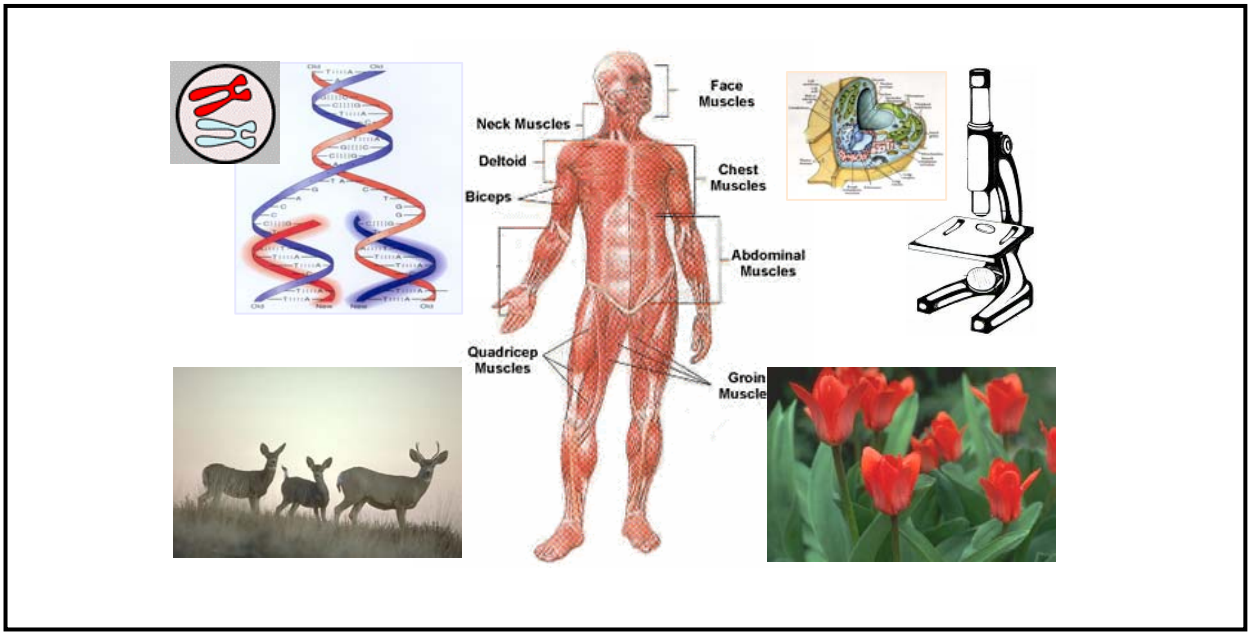
Project EASE

(Effective Alternative Secondary Education)

BIOLOGY



MODULE 14

Genetics: The Study of Inherited Traits

BUREAU OF SECONDARY EDUCATION
Department of Education
DepED Complex, Meralco Avenue
Pasig City

Module 14
Genetics: The Study of Inherited Traits

What this module is about

This module will discuss the topic on how traits are passed on from parents to offspring. It also includes the laws that govern the patterns of inheritance including the genetic material involved, the DNA. This pattern of inheritance can be observed over a series of generations as discussed in the different laws founded by Gregor Mendel. The discussion starts with the patterns of transmission of genetic traits to a more discrete topic **–** the DNA.

There are three lessons included in this module. These are:

- **Lesson 1 – MENDEL'S Law of Inheritance**
- **Lesson 2 – Non-Mendelian Patterns of Inheritance**
- **Lesson 3 – DNA: The Genetic Material**

What you are expected to learn

After going through this module, you are expected to:

- Describe the Mendelian Laws of Inheritance.
- Differentiate monohybrid cross from dihybrid cross.
- Describe the composition of the genetic material.
- Describe DNA replication and protein synthesis.
- Define genetic engineering.

How to learn from this module

There are some pointers that you have to follow as you go over this module. These pointers will help you achieve the objectives of this module successfully.

- Do not forget to take the pre-test.
- Go through the pages one by one since the topics are related to one another. If you

miss one page, you may not understand the succeeding pages.
- Perform the activities as instructed and be sure to finish them.
- If ideas are not clear you can always go back to the pages where they are discussed.
- At the end of the module, do not forget to take the posttest.

What to do before (Pretest)

I. Multiple Choice. Choose the letter of the correct answer. Write the chosen letter on a separate sheet of paper.

1. Who is considered as the father of Genetics?
   a. Darwin
   b. Linnaeus
   c. Gregor Mendel
   d. Hugh de Vries

2. Punnett squares are used to _____ the outcome of crosses of traits.
   a. assure
   b. dominate
   c. number
   d. predict

3. Which of the following are located in the chromosomes?
   a. Carbohydrates
   b. DNA codes
   c. Pedigrees
   d. Zygotes

4. A codon is composed of:
   a. 1 base
   b. 2 bases
   c. 3 bases
   d. 4 bases

5. A nucleotide is composed of:
   a. base only
   b. protein only
   c. sugar only
   d. sugar, phosphate and base

6. The science that deals with the study of how traits are inherited from parents to offsprings is called
   a. Economics
   b. Genetics
   c. Politics
   d. Polygenic

7. The component in the nucleus of a cell that codes and stores genetic information is called
   a. DNA
   b. Nucleolus
   c. Nucleoplasm
   d. RNA

8. An organism with two identical alleles for a trait is called
   a. heterozygous
   b. homologous
   c. homozygous
   d. polyploid

9. Which refers to the different forms of genes representing a certain trait?
    a. allele
    b. chromosome
    c. hybrid
    d. locus

10. Which of these is a combination of the dominant and recessive genes present in the cells of an organism?
    a. genotype
    b. lectotype
    c. neotype
    d. isotype

11. Which of the following is NOT a Mendelian law of inheritance?
    a. In every organism, there is a pair of factors that control the appearance of a particular trait.
    b. The first filial generation does resemble either parent. Therefore no allele is dominant over the other.
    c. During gamete formation, the pair of factors segregates or separates from each other.
    d. During fertilization, the genes come together again to form new combinations.

12. What is a monohybrid cross?
    a. A cross using a single factor or character.
    b. A cross using two factors or characters.
    c. A diagram that determines the possible combinations of traits.
    d. None of the above.

13. All are Non-Mendelian laws of inheritance EXCEPT,
    a. codominance
    b. multiple alleles
    c. incomplete dominance
    d. law of segregation

14. Which of the following describes DNA replication?
    a. parallel
    b. anti-parallel
    c. conservative
    d. semi-conservative

15. What is genetic engineering?
    a. It involves transcription and translation.
    b. A process of altering the genes, which you find in all living things.
    c. A method that scientists use to produce a genetic copy of another individual.
    d. None of the above.

II. Problem Solving (5 points each)

1. Provide the genotype of the given cross:

   Yellow color in peas (Y) is dominant over green peas (y). A homozygous yellow pea plant is crossed with a homozygous green pea plant. What will be the genotypes of all the possible offspring?

2. In fruit flies, long wing (L) is dominant to short wing (l). Two heterozygous long-winged

fruit flies both (LI) are crossed. What are the possible phenotypes of their offspring?

Key to answers on page 28.

Lesson 1. MENDEL'S Law of Inheritance

Look around you and notice the amazing variations among living organisms. Have you ever wondered how this happened? What could be responsible for this? These are some of the questions that will be answered as you go over the module.

Now look at Figure 1. It shows different organisms. Could you identify some differences and similarities among them? Variation is a fascinating feature of living things. It can exist among organisms of the same species (roses) or among different species (dogs and cats). Start your study of variation by comparing the different organisms in the said figure.

Figure 1. Variation among living organisms
www.yahoo.com images

Did you ever notice how much brothers and sisters look alike? Within your family, you share many of the same traits, don't you? You can start studying variation among humans by observing yourself and the members of your family.

What you will do

Activity 1.1 Observing Yourself, Relatives and Friends

1. Examine the table and Figure 2. Identify the features that you and your friends have from the list. There are two traits that are diagrammed. Do you find these traits among you and your friends?

Part of the body/Trait	Appearance	
Type of hair	Straight	Wavy or kinky hair
Earlobes	Attached	Unattached
Color of the skin	Light or fair	Dark
Hairline	Straight	With widow's peak
Dimples	With dimples	Without dimples
Handedness	Right handedness	Left handedness
Nose	High-bridged	Low-bridged

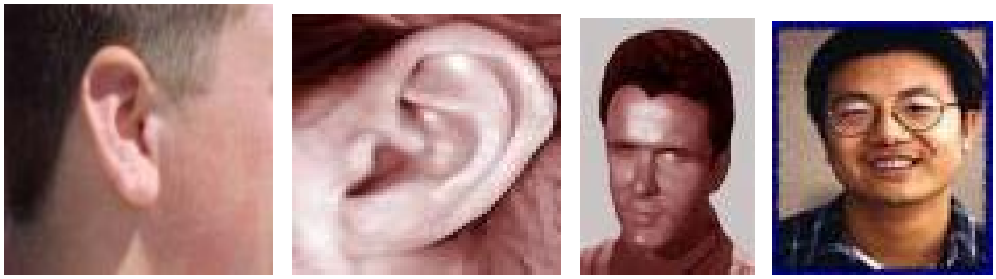


Figure 2. Variation in hairline and earlobes
(pictures from clip art collection)

2. Now focus your attention to the traits of you family members. Your family members include your mother, father, brothers and sisters. Answer the following questions:

   a. Who among your family members look similar to you?
   b. Who has the most number of differences with you?

Mendel and His Garden Peas

Heredity is the study of how traits are passed on from the parents to the offspring. Genetics is the study of heredity and variation. An understanding of the field will help you understand why you have similarity with your parents.

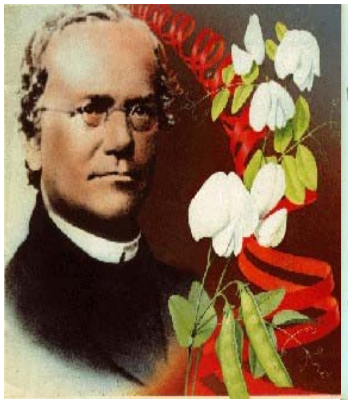


Figure 3
Gregor Mendel

Figure 4
Pea Plants

www.yahoo.com images

Do you know the first person who worked on the topic inheritance? His name is Gregor Mendel, an Austrian by nationality and a monk by vocation.

He worked and lived in a monastery with large gardens planted with different kinds of peas. Are you familiar with peas (chicharo)? These are how peas look like.

He got interested in peas and noted several of their distinguishing character traits. A clearer picture of the traits is shown below:

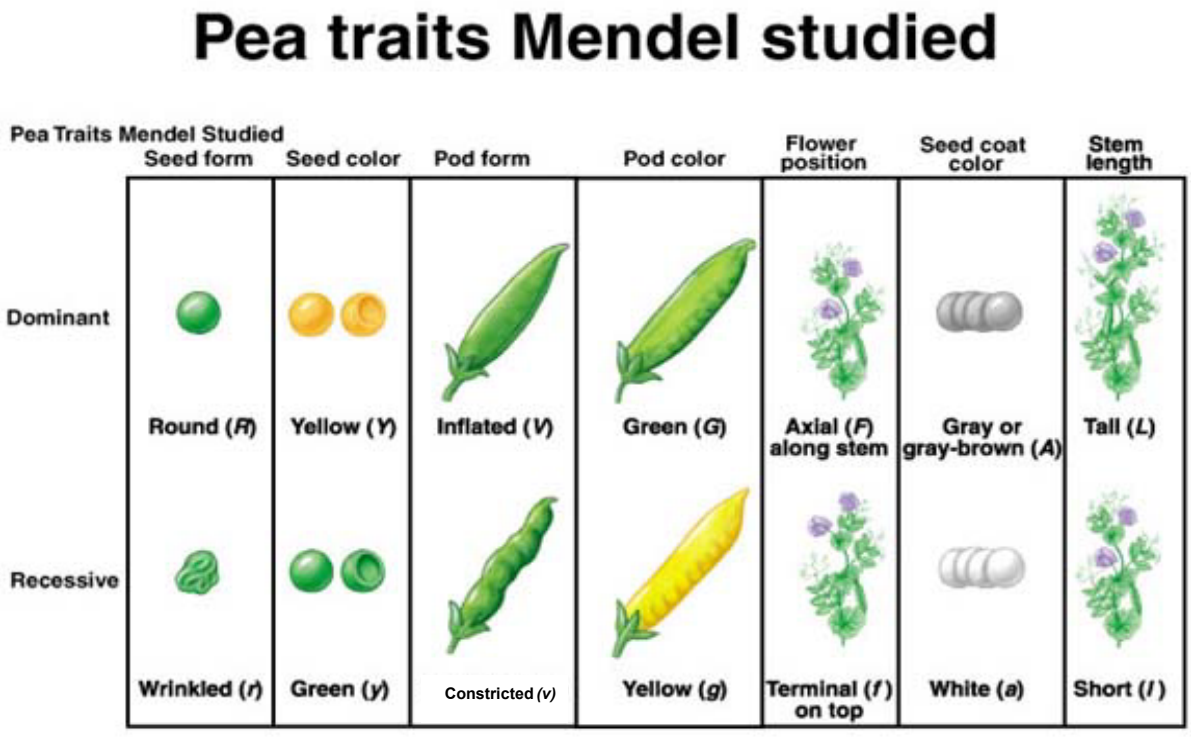


Figure 5. Mendel's Pea Traits

www.yahoo.com images

Why do you think Mendel chose green peas for his experiments? Well, peas have traits that are easily noticeable. They are easy to breed and grow, which make it easy to reproduce new generations of peas in a short period of time and in large numbers.

It has been observed that pea plant normally pollinates itself because it has perfect flowers, or flowers with both the male and female reproductive organs. The pollen grains from the same flower can pollinate the eggs cells or ovules from the same flower. However, to cross-pollinate, Mendel tried to remove the stamens while still young. Then, when the pistil matured, he dusted it with the pollen grains from another pea plant.

Mendel's First Experiment

In his first set of experiments, he needed to cross-pollinate pure breeding pea plants. To get plants that are pure breeding, he allowed the pea plants to self-pollinate for many generations. For instance, yellow seed peas were self-pollinated until all the pea plants in a given generation produced all yellow seed peas. His purpose here was to cross these pure breeding peas with other pure breeding peas and observe the kind of offspring that will be produced.

Monohybrid Cross

Monohybrid cross involves a cross using a single factor or character trait. How did Mendel execute this? Well, after producing a pure breeding stock, he started crossing or mating the pea plants. In our discussion we will use **X** to represent ***crossing*** or ***mating***. The peas that he crossed had different expressions of a given trait like for example, round or wrinkled seeds, green and yellow pods, etc. He accomplished this by carefully cross-pollinating the peas by covering the flowers to avoid accidental pollination from other peas.

At first, he used only one trait like the seed shape. So he crossed a pure breed of round seeds with the pure wrinkled seeds. He did this several times and from each cross he got the same result as shown in Figure 6.

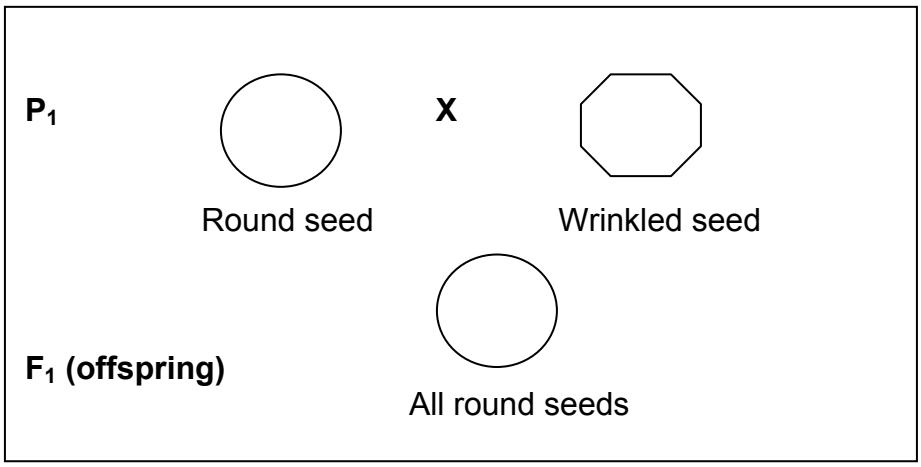


Figure 6
Mendel's cross using pure-breed round and wrinkled seed

The $\mathbf{P_1}$ in the cross stands for the first parents (the pure breeds). The $\mathbf{F_1}$ stands

for the ***first filial generation*** or first offspring. Notice that all the offspring are peas with round seeds. These are also called as the ***hybrids*** because they are the result of a cross between two pure-breeding plants. They resemble one another and one of the parents. Mendel got similar results for all the seven pairs of traits he investigated, as shown in Table 1.

Table 1. Mendel's results of the cross between pure breed pea plants

TRAITS STUDIED	PARENTS	FIRST FILIAL GENERATION (F1)
SEED SHAPE	Round **X** Wrinkled	All round
SEED COAT COLOR	Colored **X** White	All colored
SEED COLOR	Yellow **X** Green	All yellow
POD SHAPE	Inflated **X** Constricted	All inflated
POD COLOR	Yellow **X** Green	All green
FLOWER POSITION	Axial **X** Terminal	All axial
STEM LENGTH	Long **X** Short	All long

Did you ever wonder what happened to the wrinkled trait and to the other traits? Why was it that only the round trait came out? You will learn more as we go over the other interesting topics on heredity. Continue and more power!

Try this:

A pure bred red gumamela flower is crossed with a pure bred yellow gumamela flower. If the F1 were all gumamela with red flowers, how would you represent this cross? You can refer to Figure 6 on page 7. The solution is similar to this except for the diagrams and labels.

Key to answers on page 29.

Crossing the Hybrid Plants

Where then is the trait for the wrinkled seed? Will it appear in the next generation? Determined to know what happened to the other lost trait, Mendel continued his experiments. This time he used these ***hybrids*** to produce another type of offspring. What do you think came out after he tried to cross a hybrid with another hybrid? Do you have any guess? Just like you, these were also some of the questions that drove Mendel to go on with his experiments. Continue reading the module and find out what happened!

Now, with this in mind, he tried to cross the plants from the F1 generation (hybrid) with each other, meaning he used the round seed peas that were produced in his first experiment. The resulting plants from this cross, or the ***second filial generation (F_2)*** were of two types: about three fourths (**3/4)** had round seeds and about ¼ had wrinkled seeds. At last the wrinkled seed peas came out! Isn't this amazing?

Mendel was then satisfied with his experiment. Note that the $\mathbf{F_1}$ plants are now the parents of $\mathbf{F_2}$ plants. Again, Mendel's findings were similar for each of the seven pairs of traits he studied.

In the F_2 generation, he was able to count 5,474 peas with round seeds, and 1,850 wrinkled seeds. What can you infer from the results? Do you have any answer? Do you notice that the round seeds are about three times as many as the wrinkled seeds? The ratio is nearly 3:1.

Study carefully the simple diagram made for you in Figure 7. This will summarize the last discussions presented.

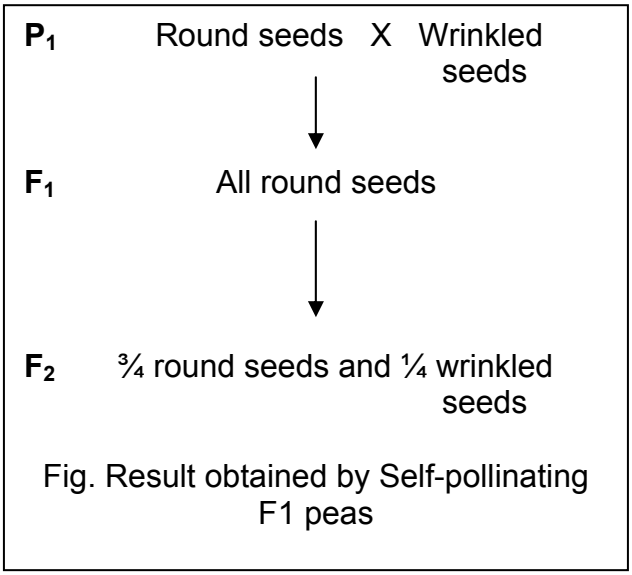


Fig. Result obtained by Self-pollinating F1 peas

Figure 7. Sample cross of hybrids

Another representation of crossing hybrid plants is shown below:

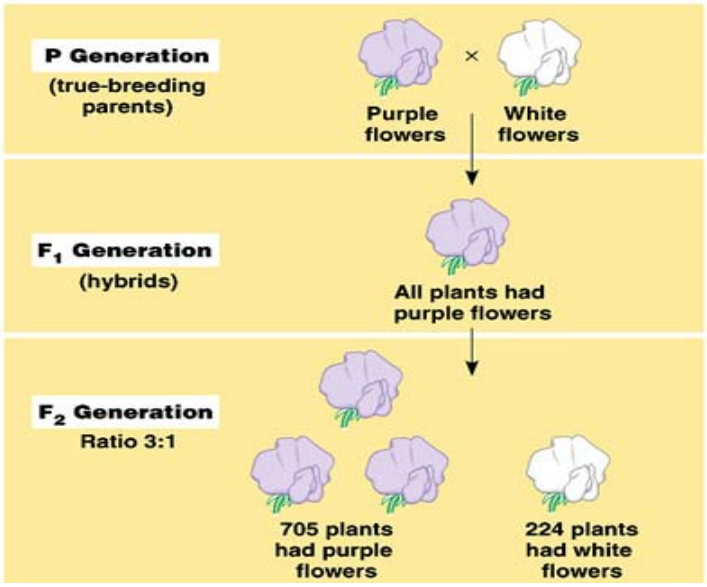


Figure 8. Crossing hybrid
www.yahoo.com images

Again, try this:

A pure breed tall plant is crossed with pure breed short plant. All the F_1 were tall. When the F_1 were crossed, the offspring were ¾ tall and ¼ short. How would you represent this in a diagram? Refer to Figure 6 for guidance.

Key to answers on page 29.

Is your answer correct? Well, congratulations! You finally made it!

Mendel's hypothesis based on his experiments

Based on his first experiment Mendel was able to hypothesize that there must be a ***factor*** in plants that controls the appearance of a trait. Recall that in the cross between pure breed round and wrinkled seeds, only the round trait came out. The wrinkled trait was hidden. This factor is now called a ***gene***. Have you ever encountered this word before? Since there are two alternative expressions of a trait, he reasoned further that traits are controlled not only by one but a pair of factors now called ***alleles***. This resulted to the formulation of his hypothesis which states that: ***In every organism, there is a pair of factors that control the appearance of a particular trait.***

Going back to the F_1 generation, although they were round seeds, the seeds were no longer like the pure round seed parent plants. The peas in the F_1 had in them a factor for round seed and a hidden factor for wrinkled seed that would appear in the F_2 generation.

One parent has a pair of factors for round seeds, while the other parent has a pair of factors for wrinkled seeds. From these, Mendel was able to hypothesize that: "***One member of the pair of factors may hide or prevent the appearance of the other factor."***

The trait of round seed that appeared on the F_1 is called a ***dominant trait***. The trait which did not appear (wrinkled because its appearance was masked by the dominant trait is called a ***recessive trait***. (Refer to Mendel's pea traits on page 6.) What are the dominant and recessive traits of pea plants?

In Genetics, the two factors mentioned by Mendel are called alleles. These alleles could be dominant or recessive. These alleles maybe represented this way: a ***capital letter*** for the dominant trait, and a ***small letter*** for the recessive trait. We can use the first letter of either the dominant or recessive trait to represent a particular trait. For example***, R*** for **round seed** and ***r*** for ***wrinkled seed***. Or it could be regarding the color of pod where you can represent ***G for green*** pod and ***g for yellow*** *pod*. Do not confuse yourself with the use

of the first letter. Remember the same letter will be used for both the dominant and recessive traits. They will only differ as to whether it will be capital letter or small letter.

Now, since genes are in pairs, the pure breeding round plant will be symbolized ***RR*** and the pure breeding wrinkled seed ***rr.*** Are you still with me? I hope everything is still clear. Now, do this simple activity:

Do this:

Represent the following traits using letters to fill-up the blanks in the table:

Dominant	Recessive	Dominant (letters only)	Recessive (letters only)
Tall	Short		
Curly hair	Straight hair		
Brown eyes	Blue eyes		
Unattached earlobe	Attached earlobe		

Key to answers on page 29.

The alleles making up a pair maybe identical or not. For example, for round it is ***RR*** and this type of allele is ***homozygous or homozygote***. If the allele is ***Rr*** like the F_1 generation, it is ***heterozygous or heterozygote***. An individual maybe heterozygous for some traits and homozygous for others.

Today, the alleles which are represented by paired letters are referred to as the individual ***genotype.*** The genotype therefore, refers to the genetic composition of the person, while ***phenotype*** is the physical appearance or feature of the person. For example, RR allele is homozygous round in genotype and the phenotype is round. Is the explanation clear? I hope so.

You might ask, "Do factors or genes change as they are transferred from one generation to the next?"

Using Mendel's experiment, the answer is *no. "In successive generations, each factor is transmitted unchanged."* Remember that the factor for wrinkled in P_1 generation is the same as that found in F_1 generation. This means that individual factors do not mix as they are transmitted from generation to generation.

Another hypothesis formulated by Mendel is known as **"The Law of Segregation"**, which states that: "During gamete formation, the pair of factors segregate or separate from each other." These factors are located in the chromosomes and are transmitted to the offspring through the egg cell and the sperm cell. Figure 9 below shows how genes are transmitted to the offspring.

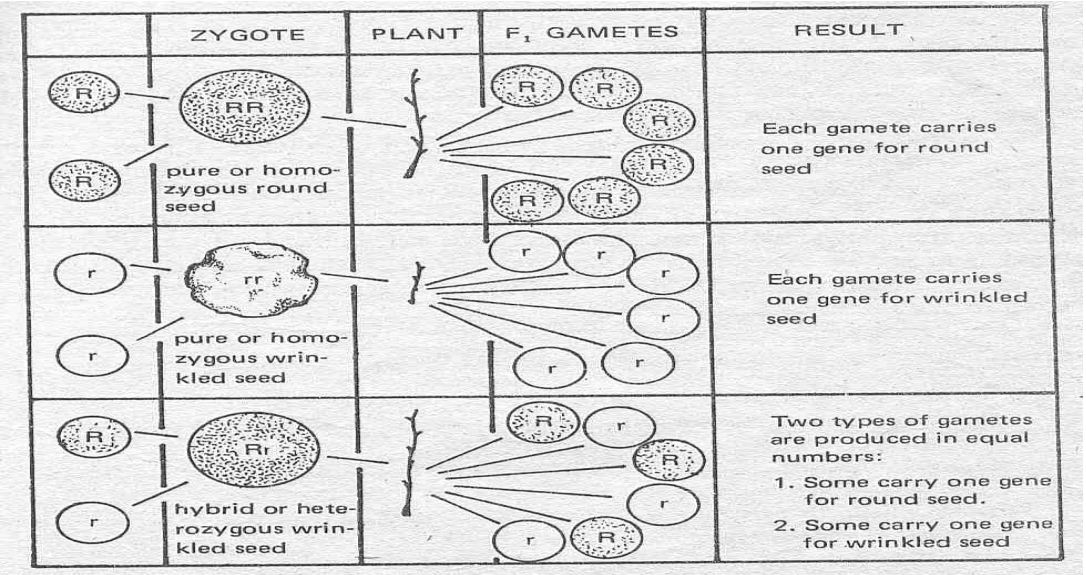


Figure 9

Science and Technology II

The other Mendelian Law of inheritance is the **Law of Recombination**. It states that during fertilization, the genes come together again to form new combinations.

We will no longer discuss these two laws in detail. Another topic on dihybrid cross will be discussed in the next lesson.

What you will do

Self-Test 1.1

1. What is a dominant trait? Recessive trait?
2. Differentiate monohybrid cross from dihybrid cross.
3. What is a homozygote? Heterozygote?
4. What is the pattern of inheritance for the first generation?
5. What is the pattern of inheritance for the second generation?

Key to answers on page 29.

Cross with Two Factors (Dihybrid Cross)

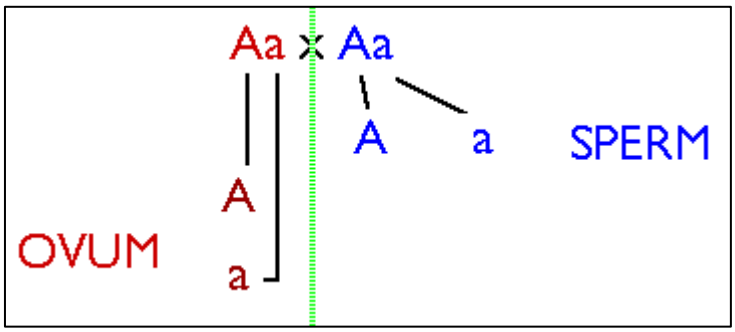
Mendel did not only study the inheritance of one pair of factors or alleles. He also studied the inheritance of two pairs of alleles. The cross that involves two pairs of alleles is called **dihybrid.**

An easy way to do this cross is through the use of Punnett square. What is a Punnett square? It is a diagram named after Reginald C. Punnett, the man who devised it. The Punnett square can help you predict the outcome of a given cross with ease. It allows us to determine the possible combinations of genes in a given cross. For example, what is the expected result if you try to cross ***two hybrids*** for the type of flowers in pea plants? Now, examine the diagram below. This is how it works:

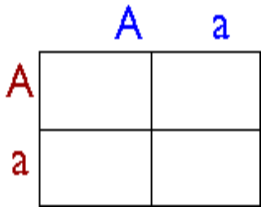
A Simplified Punnett Square

A. The basic step for a cross between two heterozygous axial flowers will be: **Aa X Aa**

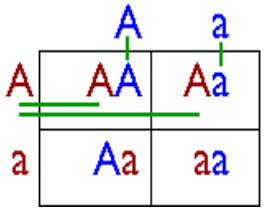
1. Next, figure out the possible ***gamete*** genotype, and try to separate the alleles, just like in the diagram below.



2. Place the possible gamete genotypes on the outside of a square.



3. Simulate fertilization by moving the gametes into each of the internal boxes (which simulate possible offspring); interpret the results.



Based on the results you will find out that there are three genotypes produced by crossing two hybrids. 1 homozygous axial; 2 heterozygous axial and 1 homozygous terminal flowers.

Now, can you do this for a dihybrid cross? To familiarize yourself with the use of Punnett square, try to examine the diagram below. It will show you how a Punnett square will look like using two types of factors or alleles for a dihybrid cross:

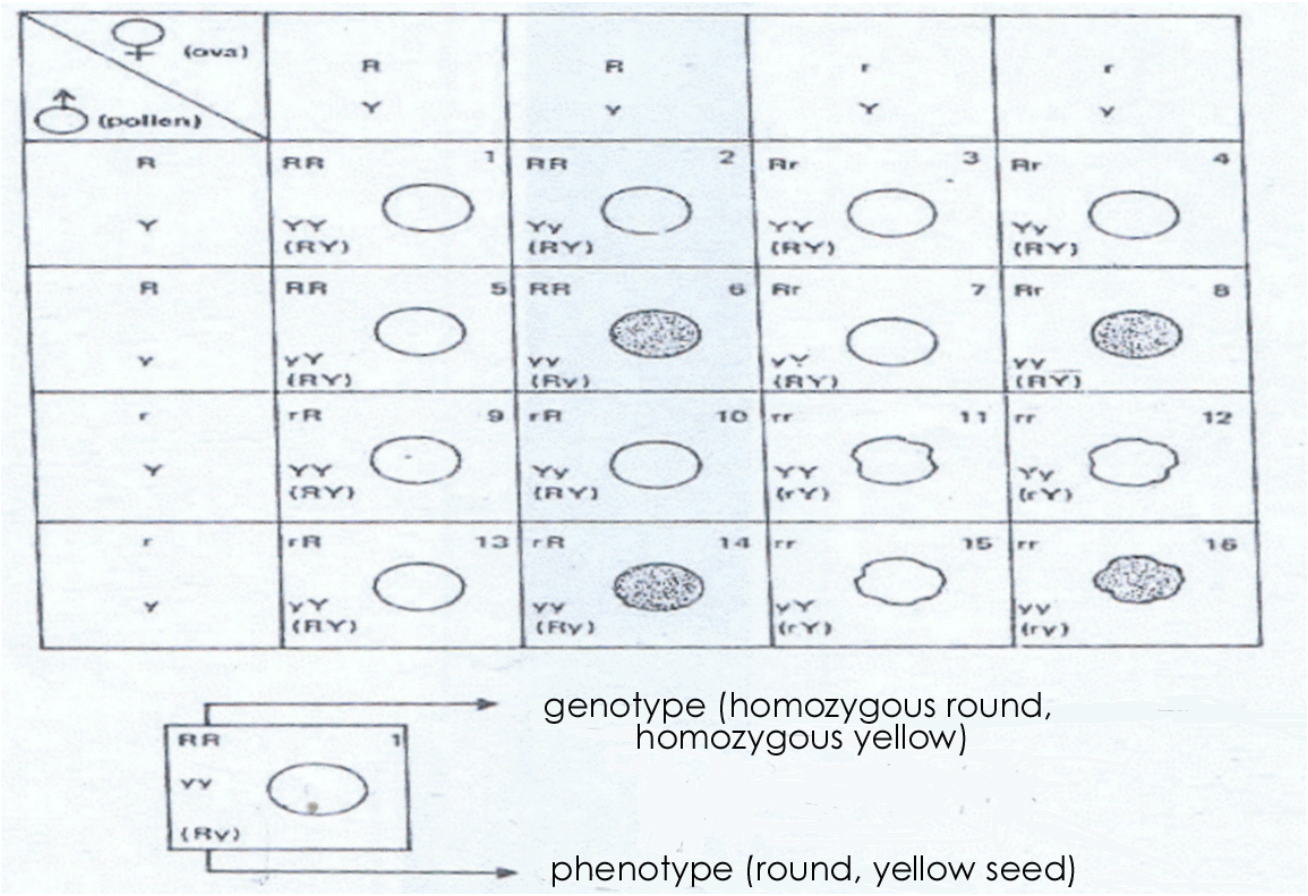
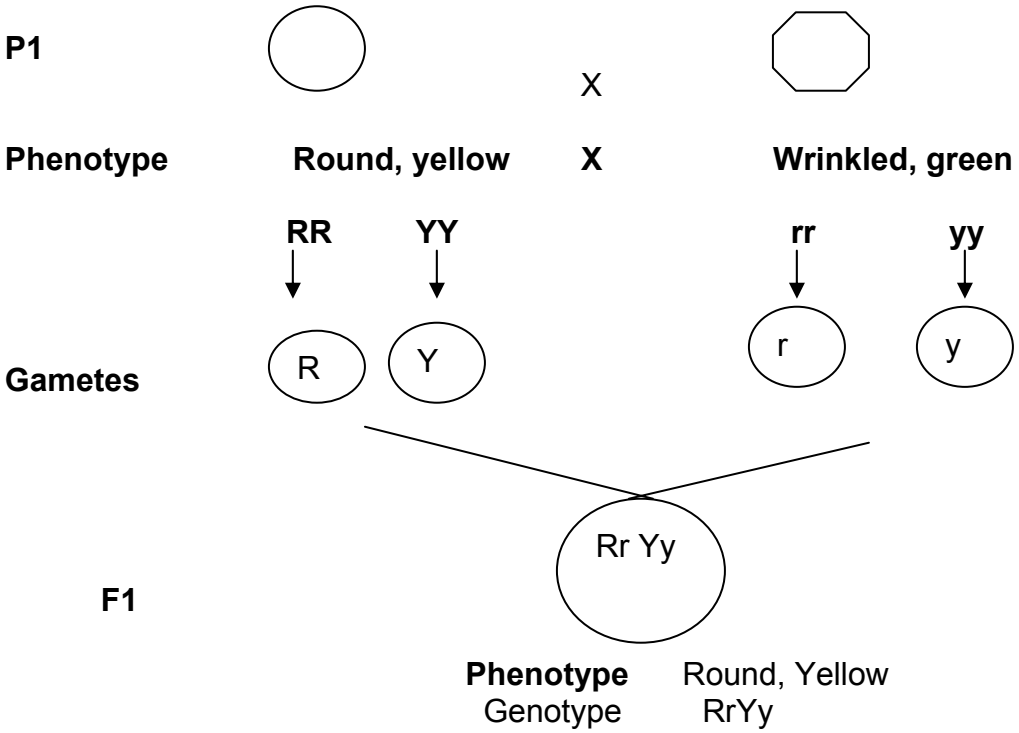


Figure 10. Phenotype and Genotype

Next is another example of a dihybrid cross using the pea plants in Mendel's work. It deals with the types of seeds and the color of seed pods among pea plants.



(F1 self-fertilized) **RrYy X RrYy**

F2 **RRYY RRYy RrYY RrYy RRYy - round, yellow**

RRyy Rryy rRyy - round, green

rrYY rrYy rryY – wrinkled yellow

rryy - wrinkled green

Based on Mendel's experiment, he got 315 round yellow, 105 round green, 101 wrinkled yellow and 32 wrinkled green pea plants. This is equivalent to a phenotypic ratio of 9:3:3:1. Meaning , there are 9 round yellow, 3 round green, 3 wrinkled yellow, and 1 wrinkled green.

Now let us see how good you are in doing a cross using a Punnett square. Do this activity below:

What you will do

Activity 1.2 Filling Up the Punnett Square

Given this cross, TtGg X TtGg, fill-up the squares with the correct answer.

Ovum ♀ / Sperm ♂	T G	T g	t G	t g
T G				
T g				
t G				
t g				

Were you able to fill - up the table correctly? You can compare your answer with the answer key at the back of this module. If you are through try to continue answering these questions:

1. How many are tall green? Short yellow? Tall yellow? Short yellow?
2. Give the phenotypic ratio.

Key to answers on page 30.

What you will do

Self-Test 1.2

1. Given the cross **AaBb X AaBb,** construct a Punnett square and determine the write the genotypic ratio (the probability that a particular genotype will occur) of the resulting cross.

Key to answers on page 30.

Lesson 2. Non-Mendelian Patterns of Inheritance

History records that the works of Mendel were incomplete, because he failed to discuss in detail the " factors" or genes that he mentioned in his Laws of inheritance.

After his time the ***Chromosomal Theory of Inheritance*** formulated by Sutton and Boveri became very popular as it explained that genes are found in the chromosomes. What are chromosomes? **Chromosomes** are structures found inside the nucleus of a cell that carries the genes.

Incomplete Dominance

Why is it that in nature we do not always observe the dominant - recessive relationship? Are you familiar with a red gumamela and a white gumamela? A cross between the two (red and white gumamela) will produce all pink flowers. With incomplete dominance, we get a blending of the dominant and recessive traits so that the third phenotype is something in the middle, e.g red X white = pink flowers.

There are cases in which the dominant allele is unable to completely hide the effect of the recessive allele. The flowers in the F_1 are pink, not red. The situation in which the F_1 does not resemble either parent is called **incomplete dominance**. In this case, no allele is completely dominant over the other. A clear picture of incomplete dominance is shown in Figure 11. Here plants with red flowers are crossed with plants with white flowers. The F_1 and F_2 generations are shown. What can you say about the offspring in the F1? It produced all pink flowers while in the F2 1 red, 2 pink and 1 white flower are produced.

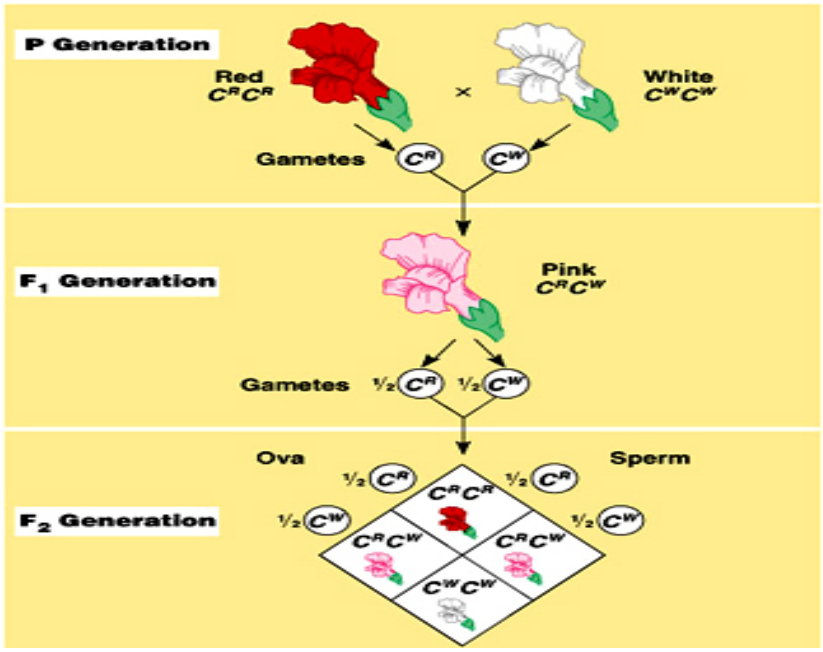


Figure 11
An example of Incomplete dominance

www.yahoo.com images

Now do a simple activity by filling up the blanks with the correct answers.

If BB – black
bb - white **P_1** **BB x bb**

F_1 ____(gray)

(self-fertilized) Bb x Bb

F_2 BB Bb Bb bb

___ ____ ____ ____

(give the phenotypes)

Key to answers on page 31.

Now that you are familiar with incomplete dominance, let us move on to co-dominance.

Codominance

Another example that is non-Mendelian is **codominance**. What is co-dominance? Codominance describes a situation in which both alleles are expressed at the same time. The hybrid organism shows a third phenotype - not the usual "dominant" and not the "recessive" one… but a third, different phenotype.

Figure 12. Codominance
www. yahoo.com images

The observed red and white striped petals of some carnation plants are example of codominance. Another codominance is shown in the roan coat of cows, where both brown and white hair colors appear (see Figure 12).

Multiple Alleles

Do you know your blood type? What about your parent's blood type? Do you know that your blood type could be inherited? Some issues on parentage can be resolved through blood typing.

It is true that individuals within a population have two alleles per gene. However, ***multiple alleles*** (3 or more) may exist for that gene within a population. A good example of multiple alleles is the ***ABO*** blood group of humans. A single gene controls ABO blood type.

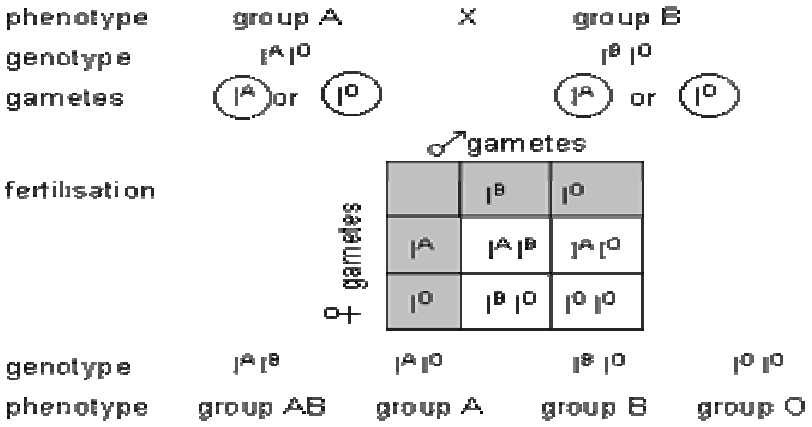
But there are three common alleles of this gene in human populations - I^A, I^B, and I^o. The I^A and I^B are dominant over I^O. Individuals with genotype I^AI^A or genotype I^AI^O have blood type A. Those with genotype I^BI^B or genotype I^BI^O have blood type B. The I^A and I^B alleles are codominant, thus individuals with genotype I^AI^B have blood type AB.

Examine the table 2 below on the different blood groups.

Table 2

Phenotype (blood group)	Genotypes	antigens on red blood cells	plasma antibodies
A	I^AI^A, I^AI^O	A	anti-B
B	I^BI^B, I^BI^O	B	anti-A
AB	I^AI^B	A and B	none
O	I^OI^O	none	anti-A and anti-B

The cross below shows how all four blood groups can arise from a cross between a group A and a group B parent.



Notice that a heterozygous blood type A and B can produce offspring with blood Type O. But all blood Type O parents can only produce Type O children.

Lesson 3. DNA: the Genetic Material

In the last previous two lessons we discussed the patterns of inheritance in living organisms based on Mendel's Laws. Now, it is necessary for you to know in detail the "factors" or genes that control inheritance that we repeatedly discussed.

What is a ***gene***? A gene is a segment of DNA that encodes a unique protein that performs a specialized function in the cell. A gene is capable of storing information and capable of self-replication and can undergo mutations. But how does something so small contain all the genetic information of an organism? The answer to this question lies in the chemical make up of DNA.

The chemical composition of DNA

DNA, which stands for ***deoxyribonucleic acid***, is found within the nucleus of every cell. Your DNA is like your thumbprint. It is yours and yours alone. Unless you have an identical twin, no one else in this world has exactly the same DNA as you. DNA holds the genetic information needed to make and control all cellular activities within a living organism.

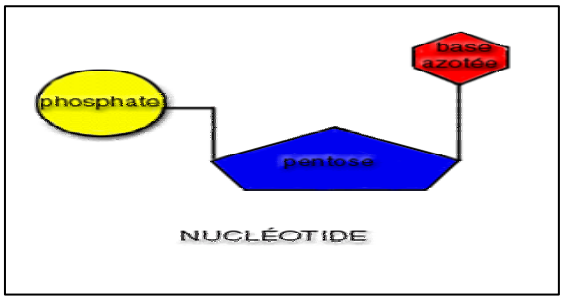


Figure 13
www.yahoo.com mages

Examine figure 13. It shows the composition of a DNA molecule.

DNA contains four bases: adenine **(A),** guanine **(G),** cytosine **(C),** and thymine **(T).** A and G are double-ring structures called **purines**; T and C are single-ring structures called **pyrimidines**. The nucleotide is the building block of DNA. It is made up of four bases, a five-carbon sugar deoxyribose, and a phosphate group.

Watson and Crick Model

In 1953, James Watson and Frances Crick worked out that DNA is like a "double helix". A helix is a screw-shaped spiral. The DNA is double helix because of the two strands which wind around each other. The double helix DNA is like a winding staircase. The two sugar-phosphate backbones make up the sides and the base pairs make up the rungs or steps of the winding staircase.

The model shows that paired nucleotide, which always occur as A-T or G-C, are linked by ***hydrogen bonds.*** This is called the complementary base pairing. Figure 14 illustrates Watson and Crick model.

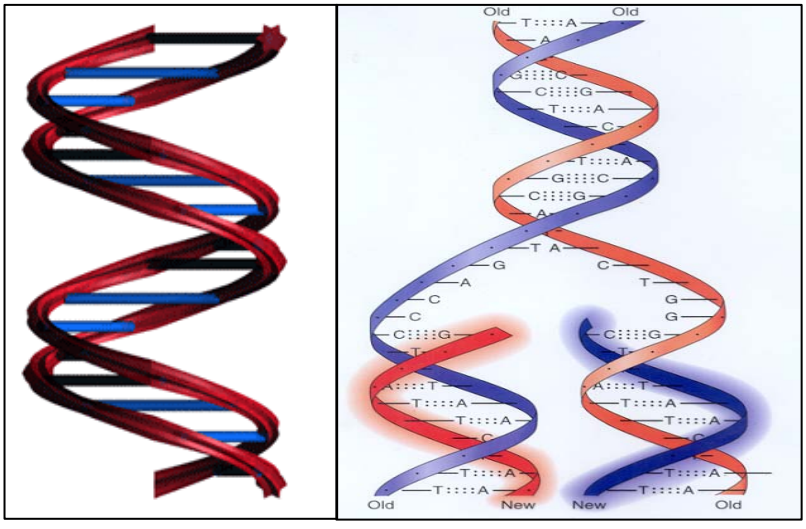


Figure 14
Watson and Crick Model of DNA (www.yahoo.com images)

Why is DNA Important?

All the characteristics that you have are affected by the DNA in your cells. It controls the color of your eyes, color of your hair, complexion, height and many more. These characteristics, just like what we have mentioned in the last two lessons, are traits that can be inherited just like those in pea plants. How traits appear in you depends on the kind of proteins your cells make. DNA stores the blueprints for making proteins.

How DNA Copies Itself

What is the process by which DNA copies itself? The following are the events while DNA copies itself:

- Step 1. An enzyme breaks the bond between the nitrogen bases. The two strands of DNA split.
- Step 2. The bases attached to each strand then pair up with the free nucleotides found in the cytoplasm.
- Step 3. The complementary nucleotides join to form new strands. Two new DNA molecules, each with a parent strand and each with a new daughter strand, are formed.

The DNA replication is known as semi-conservative replication, because one of the old strands is conserved in each daughter molecule. Figure 15 illustrates the semi conservative replication of DNA.

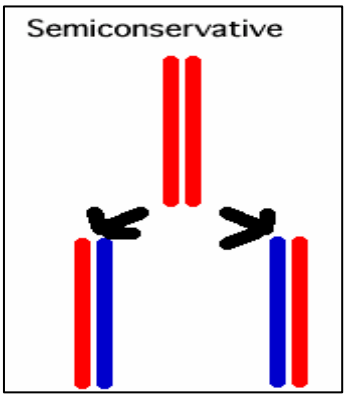


Figure 15
Semi-conservative DNA Replication
(www.yahoo.com images)

So now you are familiar with the DNA molecule? The next topic that we will discuss is another nucleic acid patterned from the DNA, the RNA.

What is RNA?

RNA stands for **ribonucleic acid.** Like DNA, RNA is a long strand made up of building blocks called nucleotides. But unlike DNA, RNA has a single chain and does not entwine in a double helix. Table 3 shows how DNA is compared to RNA. Figure 16 illustrates the structure of RNA.

RNA is a single stranded molecule with no helix. The four bases are guanine, cytosine, adenine, and ***uracil*** instead of thymine.

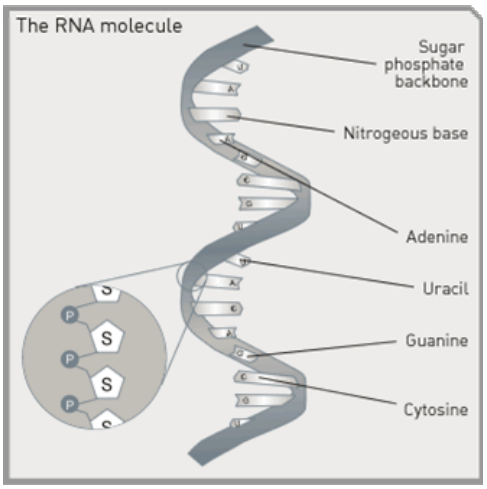


Figure16. The RNA Structure
www.yahoo.com images

Table 3. DNA Compared to RNA

	DNA	RNA
sugar	Deoxyribose	Ribose
bases	A,T,G,C	A,U,G,C
strands	Double strands	Single strand
helix	yes	No

What you will do

Activity 3.1 DNA Replication

Direction: Provide the correct base pair on the columns provided.

Split DNA (old strand)	New DNA strand	Split DNA (old strand)	New DNA strand
A		T	
T		A	
T		A	
A		T	
G		C	
G		C	
C		G	
A		T	
T		A	
G		C	
C		G	
A		T	
T		A	
T		A	
G		C	
C		G	
C		G	

Key to answers on page 31.

What you will do

Self-Test 3.1

1. Describe the composition of genetic material.
2. Describe DNA replication.

Key to answers on page 31.

Translating the code of life: From DNA to RNA to protein.

Proteins control the activities of the cell, and so the life of the entire organism. But, how does DNA make a unique protein that will perform special function?

The following are the steps in making proteins:

I. The DNA is inside the nucleus. It contains the information for making proteins. This information has to be copied or transcribed by the RNA called messenger RNA (mRNA).
II. The copied information called codon, which is made up of three consecutive nitrogenous bases, is sent to the cytoplasm where it will enter the ribosomal RNA.
III. Once inside the ribosome, translation begins, meaning, the transfer of RNA (tRNA) from the cytoplasm starts to bring the anticodon, the three consecutive nitrogenous pairs, that fits the mRNA codon. A codon is a base triplet of nucleotides in mRNA which calls for an amino acid. Each anticodon represents one type of amino acid. Amino acids are the basic units of protein molecules.
IV. When all codons are converted into amino acids, translation stops and a protein molecule is produced.

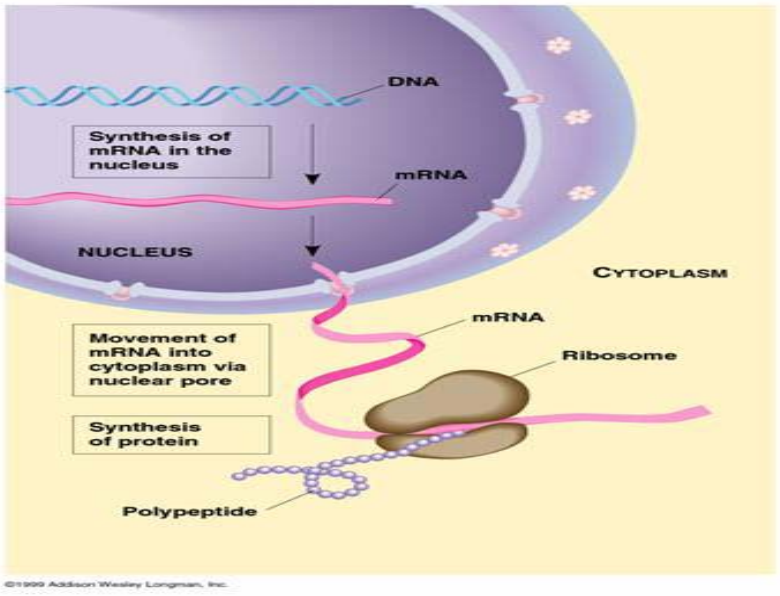


Figure 17. Protein synthesis
www.yahoo.com images

Always remember this: genes make proteins, proteins make cells, cells make tissues, tissues make organs, organs make organ systems, and organ systems make you!

Biotechnology

Another very interesting topic in science today is biotechnology. What is biotechnology? The term refers to any technique that uses living organisms, or parts of organisms, to make or modify products, improve plants or animals, or to develop microorganisms for specific uses. Are you familiar with the latest biotechnologies? Well, under this topic we are going to discuss some very familiar biotechnologies.

What is Genetic Engineering?

Genetic engineering is a process of altering the genes which you find in all living things. It involves the transfer of genes or parts of DNA from one organism to another. Organisms whose genes are altered or modified for specific purposes are called ***transgenic organisms***.

What are the uses of genetic engineering?

The purposes of doing genetic engineering are many and various. A range of them are listed below. These include:

- repairing a genetic "defect" (as with the current early trials of gene therapy in humans);
- enhancing an effect already natural to that organism (e.g. to increase its growth rate);
- increasing resistance to disease or external damage (e.g. crops - blight, cold or drought);
- getting a micro-organism to produce human insulin for diabetics, or a sheep to produce a human blood-clotting protein in her milk, in both cases a transgenic method; and
- getting a tomato to ripen without going squashy - this can be done simply by taking one of its own genes, turning its "pattern" upside down and putting it back again!

Isn't this amazing? Continue reading the modules and enjoy

What is Cloning?

In 1997, a 7-month-old sheep named Dolly became a celebrity (Figure 18). Do you know why? Dolly is the first cloned animal. What is cloning? Cloning is a method that scientists use to produce a genetic copy of another individual. In other words, Dolly is a clone of her mother.

Figure 18
www.yahoo.com images

Well, actually, Dolly had three mothers. One mother gave Dolly her DNA, one mother supplied an egg, and the third mother, her surrogate mother, gave birth to her. Isn't this interesting?

Normally, an animal gets half of its DNA from its mother and half from its father. Dolly is an identical twin of the mother who gave her DNA. But Dolly is six years younger. However, Dolly and her mother are not identical in every way. Since Dolly and her "DNA mother" have different experiences, they are different in many ways. Like human twins, clones have unique personalities. Unluckily, just last year, Dolly, the first cloned sheep died after more or less 7 years of survival.

Congratulations! At last you are through with the module. Did you enjoy it? Before you end this module answer the self-test below and proceed with the summary and posttest.

What you will do

Self-Test 3.2

1. What is genetic engineering? Are you in favor of genetic engineering? Why?
2. What do you think are some of the issues related to biotechnology? Why do you consider them as issues?

Key to answers on page 32.

Let's Summarize

1. Heredity is the study of how traits are passed on from the parents to the offspring. Genetics is the study of heredity and variation.
2. Monohybrid cross involves a cross using a single factor or character trait.
3. Dihybrid cross involves a cross using two factors or character traits.
4. In Genetics, the two factors mentioned by Mendel are called alleles. These alleles could be dominant or recessive.
5. Alleles can be represented by paired letters and referred to as the individual ***genotype.*** The genotype refers to the genetic composition of the person.
6. The ***phenotype*** is the physical appearance or feature of the person.
7. Identical alleles are called homozygous while dissimilar alleles are called heterozygous.
8. **The Law of Segregation** states that during gamete formation, the pair of factors segregate or separate from each other.
9. The **Law of Recombination** states that during fertilization, the genes come together again to form new combinations.
10. The Punnett square is a diagram that allows us to determine the possible combinations of genes in a given cross.
11. A gene is a segment of DNA that encodes a unique protein that performs a specialized function in the cell.
12. DNA stands for deoxyribonucleic acids. It is a double-stranded molecule.
13. RNA stands fro ribonucleic acids. It is a single-stranded molecule.
14. DNA contains four bases: adenine **(A),** guanine **(G),** cytosine **(C),** and thymine **(T).** A and G are double-ring structures called **purines**; T and C are single-ring structures called **pyrimidines**. The nucleotide is the building block of DNA. It is made up of four bases, a five-carbon sugar deoxyribose, and a phosphate group.
15. The DNA replication is known as semi - conservative replication, because one of the old strands is conserved in each daughter molecule.
16. Protein synthesis involves transcription and translation.

17. The situation in which the F_1 does not resemble either parent is called **incomplete dominance**. In this case, no allele is completely dominant over the other.
18. **Codominance** describes a situation in which both alleles are expressed at the same time.
19. **Biotechnology** refers to any technique that uses living organisms, or parts of organisms, to make or modify products, improve plants or animals, or to develop microorganisms for specific uses.
20. Genetic engineering is a process of altering the genes which you find in all living things. It involves the transfer of genes or parts of DNA from one organism to another. Organisms whose genes are altered or modified for specific purpose are called ***transgenic organisms***.
21. Cloning is a method that scientists use to produce a genetic copy of another individual.

Posttest

I. Multiple Choice. Choose the letter of the correct answer. Write the chosen letter on a separate sheet of paper.

1. Who is considered as the father of Genetics?
   a. Darwin
   b. Linnaeus
   c. Gregor Mendel
   d. Hugh de Vries

2. Punnett squares are used to _____ the outcome of crosses of traits:
   a. assure
   b. dominate
   c. number
   d. predict

3. Which of the following are located in chromosomes?
   a. Carbohydrates
   b. DNA codes
   c. Pedigrees
   d. Zygotes

4. A codon is composed of:
   a. 1 base
   b. 2 bases
   c. 3 bases
   d. 4 bases

5. A nucleotide is composed of:
   a. base only
   b. protein only
   c. sugar only
   d. sugar, phosphate and base

6. The science that deals with the study of how traits are inherited from parents to offsprings is called
   a. Economics
   b. Genetics
   c. Politics
   d. Polygenic

7. The component in the nucleus of a cell that codes and stores genetic information is called:
    a. DNA
    b. Nucleolus
    c. Nucleoplasm
    d. RNA

8. An organism with two identical alleles for a trait is called:
    a. heterozygous
    b. homologous
    c. homozygous
    d. polyploid

9. Which refers to the different forms of genes representing a certain trait?
    a. allele
    b. chromosome
    c. hybrid
    d. locus

10. What do you call a combination of the dominant and recessive genes present in the cells of an organism?
    a. genotype
    b. lectotype
    c. neotype
    d. phenotype

11. Which of the following is NOT a Mendelian law of inheritance?
    a. In every organism, there is a pair of factors that control the appearance of a particular trait.
    b. The first filial generation does resemble either parent. Therefore no allele is dominant over the other.
    c. During gamete formation, the pair of factors segregates or separates from each other.
    d. During fertilization, the genes come together again to form new combinations.

12. What is a monohybrid cross?
    b. A cross using a single factor or character.
    c. A cross using two factors or characters.
    d. A diagram that determines the possible combinations of traits.
    e. None of the above.

13. All are Non-Mendelian laws of inheritance EXCEPT,
    a. codominance
    b. multiple alleles
    c. incomplete dominance
    c. incomplete dominance
    d. law of segregation

14. Which of the following describes DNA replication?
    a. parallel
    b. anti-parallel
    c. conservative
    d. semi-conservative

15. What is genetic engineering?
    a. It involves transcription and translation.
    b. A process of altering the genes, which you find in all living things.
    c. A method that scientists use to produce a genetic copy of another individual.
    d. None of the above.

II. Problem Solving (5 points each)

1. Show the given cross below:

   a. Axial flower (A) in peas is dominant over terminal flowers (a) in peas. A homozygous axial pea plant is crossed with a homozygous terminal pea plant. What will be the genotypes of all the possible offspring?

   b. In man, brown eyes (B) is dominant over blue eyes(b). If a homozygous brown-eyed man marries a blue-eyed woman, what percent of their children will be blue-eyed?

Key to answers on page 32.

Key to Answers

Pretest

I.

1. c
2. d
3. b
4. c
5. d
6. b
7. a
8. c
9. a
10. a
11. b
12. a
13. d
14. d
15. b

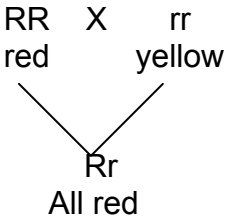
II.

1. Result:
   Genotypes of all possible offspring: All Yy
   Phenotype of offspring: All yellow

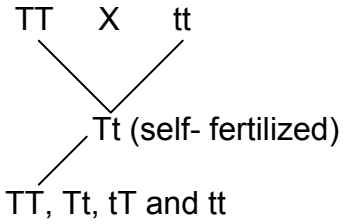
2. Result:
   Genotypes of all possible offspring: LL, Ll, and ll
   Phenotypes of all possible offspring: LL and Ll = long wings
   ll = short wings

Lesson 1

Try this:



Again Try this:



Do this:

Dominant	Recessive	Dominant (letters only)	Recessive (letters only)
Tall	Short	**TT**	**tt**
Curly hair	Straight hair	**CC**	**cc**
Brown eyes	Blue eyes	**BB**	**bb**
Unattached earlobe	Attached earlobe	**AA**	**aa**

Self-Test 1.1

1. Dominant trait - a form of a trait that appears to dominate or mask another form of the same trait, while recessive trait is a form of a trait that appears least often in offspring.
2. Monohybrid cross involves a cross using a single factor or character trait, while dihybrid cross involves a cross using two factors or character traits.
3. Homozygote - an organism that has two identical alleles for a trait while heterozygote refers to an organism that has two different alleles for a trait.
4. When two different pure breed parents are crossed, the first generation shows only one trait (the dominant) the other trait is hidden (recessive).
5. In the second generation he got plants that showed the dominant trait to everyone plant that showed the recessive trait

Activity 1.2

Ovum / sperm	T G	T g	t G	t g
T G	TTGG	TT Gg	Tt GG	Tt Gg
T g	TT gG	TT gg	Tt gG	Ttgg
t G	tT GG	tT Gg	tt GG	ttGg
t g	tT gG	tT gg	ttgG	ttgg

1. There are 9 tall and green peas; 3 short green; 3 tall yellow, and 1 short yellow peas.
2. The phenotypic ratio is 9:3:3:1

Self-Test 1.2

Ovum / sperm	A B	A b	a B	a b
A B	AABB	AABb	AaBB	AaBa
A b	AAbB	AAbb	AabB	Aabb
a B	AaBB	AaBb	aaBB	aaBb
a b	aAbB	aAbb	aabB	aabb

1. The genotypic ratio of the cross is 4:2:2:2:2:1:1:1:1:1 or 4 AaBb; 2 AaBB; 2 AABb: 2 aaBb: 2Aabb: 1 aaBB: 1 AABB: 1AAbb: and 1aabb

Lesson 2

Activity 2.1 Answer for Incomplete Dominance

If BB – black
bb - white P_1 BB x bb

F_1 Bb (gray)

(self-fertilized) Bb x Bb

F_2 BB Bb Bb bb
(black) (gray) (gray) (white)

Lesson 3

Activity 3.1
DNA replication

Split DNA (old strand)	New DNA strand (Answer)	Split DNA (old strand)	New DNA strand (Answer)
A	T	T	A
T	A	A	T
T	A	A	T
A	T	T	A
G	C	C	G
G	C	C	G
C	G	G	C
A	T	T	A
T	A	A	T
G	C	C	G
C	G	G	C
A	T	T	A
T	A	A	T
T	A	A	T
G	C	C	G
C	G	G	C
C	G	G	C

Self Test 3.1

1. DNA contains four bases: adenine **(A),** guanine **(G),** cytosine **(C),** and thymine **(T).** A and G are double-ring structures called **purines**; T and C are single-ring structures called **pyrimidines**. The nucleotide is the building block of DNA. It is made up of four bases, a five-carbon sugar deoxyribose, and a phosphate group.

The double helix DNA is like a winding staircase. The two sugar-phosphate backbones make up the sides and the base pairs make up the rungs or steps of the winding staircase.

2. The DNA replication is known as semi-conservative replication, because one of the old strands is conserved in each daughter molecule. In step 1, an enzyme breaks the bond between the nitrogen bases. The two strands of DNA split. In step 2, the bases attached to each strand then pair up with the free nucleotides found in the cytoplasm. In step 3, the complementary nucleotides join to form new strands. Two new DNA molecules, each with a parent strand and each with a new daughter strand, are formed.

Self-Test 3.2
Possible answers:

1. Genetic engineering is a process of altering the genes which you find in all living things. Yes, because it can improve the economic condition of the people in one way, but may also cause some harm in the future.
2. Some of the issues related to biotechnology are related to the outcome of this technology on the health and environmental condition of the people in the near future. It is said that only God can modify his creations. We are not supposed to play GOD.

Posttest

I.

1. c	6. b
2. d	7. a
3. a	8. c
4. c	9. a
5. d	10. a

II. Given the following cross:

1. AA X aa

Aa (All heterozygous axial flowers)

2. BB X bb

Bb (All or 100% brown-eyed)

References

Books:

Johnson, G. (1998). *Biology visualizing life*. Austin, USA: Holt, Rinehart and Winston Co. Inc.

Lewis, R. (1998). *Life.* (3rd Ed.) USA: WCB McGraw- Hill Co Inc.

Mader, S. (1998). *Biology.* (6th Ed.) USA: WCB McGraw- Hill Co. Inc.

Merril. (1994). *Life science*. Ohio, USA: Glencoe Division, Macmillan/McGraw-Hill Publishing Co.

Wong, H. K. & Dolmatz, M.S. (1990). *Biology: The key ideas*. Englewoods, NJ: Prentice Hall.

Electronic sources:

Retrieved March 15, 2005 http://www.mcrel.org/compendium/Benchmark.asp?SubjectID =2&StandardID=4

Retrieved March 16, 2005 http://www.accessexcellence.org/

Retrieved March 20, 2005 http://sciencespot.net/Pages/classbio.html

Retrieved March 25, 2005 http://www.accessexcellence.org/AE/AEC/index.html

Retrieved April 4, 2005 http://gslc.genetics.utah.edu/units/cloning/