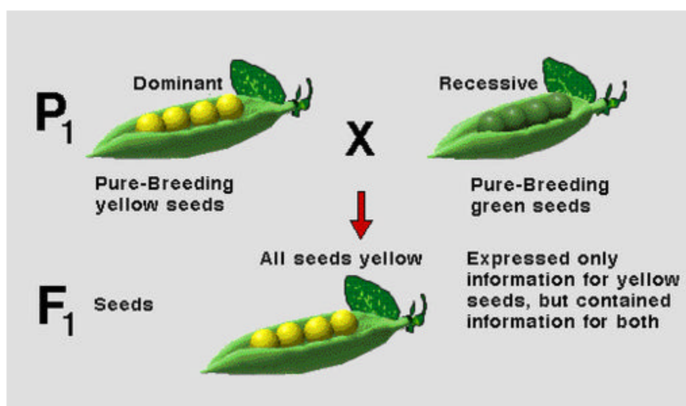
When we ended Study Guide #2, Mendel was looking at the inheritance of seed color. The parents, or P generation, consisted of pure breeding yellow seed plants and pure breeding green seed plants. Offspring of two pure breeding plants with different characteristics are called hybrids. Mendel examined the seed color of the hybrid offspring of the $F_1$ generation. You might suspect that some seeds were yellow and some were green. Mendel found that this was not the case.

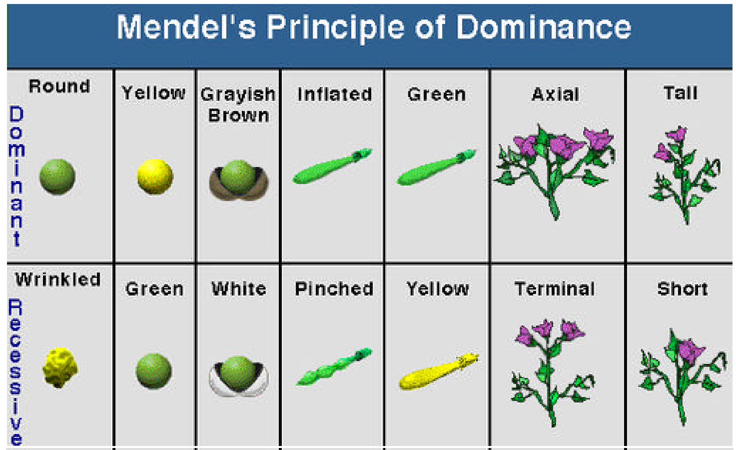



What color seeds did Mendel find? In this cross, Mendel discovered that **all** of the seeds in the $F_1$ generation were yellow. He then allowed these hybrid plants of the $F_1$ generation to self fertilize and looked at the color of seeds in the next, or $F_2$, generation.

In the $F_2$ generation, Mendel found both yellow and green seeds. The ratio of yellow seed producing plants to green seed producing plants in this generation was 3:1. This means that for every three yellow seed producing plants Mendel found he also found one green seed producing plant. But how did this occur if all of the plants in the $F_1$ generation had yellow seeds?

Mendel reasoned that the $F_1$ generation carried the information to produce green seeds even though they did not express this trait. The information for green seeds, which must have come from the P generation plants, had been hidden in the $F_1$ generation. He hypothesized that the trait for yellow seeds is dominant to the trait for green seeds. Mendel called a trait (in this case green seeds) that could be masked by another competing trait (in this case yellow seeds) a recessive trait.






Mendel performed many other crosses, comparing two competing traits in each cross. For all seven of the characteristics examined (such as seed color or seed shape), he found one trait to be dominant over the other (such as yellow color and round seed shape). In cases involving a cross breeding of two pure plants for these competing traits, the $F_1$ generation would be made up entirely of plants expressing the dominant trait. In the $F_2$ generation, the recessive trait would reappear in one quarter of the plants while three quarters of the plants possessed the dominant trait. These results provided the foundation for Mendel's Law of Dominance.

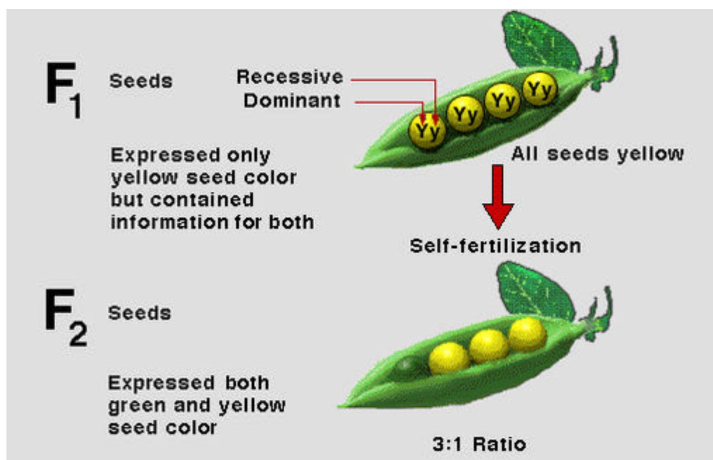
Law of Dominance: If one trait is dominant to a second competing trait, the dominant trait will be expressed, therefore masking the presence of the recessive trait.

## Study Guide #4
## INTRODUCTION TO MENDEL'S LAW OF SEGREGATION

Why were the recessive traits seen again in the $F_2$ generation and why were they always found in the same 3:1 ratio? In answering these questions, Mendel developed his Law of Segregation.

Mendel hypothesized correctly that every pea plant must posses one pair of factors for each of the seven traits he was observing. He concluded that one factor was the dominant factor, and the other factor was the recessive factor. The pure breeding yellow seed plants possessed two copies of the dominant factor, and therefore the seeds were always yellow. The pure breeding green seed plant, on the other hand, possessed two copies of the recessive factor, and the seeds were always green.

Mendel assigned uppercase and lowercase versions of the same letter to symbolize the dominant and recessive versions of each factor. For instance, he assigned a capital "Y" to represent the dominant factor for seed color and a small "y" to represent the recessive factor for seed color. The pure breeding plants of the P generation were therefore either YY (two copies of the dominant factor) and yellow, or yy (two copies of the recessive factor) and green. As long as these plants were allowed to self-fertilize, the offspring would look identical to the parents for generation after generation.




So what happened when the cross-fertilization was performed? Why were these plants always yellow? In this case, the offspring ($F_1$ generation) were receiving seed color factors from two pure parents with different traits. The pure breeding yellow seed plants passed on only dominant (Y) factors to the $F_1$ generation. The pure breeding green seed plants passed on only recessive (y) factors to the $F_1$ generation. Since each plant in the $F_1$ generation received one factor from each parent, these plants all had one dominant factor and one recessive factor. Therefore, the $F_1$ plants were either Yy or yY. Since Y is dominant to y, all of these plants will have yellow seeds. Mendel concluded that seed color depended upon whether a dominant factor was present or not.

So what happened when the $F_1$ generation was allowed to self fertilize? Why were both green seeds and yellow seeds found in the $F_2$ generation? Remember, when a plant self fertilizes, its own pollen fertilizes its own egg cells to produce another plant. Each pollen cell and each egg cell carries one copy of the factor determining seed color. Since all plants in the $F_1$ generation had one copy of each color-determining factor (all plants were Yy), each pollen cell and each egg cell carried either the dominant Y factor or the recessive y factor. There are then four possible combinations in which the factors can come together:

1) Y pollen can fertilize Y egg cell (result, YY) (result, yellow seeds) (result = YY, yellow seeds)
2) y pollen can fertilize Y egg cell (result, yY) (result, yellow seeds) (result = yY, yellow seeds)
3) Y pollen can fertilize y egg cell (result, Yy) (result, yellow seeds) (result = Yy, yellow seeds)
4) y pollen can fertilize y egg cell (result, yy) (result, green seeds) (result = yy, yellow seeds)

As far as determining color is concerned, Yy is the same as yY. These Yy or yY plants all carry one dominant factor and will all have yellow seeds. The YY plants have two dominant factors and will all have yellow seeds as well. Some plants in this generation, however, will not receive a copy of the dominant factor. These yy plants will have green seeds.

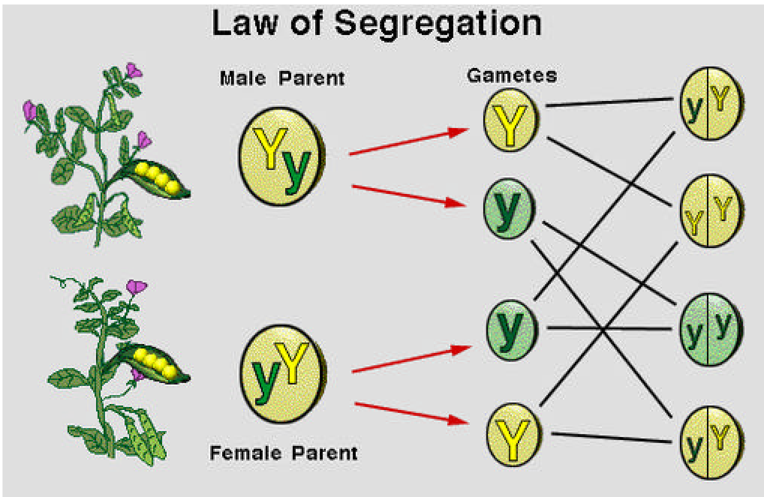
If each of these four combinations (YY, Yy, yY, and yy) have an equal chance of occurring, then you should find one plant with green seeds for every three plants with yellow seeds in the $F_2$ generation. This seed color ratio of 3:1 is exactly what Mendel observed.

## Study Guide #5
## MODERN LOOK AT MENDEL'S LAW OF SEGREGATION

Modern geneticists know that the traits or factors Mendel observed were actually genes. Different forms of the same gene are known as alleles. In this terminology, Y would represent a dominant allele coding for yellow seed color and y would represent a recessive allele coding for green seed color.

Geneticists have given names to certain pairings of alleles. If an organism carries two copies of the same allele, then it is called homozygous for that trait. The two homozygous possibilities for seed color are YY and yy. If an organism carries two different alleles, then it is called heterozygous for that trait. The two heterozygous possibilities for seed color are Yy and yY.

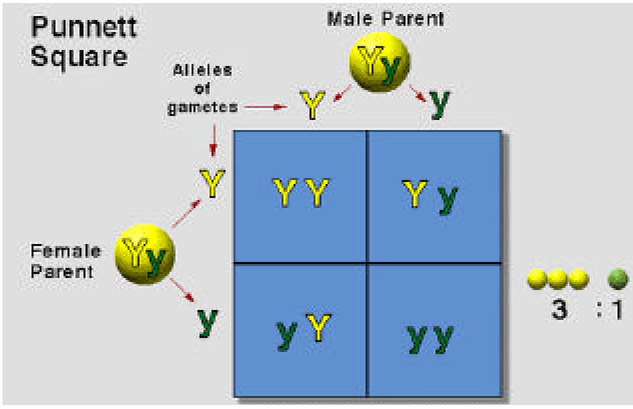
When geneticists refer to the physical characteristics of an organism, such as seed color, height, or flower position, they are referring to the organism's phenotype. Phenotype refers to the physical appearance of a trait or traits of an organism. When geneticists refer to the alleles carried by an organism, they are referring to its genotype. Genotype refers to the gene or genes that are responsible for the traits of an organism.




Continuing to use seed color as our example, how many different genotypes are there for the phenotype of green seeds? Remember that green seed color is a recessive trait requiring two recessive alleles. The only possible genotype for these plants is yy. How many different genotypes are there for the phenotype of yellow seeds? Remember, yellow seed color is determined by the possession of at least one dominant allele. There are three possible genotypes for these plants: YY, Yy, and yY.

To fully understand Mendel's Law of Segregation, we must examine the process of meiosis. Meiosis is the production of sex cells. Each sex cell contains one-half of the genetic material found in normal cells. For example, your skin cells and muscle cells contain the normal amount of genetic material. Your father's sperm cell and your mother's egg cell initially provided this genetic material. Each of these sex cells carried half of your total genetic material, so that when they united, the proper amount of genetic material was established. In other words, each parent sex cell carries half of the alleles to be passed to their offspring.

In the production of gametes (sex cells), cells have the amount of their genetic material reduced by one-half. In other words, one cell containing a pair of alleles becomes a pair of cells, each containing one allele. The alleles from a single cell have become segregated in different sex cells. This event, the segregation of alleles, is covered by Mendel's Law of Segregation and takes place during meiosis.




Once the alleles have been segregated into different sex cells, they are ready to be paired with other alleles after fertilization takes place. Mendel was able to predict how frequently certain phenotypes would appear. He accomplished this with the use of punnett squares, which make predictions based upon probabilities. That is, if you know the probability of two different alleles coming together then you can predict how frequently a specific phenotype will appear. By using a punnett square to predict seed color after a heterozygote cross for example, we see that the probability of two y alleles coming together is 1 out of 4. Using this information, we predict that 25% (1 out of 4) of the offspring in the next generation will have the genotype yy and, therefore, will have green seeds. Punnett squares were very useful when Mendel moved on to the next portion of his experiments, which were dihybrid crosses.

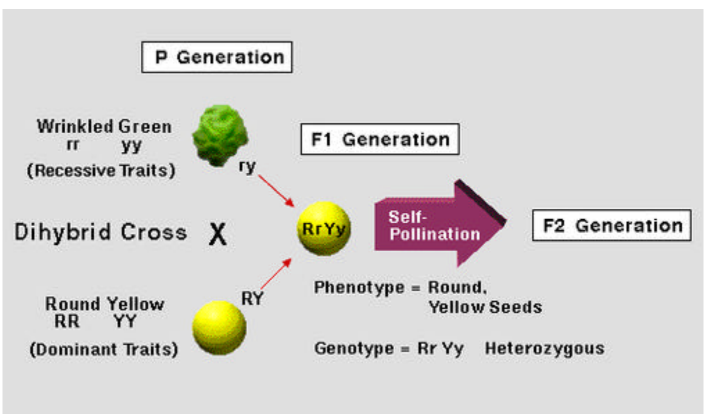
Law of Segregation: During gamete formation, allele pairs become separated and then randomly recombine into pairs at fertilization

## Study Guide #6
## DIHYBRID CROSSES AND MENDEL'S LAW OF INDEPENDENT ASSORTMENT

Mendel was also curious about how different traits are inherited relative to one another. For instance, does the inheritance of seed color affect the inheritance of seed shape? To answer this question, Mendel performed dihybrid crosses.

Dihybrid crosses are crosses between two plants that are heterozygous for two distinct traits. In other words, these plants carried one dominant and one recessive copy of the alleles for seed color (Y and y), as well as one dominant and one recessive copy of the alleles for seed shape (R and r). These dihybrids were therefore Yy, Rr.

To produce his dihybrids, Mendel crossed pure breeding plants with yellow, round seeds (YY, RR) and pure breeding plants with green, wrinkled seeds (yy, rr). The resulting plants in the $F_1$ generation were all double heterozygotes, or heterozygous for both seed color and seed shape (Yy, Rr).




The $F_1$ generation was then allowed to self fertilize and Mendel observed the $F_2$ generation's seeds. If these traits did not affect each other, that is if seed color had absolutely no affect on seed shape and if seed shape had absolutely no affect on seed color, then these traits must undergo independent assortment. That is, using today's terminology, the packaging of a seed color allele into a sex cell during meiosis has no affect on the packaging of a seed shape allele in that same sex cell. Mendel suspected that alleles were assorted into gametes independently of one another.

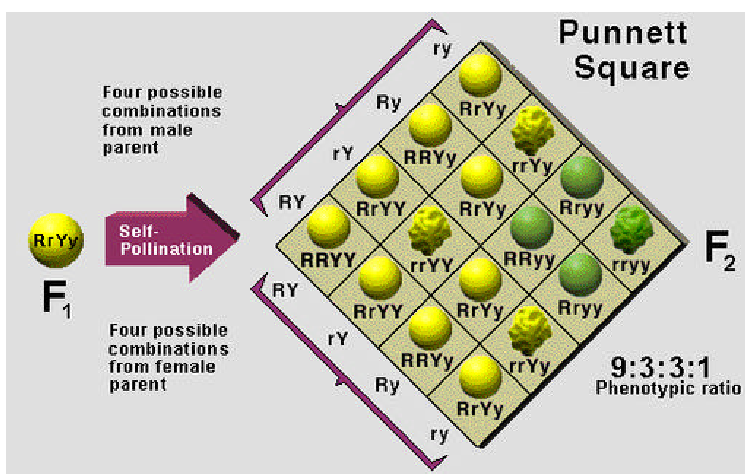
After constructing a punnett square for this dihybrid cross, Mendel knew there were 16 different genotypic combinations that could result, and from these he calculated his expected number of phenotypes. These were:

| **Genotypes** | **Phenotypes** |
|---|---|
| 1) YY, RR | yellow, round |
| 2) YY, Rr | yellow, round |
| 3) Yy, RR | yellow, round |
| 4) Yy, Rr | yellow, round |
| 5) YY, Rr | yellow, round |
| 6) YY, rr | yellow, wrinkled |
| 7) Yy, Rr | yellow, round |
| 8) Yy, rr | yellow, wrinkled |
| 9) Yy, RR | yellow, round |

| **Genotype** | **Phenotype** |
|---|---|
| 10) Yy, Rr | yellow, round |
| 11) yy, Rr | green, round |
| 12) yy, Rr | green, round |
| 13) Yy, Rr | yellow, round |
| 14) Yy, rr | yellow, wrinkled |
| 15) yy, Rr | green, round |
| 16) yy, rr | green, wrinkled |

Mendel's total expected ratio was 9:3:3:1, or

9 yellow, round
3 yellow, wrinkled
3 green, round
1 green wrinkled




This is exactly the ratio Mendel found in the F2 generation. From this information, he determined that traits, or alleles, do sort independent of one another. This information led to the formation of his Law of Independent Assortment.

Mendel's research on simple pea plants in his monastery garden lead to some amazing scientific discoveries. Before Mendel, man had little knowledge of how traits were passed from parent to offspring. His research gave us three laws providing a firm foundation for genetic research.

## Mendel's Principles of Heredity
## QUIZ PACK

The following quizzes are meant to test student understanding of specific topic areas covered in the Interactive Biology Multimedia Courseware program, *Mendel's Principles of Heredity.* Many, but not all, of these questions have been addressed directly in the study guides. All questions have been addressed in the program.

QUIZ #1 GREGOR MENDEL
QUIZ #2 MENDEL'S EXPERIMENT
QUIZ #3 MENDEL'S EXPERIMENT, CONTINUED
QUIZ #4 MENDEL'S LAW OF DOMINANCE
QUIZ #5 A MODERN LOOK AT MENDEL'S WORK
QUIZ #6 MENDEL'S DIHYBRID CROSSES

## Quiz #1
## GREGOR MENDEL

1. Mendel was born in Paris, France.

    A. True
    B. False

2. For hundreds of years before Mendel's research, man had been selectively breeding livestock.

    A. True
    B. False

3. Mendel's education was provided by __________.

    A. his wealthy parents
    B. his wealthy brother
    C. an athletic scholarship
    D. his monastery

4. Gregor Mendel became known as the father of _________.

    A. science
    B. genetics
    C. botany
    D. chemistry

5. Mendel was conducting his research in __________.

    A. the mid 1600's
    B. the mid 1700's
    C. the mid 1800's
    D. the mid 1900's

6. Mendel's research was conducted __________.

   A. on pea plants
   B. in the monastery garden
   C. Both A and B.

# Quiz #2
# MENDEL'S EXPERIMENT

1. An essential part of Mendel's experiments were plants that were pure breeding for specific traits.

   A. True
   B. False

2. Plants self fertilize when they are fertilized by other plants.

   A. True
   B. False

3. When a trait is seen, it is said that the trait has been _________.

   A. exercised
   B. extinguished
   C. exaggerated
   D. expressed

4. In Mendel's crosses, the pure breeding plants were the first to be crossed. This first generation of plants was called the ___________.

   A. "A" generation
   B. "$F_1$" generation
   C. "P" generation
   D. "T" generation

5. The generation of plants resulting from this crossing between pure breeding plants was called the __________.

   A. "A" generation
   B. "$F_1$" generation
   C. "P" generation
   D. "T" generation

6. Mendel cut the stamens off of selected plants ____________.

   A. to ensure that these plants were not able to self fertilize
   B. and used these stamens to cross fertilizing other selected plants
   C. Both A and B.
   D. Neither A nor B.

7. Which of the following **is not** a trait Mendel was observing?

   A. Seed color
   B. Seed shape
   C. Stem color
   D. Stem length

8. Which of the following **is not** a trait Mendel was observing?

   A. Flower scent
   B. Flower position
   C. Pod color
   D. Pod shape

## Quiz #3
## MENDEL'S EXPERIMENT, CONTINUED

1. Offspring of two pure breeding plants with different characteristics are called hybrids.

   A. True
   B. False

2. In Mendel's experiment crossing pure breeding green seed plants and pure breeding yellow seed plants, the plants in the $F_1$ generation ____________.

   A. had green seeds
   B. had yellow seeds
   C. Both A and B.
   D. Neither A nor B.

3. When the $F_1$ generation was allowed to self fertilize, the resulting plants _______.

   A. had green seeds
   B. had yellow seeds
   C. Both A and B.
   D. Neither A nor B.

4. When Mendel looked at the seed color in the $F_2$ generation, he observed _______.

   A. all green seeds once more
   B. all yellow seeds once more
   C. 3 plants with yellow seeds for every 1 plant with green seeds
   D. 3 plants with green seeds for every 1 plant with yellow seeds

5. Mendel determined that green seed color was a __________ trait and yellow seed color was a _________ trait.

   A. harmful, helpful
   B. helpful, harmful
   C. dominant, recessive
   D. recessive, dominant

6. Of the seven characteristics Mendel was observing, he found that ___________.

   A. each had a dominant and a recessive trait
   B. each had a helpful and a harmful trait
   C. half were dominant and half were harmful
   D. half were recessive and half were helpful

7. Mendel used this information in forming his ___________.

   A. Law of Traits
   B. Law of Order
   C. Law of Dominance
   D. Law of Harmful Interaction

## Quiz #4
## MENDEL'S LAW OF DOMINANCE

1. Mendel hypothesized that his pea plants had two pairs of factors for each of the seven traits he was observing. These factors could be dominant, recessive, helpful, harmful, or neutral.

   A. True
   B. False

2. Mendel assigned letters to keep track of the various factors. He assigned _________ to the recessive factors and _________ to the dominant factors.

   A. vowels, consonants
   B. consonants, vowels
   C. lower case letters, upper case letters
   D. upper case letters, lower case letters

3. In the generation of pure breeding plants Mendel began with, the yellow seed producing plants were _________ and the green seed producing plants were ___________.

   A. GG, EE
   B. EE, GG
   C. yy, YY
   D. YY, yy

4. After the pure breeding yellow seed producing plants were crossed with the pure breeding green seed producing plants, the offspring were all ____________.

   A. GE
   B. EG
   C. YY
   D. yy
   E. Yy (or yY)

5. The plants from question #4 all had seeds that were __________ in color.

   A. yellow
   B. green
   C. green or yellow

6. After the pea plants in question #4 were crossed with each other, the resulting generation of plants were __________.

   A. GG, EE, GE, or EG
   B. YY, yy, YY, or yy
   C. YY, GG, yy, or EE
   D. YY, Yy, yY, or yy

7. The generation of plants in question #6 had seeds that were _________ in color.

   A. yellow
   B. green
   C. yellow and green

8. Yellow seeds would be seen in plants that were _________.

   A. YY
   B. yy
   C. Yy
   D. All of the above.
   E. A and C only.
   F. None of the above.

9. Green seeds would be seen in plants that were __________.

   A. EE
   B. EG
   C. GG
   D. All of the above.
   E. B and C only.
   F. None of the above.

## Quiz #5
## A MODERN LOOK AT MENDEL'S WORK

1. Today, we know that the "factors" Mendel suspected to control heredity are really genes, and different forms of the same gene are called alleles.

   A. True
   B. False

2. When a cell or organism possesses two copies of the same allele, it is said to be ___________.

   A. mutant
   B. normal
   C. homozygous
   D. heterozygous

3. When a cell or organism possesses two different or competing alleles, it is said to be ___________.

   A. mutant
   B. normal
   C. homozygous
   D. heterozygous

4. The physical characteristics of an organism make up its ____________.

   A. genotype
   B. genome
   C. phenotype
   D. pheromone

5. The genetic makeup of an organism constitutes its ____________.

   A. genotype
   B. phenotype
   C. pheromone

6. Segregation of alleles takes place during ___________.

   A. fertilization
   B. mitosis
   C. meiosis
   D. photosynthesis

7. Mendel used __________ to calculate the traits that would appear in his next generation of pea plants.

   A. punnett squares
   B. Pascal's triangle
   C. his knowledge of physics
   D. a primitive computer

## Quiz #6
## MENDEL'S DIHYBRID CROSSES

1. A dihybrid cross is conducted by crossing two plants that are each heterozygous for two traits, such as seed color and seed shape.

   A. True
   B. False

2. Sadly, little useful information was gained from Mendel's dihybrid crosses.

   A. True
   B. False

3. Which of the following best represents a dihybrid cross?

   A. YY x YY
   B. Yy x Yy
   C. YY RR x yy rr
   D. Yy Rr x Yy Rr

4. Mendel's Law of Independent Assortment states that ____________.

   A. alleles sort independently of one another
   B. alleles do not sort independently of one another

5. The trait of green seed color was _________ to the trait of yellow seed color.

   A. dominant
   B. neutral
   C. harmful
   D. recessive

6. The trait of round seed shape was __________ to the trait of wrinkled seed shape.

   A. dominant
   B. neutral
   C. harmful
   D. recessive

# Mendel's Principles of Heredity
# COMPREHENSIVE EXAM

The following questions are based on information presented in the Interactive Biology Multimedia Courseware program, *Mendel's Principles of Heredity.*

**Please determine if the following statements are true or false.**

1. Mendel was born in Paris, France.

   A. True
   B. False

2. For hundreds of years before Mendel's research, man had been selectively breeding livestock.

   A. True
   B. False

3. An essential part of Mendel's experiments were plants that were pure breeding for specific traits.

   A. True
   B. False

4. Plants self fertilize when they are fertilized by other plants.

   A. True
   B. False

5. Offspring of two pure breeding plants with different characteristics are called hybrids.

   A. True
   B. False

6. Mendel hypothesized that his pea plants had two pairs of factors for each of the seven traits he was observing. These factors could be dominant, recessive, helpful, harmful, or neutral.

   A. True
   B. False

7. Today, we know that the "factors" Mendel suspected to control heredity are really genes, and different forms of the same gene are called alleles.

   A. True
   B. False

8. A dihybrid cross is conducted by crossing two plants that are each heterozygous for two traits, such as seed color and seed shape.

   A. True
   B. False

9. Sadly, little useful information was gained from Mendel's dihybrid crosses.

   A. True
   B. False

**In the following portion of the exam, please select the letter next to the word, words, or phrase that best completes each question.**

10. Mendel's education was provided by __________.

    A. his wealthy parents
    B. his wealthy brother
    C. an athletic scholarship
    D. his monastery

11. Gregor Mendel became known as the father of _________.

    A. science
    B. genetics
    C. botany
    D. chemistry

12. Mendel was conducting his research in __________.

A. the mid 1600's
B. the mid 1700's
C. the mid 1800's
D. the mid 1900's

13. Mendel's research was conducted __________.

A. on pea plants
B. in the monastery garden
C. Both A and B.

14. When a trait is seen, it is said that the trait has been _________.

A. exercised
B. extinguished
C. exaggerated
D. expressed

15. The first generation of plants resulting from a crossing between pure breeding parental plants is called the __________.

A. "A" generation
B. "$F_1$" generation
C. "P" generation
D. "T" generation

16. Mendel cut the stamens off of selected plants ____________.

A. to ensure that these plants were not able to self fertilize
B. and used these stamens to cross fertilizing other selected plants
C. Both A and B.
D. Neither A nor B.

17. Which of the following **is not** a trait Mendel was observing?

A. Seed color
B. Seed shape
C. Stem color
D. Stem length

18. Which of the following **is not** a trait Mendel was observing?

A. Flower scent
B. Flower position
C. Pod color
D. Pod shape

19. In Mendel's experiment crossing pure breeding green seed plants and pure breeding yellow seed plants, the plants in the $F_1$ generation ____________.

A. had green seeds
B. had yellow seeds
C. Both A and B.
D. Neither A nor B.

20. When the $F_1$ generation was allowed to self fertilize, the resulting plants _______________.

A. had green seeds
B. had yellow seeds
C. Both A and B.
D. Neither A nor B.

21. When Mendel looked at the seed color in the $F_2$ generation, he observed ___________.

A. all green seeds once more
B. all yellow seeds once more
C. 3 plants with yellow seeds for every 1 plant with green seeds
D. 3 plants with green seeds for every 1 plant with yellow seeds

22. Of the seven characteristics Mendel was observing, he found that ___________.

A. each had a dominant and a recessive trait
B. each had a helpful and a harmful trait
C. half were dominant and half were harmful
D. half were recessive and half were helpful

23. Mendel used this information in forming his ___________.

A. Law of Traits
B. Law of Order
C. Law of Dominance
D. Law of Harmful Interaction

24. Mendel assigned letters to keep track of the various factors. He assigned _________ to the recessive factors and _________ to the dominant factors.

A. vowels, consonants
B. consonants, vowels
C. lower case letters, upper case letters
D. upper case letters, lower case letters

25. In the generation of pure breeding plants Mendel began with, the yellow seed producing plants were _________ and the green seed producing plants were ___________.

A. GG, EE
B. EE, GG
C. yy, YY
D. YY, yy

26. After the pure breeding yellow seed producing plants were crossed with the pure breeding green seed producing plants, the offspring were all _________.

A. GE
B. EG
C. YY
D. yy
E. Yy

27. The plants from question #26 all had seeds that were __________ in color.

    A. yellow
    B. green
    C. green or yellow

28. After the pea plants in question #26 were crossed with each other, the resulting generation of plants were __________.

    A. GG, EE, GE, or EG
    B. YY, yy, YY, or yy
    C. YY, GG, yy, or EE
    D. YY, Yy, yY, or yy

29. The generation of plants in question #28 had seeds that were _________ in color.

    A. yellow
    B. green
    C. yellow and green

30. Yellow seeds would be seen in plants that were _________.

    A. YY
    B. yy
    C. Yy
    D. All of the above.
    E. A and C only.
    F. None of the above.

31. Green seeds would be seen in plants that were __________.

    A. EE
    B. EG
    C. GG
    D. All of the above.
    E. B and C only.
    F. None of the above.

32. When a cell or organism possesses two different or competing alleles, it is said to be ___________.

A. mutant
B. normal
C. homozygous
D. heterozygous

33. The physical characteristics of an organism make up its ____________.

A. genotype
B. genetic drift
C. phenotype
D. pheromone

34. The genetic makeup of an organism constitutes its ____________.

A. genotype
B. genome
C. phenotype
D. pheromone

35. Segregation of alleles takes place during ___________.

A. fertilization
B. mitosis
C. meiosis
D. photosynthesis

36. Which of the following best represents a dihybrid cross?

A. YY x YY
B. Yy x Yy
C. YY RR x yy rr
D. Yy Rr x Yy Rr

37. Mendel's Law of Independent Assortment states that ____________.

A. alleles sort independently of one another
B. alleles do not sort independently of one another

38. The trait of green seed color was _________ to the trait of yellow seed color.

    A. dominant
    B. neutral
    C. harmful
    D. recessive

39. The trait of round seed shape was __________ to the trait of wrinkled seed shape.

    A. dominant
    B. neutral
    C. harmful
    D. recessive

**In the following portion of the exam, please fill in the word, words, or phrase that best completes each sentence.**

40. In Mendel's crosses, pure breeding plants were the first to be crossed. This first generation of plants was called the ___________ generation.

41. Mendel determined that green seed color was a ___________________ trait and yellow seed color was a _____________________ trait.

42. When a cell or organism possesses two copies of the same allele, it is said to be ___________________________________.

43. Mendel used ____________________________________ to calculate the traits that would appear in his next generation of pea plants.

# Mendel's Principles of Heredity
# ANSWER GUIDE

## QUIZ PACK

| QUIZ #1 | QUIZ #2 | QUIZ #3 | QUIZ #4 | QUIZ #5 | QUIZ #6 |
|---|---|---|---|---|---|
| 1. B | 1. A | 1. A | 1. B | 1. A | 1. A |
| 2. A | 2. B | 2. B | 2. C | 2. C | 2. B |
| 3. D | 3. D | 3. C | 3. D | 3. D | 3. D |
| 4. B | 4. C | 4. D | 4. E | 4. C | 4. A |
| 5. C | 5. B | 5. D | 5. A | 5. A | 5. D |
| 6. C | 6. C | 6. A | 6. D | 6. C | 6. A |
| | 7. C | 7. A | 7. C | 7. A | |
| | 8. A | | 8. E | | |
| | | | 9. F | | |

## COMPREHENSIVE EXAM

| | | | | |
|---|---|---|---|---|
| 1. B | 11. B | 21. C | 31. F | 41. recessive, dominant |
| 2. A | 12. C | 22. A | 32. D | 42. homozygous |
| 3. A | 13. C | 23. C | 33. C | 43. punnett squares |
| 4. B | 14. D | 24. C | 34. A | |
| 5. A | 15. B | 25. D | 35. C | |
| 6. B | 16. C | 26. E | 36. D | |
| 7. A | 17. C | 27. A | 37. A | |
| 8. A | 18. A | 28. D | 38. D | |
| 9. B | 19. B | 29. C | 39. A | |
| 10. D | 20. C | 30. E | 40. "P" | |

# Mendel's Principles of Heredity
# GLOSSARY

**alleles**: different forms of a gene controlling a certain trait.

**chromosome**: a threadlike structure consisting of protein and tightly compacted DNA with RNA, found in the nucleus of a eukaryotic cell.

**carpel**: the female reproductive organ of a flower.

**chromosomal theory of inheritance**: the theory that hereditary material is located on chromosomes which are made up of genes.

**crossbreed**: fertilization between separate organisms.

**cross-fertilization**: see "crossbreed".

**dihybrid cross**: a cross between plants that are heterozygous for two traits. For example, Mendel crossed plants that contained a dominant and a recessive allele for both seed color and seed shape (YyRr). This cross is shown by "YyRr x YyRr".

**dominant allele**: an allele that is expressed in an organism that is heterozygous for that allele's trait. Usually denoted by an uppercase letter, such as "Y".

**$F_1$ (first filial) generation**: the first generation of offspring.

**$F_2$ (second filial) generation**: the second generation of offspring.

**fertilization**: the union of male and female gametes.

**gamete**: a sperm or egg cell that has one-half the number of genes or chromosomes found in a typical body cell.

**gene**: a distinct unit of hereditary information.

**genetics**: the field of biology that studies how hereditary information is passed on parent to offspring.

**genotype**: the genetic makeup of an organism.

**heredity**: the transmission of traits from parents to offspring.

**heterozygous**: having two different alleles for a particular trait.

**homozygous**: having two of the same alleles for a particular trait.

**hybrids**: the offspring of crosses between parents showing contrasting traits.

**Law of Dominance**: Mendel's law, or principle, which states that only the dominant trait will be expressed in an organism that is heterozygous for that trait.

**Law of Independent Assortment**: Mendel's law, or principle, which states that alleles of one gene separate independently from the alleles of another gene during gamete formation.

**Law of Segregation**: Mendel's law, or principle, which states that allele pairs separate during gamete formation with each gamete receiving only one allele from each pair. Allele pairs recombine when gametes come together in fertilization to form an offspring.

**meiosis**: a process consisting of two cell divisions that result in the formation of gametes. The second meiotic division reduces the number of chromosomes in half.

**P (parental) generation**: the generation of organisms which produce the $F_1$ generation.

**phenotype**: the physical characteristics of an organism.

**pollination**: the transfer of pollen from a male reproductive organ onto the stigma of a carpel of a female reproductive organ, thus allowing fertilization to occur.

**probability**: the likelihood or chance that an event will occur.

**punnett square**: a box diagram that is used to predict the outcome of a genetic cross.

**pure-breeding**: a parent that always produces offspring with traits identical to its own.

**recessive allele**: an allele that is not expressed in an organism that is heterozygous for that allele's trait. Usually denoted by a lowercase letter, such as "y".

**self-fertilization**: the process that unites male and female gametes from one individual organism.

**self-pollination**: see self-fertilization.

**stamen**: the male reproductive organ of a flower.

**trait:** each difference in an inherited characteristic, such as yellow or green pea pods.

**true-breeding**: see "pure-breeding".