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DEPARTMENT OF EDUCATION

Science

Quarter 1 – Module 7
NON-MENDELIAN PATTERNS OF INHERITANCE

Source: https://khn.org/news/genetic-insights-about-health-risks-limited-by-lack-of-diversity-study-finds/

DEPARTMENT OF EDUCATION
REGION V BICOL

Science– Grade 9
Quarter 1 – Module 7: NON-MENDELIAN PATTERNS OF INHERITANCE

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MOST ESSENTIAL
LEARNING
COMPETENCY

Explain the different patterns of Non-Mendelian inheritance.

Supplementary Learning Module for Junior High School Learners

LESSON 7

NON-MENDELIAN PATTERNS OF INHERITANCE

In the previous module you learned about the structure and composition of the genetic material which is the DNA. The DNA makes up the genes and chromosomes. Genes are segments in the chromosomes that carry the traits of an individual. Some traits are inherited following the Mendelian Principles of Inheritance but others do not. These traits are inherited through non-Mendelian patterns.

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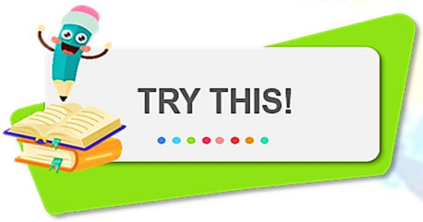
What are some of these traits that do not follow Gregor Mendel's Principle of Dominance? How do they differ from Mendel's work? Read on and perform the activities prepared for you in this module.

At the end of the module, you should be able to:

- describe the different types of non-Mendelian patterns of inheritance (incomplete dominance, codominance, multiple allelism, and polygenic pattern);
- solve sample problems on non-Mendelian patterns of inheritance;
- compare Mendelian and non-Mendelian patterns of inheritance;
- realize that not all traits are inherited the same way through picture analysis.



Directions: Identify what is asked or described in each item then write the letter of the correct answer.

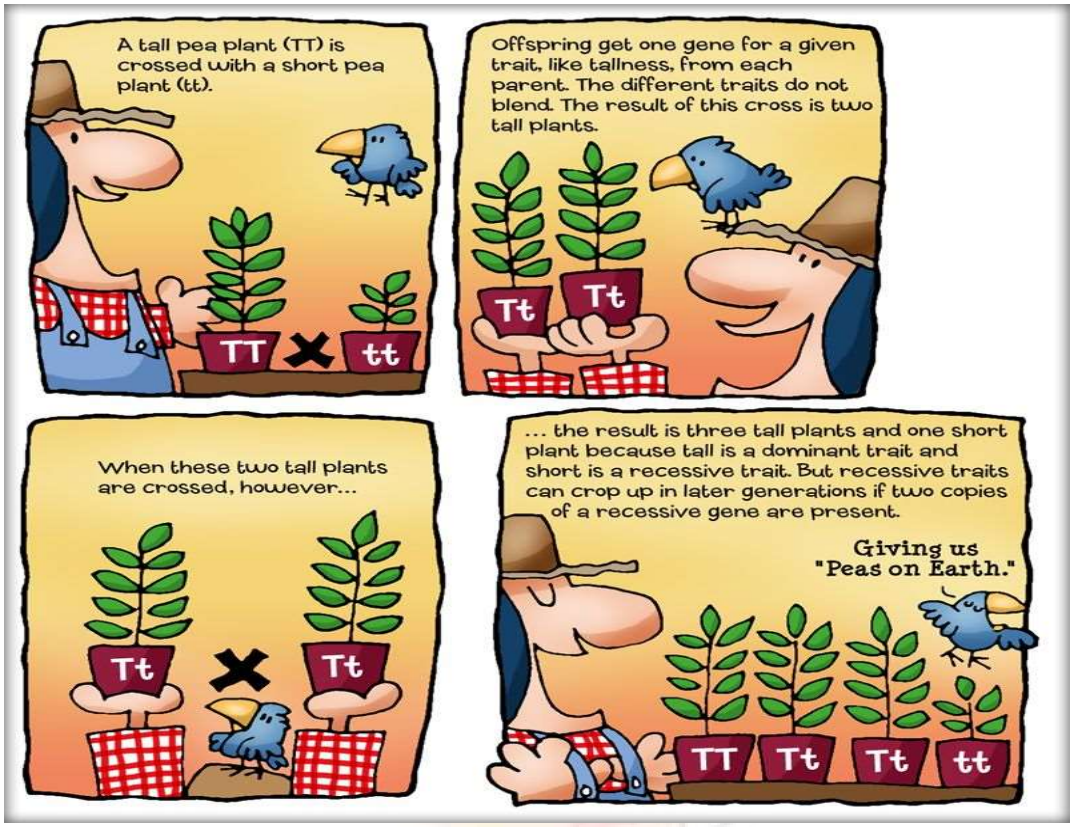
1. What would be the possible characteristics of the flowers if a red four o'clock plant is crossed with a pink four o'clock plant?
   a. all flowers will be red
   b. some will be pink, others will be red
   c. some flowers will be white, others will be red
   d. all flowers will be pink
2. A man with blood type O marries a woman with blood type AB. What would be the probable blood types of their children?
   a. A, AB, O
   b. A, B
   c. A, B, O
   d. AB, A, B

3. Which of the following traits in humans is controlled by polygenes?
   a. height
   b. blood type
   c. color of hair
   d. tongue rolling
4. In codominance, heterozygotes
   a. display the dominant trait
   b. display the recessive trait
   c. display both characteristics
   d. display the blended characteristic
5. Polygenes
   a. are governed by two alleles
   b. controlled by codominant genes
   c. controlled by several genes
   d. display a fixed number of phenotypes

Hi! How did you find the test?

I know these are new information for you. Just check your answers using the answer key section. But don't worry if you got a low score. This just means that there are more things that you can learn from this module. So, hop on!

Directions: Read the comic strip below and answer the questions that follow.



Source: https://www.pinterest.ph/pin/420523683925513256/

Figure 1

Questions:

1. What pattern of inheritance is shown here?_____
2. What characteristic is expressed in the F_1 generation, dominant or recessive trait?_____
3. When does the recessive trait appear in the offspring, F_1 or F_2 generation? _____
4. In the Mendelian pattern, does the recessive trait come out in heterozygotes? Yes or No._____

The Mendelian pattern of inheritance follows the Principle of dominance wherein the **dominant trait masks the expression of the recessive trait**. The recessive trait comes out only in the F_2 generation when it is homozygous.

NON-MENDELIAN PATTERNS OF INHERITANCE

A. Incomplete dominance

Study the illustration below and answer the guide questions:

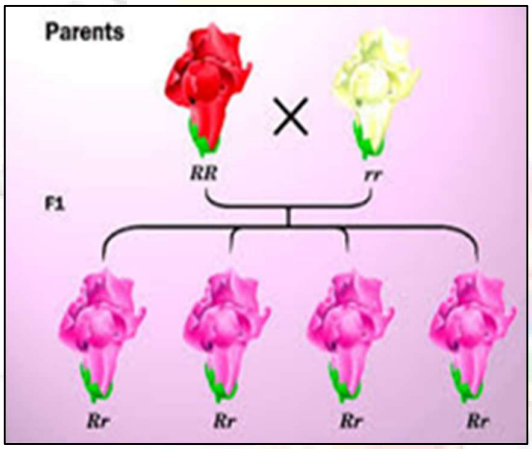


Figure 2

Questions:

1. What is the color of the flower of the F1 generation when a plant with red flower is crossed with a plant with white flower?
   _____
2. Describe what happens to the phenotype of the offspring of the F_1 generation.
   _____
3. Look at the genotypes of the parents and F1 generation. What is the genotype of the plant with pink flowers? _____ What are the genotype of the parents? _____
4. Give other example of organism that shows the same pattern of inheritance.
   _____

Solve a sample problem using Punnet square. Use the sample below as your guide.

Red flower x Pink flower

	R	R
R	RR	RR
r	Rr	Rr

	genotypes	phenotypes
	RR - 2	Red - 2
	Rr - 2	Pink - 2
ratio	2:2	2:2

5. Pink flower x Pink flower

	genotypes	phenotypes
ratio		

oncepts

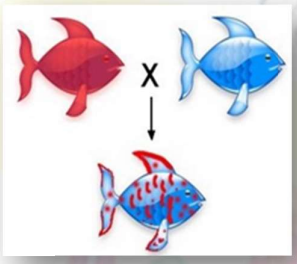
plete dominance is a form of intermediate inheritance in which one **allele** for a specific trait is not completely dominant over the other allele. This results in a third **phenotype** in which the expressed physical trait is a combination of the dominant and recessive phenotypes.

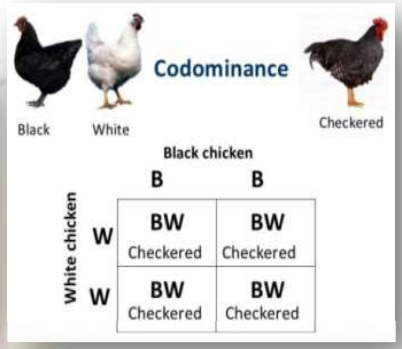
EXPLORE

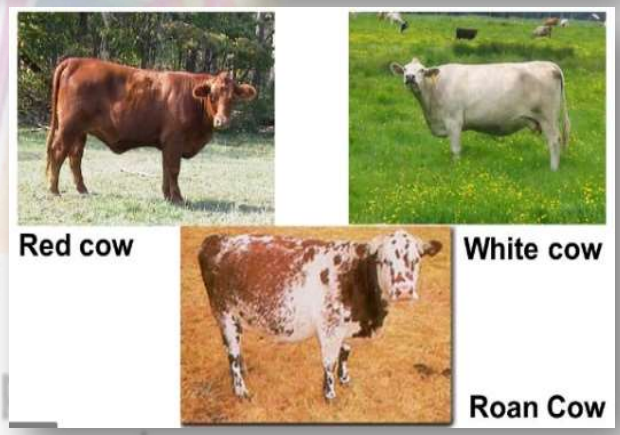
Study closely how the characteristics of the parents are expressed in the offspring.

Examples in plants

Examples in animals







Adapted from Grade 9 *LM DRAFT 4.29.2014* pdf pp. 5

Figure 3. Examples of codominance in plants and in animals

Questions:

1. Describe what happens to the characteristics of the offspring as compared to that of the parents. _____

2. Can you identify which characteristic of the parents is dominant or recessive? _____

In humans, there are two characteristics that are codominant: **AB blood type** and **sickle-cell anemia**. Study the illustrations below and answer the questions that follow.

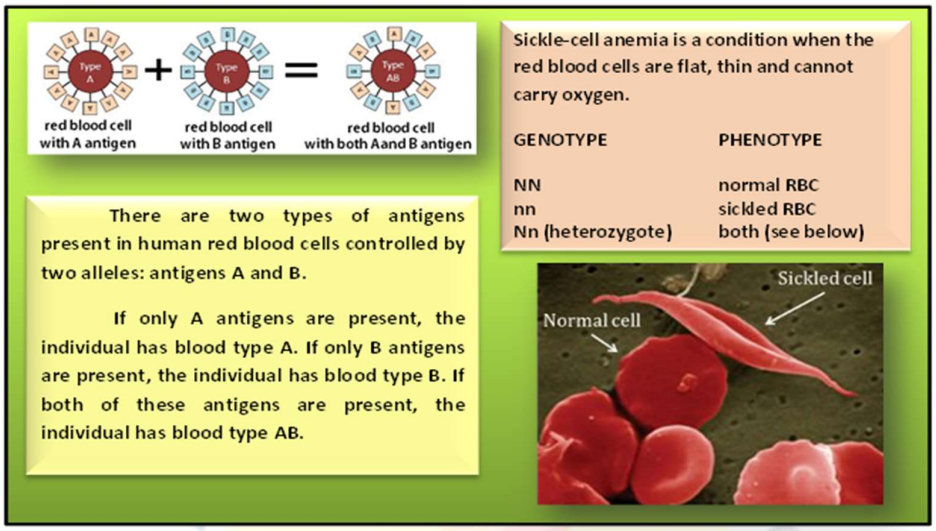


Figure 4. Codominant traits in humans

Consider the following situations and perform the required task.

A B C

Write the genotypes of the following variety of this plant based on their flowers: (choices: RR, rr, Rr)

1. Solve using Punnet square the following cross and write the genotypic and phenotypic ratios.

A. RR x Rr

	genotypes	phenotypes
ratio		

B. rr x Rr

	genotypes	phenotypes
ratio		

2. A cow with red fur (RR) is mated with another cow with white fur (rr). The resulting offspring is a roan, a cow with both red and white fur (Rr). What would be the genotypic and phenotypic ratios of the cross of two heterozygotes?

C. Rr x Rr

	genotypes	phenotypes
ratio		

3. What would be the possible blood types of a couple with both blood type AB?

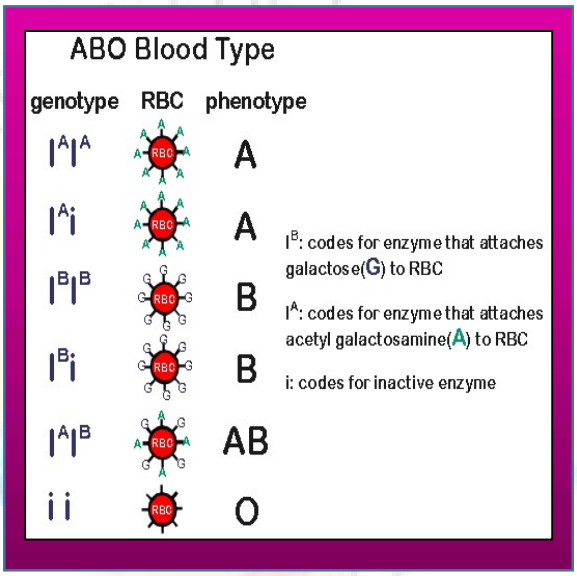
D. AB x AB

	genotypes	phenotypes
ratio		

Key Concepts

In codominance, both alleles are expressed equally in the phenotype of the heterozygote.

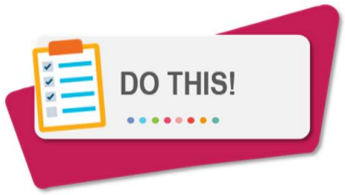
Some traits are controlled by more than two alleles. These alleles are found in different chromosomes so that there could be several combinations in a population since only two alleles can be present in an individual.



An example of trait with multiple alleles is the **ABO blood group** in humans which is controlled by three alleles. Analyze the illustration at the right.

Questions:

1. How many types of alleles are there? ____
   What are these? _____
2. How many possible genotypes can be formed out of these alleles? _____
3. How many phenotypes can be expressed? _____
4. Which is dominant, allele A or B? ___
5. Which allele is recessive? _____



Try solving the following cross below using Punnet square.

1. **AA x AO**

	genotypes	phenotypes
ratio		

2. **AB x O**

	genotypes	phenotypes
ratio		

Key Concepts:

- In humans, there are four blood types (phenotypes): A, B, AB, O.
- Blood type is controlled by three alleles: A, B, O.
- O is recessive, two O alleles must be present for a person to have type O blood.
- A and B are codominant. If a person receives an A allele and a B allele, their blood type is type AB.

B. Polygenic pattern of inheritance

So far the pattern of inheritance we discussed involved only two or three alleles of a gene. However there are some traits that are controlled by several genes found in different chromosomes. These genes all contribute to the expression of the trait. Some of these traits in humans that are controlled by **polygenes** are *skin color, height, IQ, eye color* and *weight*. In plants, examples include *length of maize, number of leaves in a plant, color of grains in maize and height* of the plant. In animals, *size, longevity and resistance to diseases* are some examples.

Suppose the skin color is controlled by 3 genes A, B and C. The dominant variants (A, B, and C) control the production of more melanin in the skin and the recessive alleles (a, b and c) control light skin color because less melanin is produced.

Study the Punnet square below showing the results of the cross between two heterozygotes or mulatto (AaBbCc x AaBbCc).

Multiple Gene (Polygenic) Inheritance

Gametes	ABC	ABc	AbC	Abc	aBC	aBc	abC	abc
ABC	6	5	5	4	5	4	4	3
ABc	5	4	4	3	4	3	3	2
AbC	5	4	4	3	4	3	3	2
Abc	4	3	3	2	3	2	2	1
aBC	5	4	4	3	4	3	3	2
aBc	4	3	3	2	3	2	2	1
abC	4	3	3	2	3	2	2	1
abc	3	2	2	1	2	1	1	0

Table 1. Polygenic inheritance in people showing a cross between two mulatto parents (AaBbCc x AaBbCc). The offspring contain seven different shades of skin color based on the number of capital letters in each genotype.

Answer the following questions:

1. How many possible shades of skin color are there? _____

The numbers on the boxes indicate the number of capital letters present in the genotype. The shade of the boxes shows the phenotype of the offspring.

2. Complete the sentences:
   a. The higher the number in the box, the _____ (*darker/lighter*) the shade.
   b. The more capital letters present in the genotype, the _____ *(darker/lighter)* the skin color.
   c. The more genes that control the production of melanin there are in the genotype, _____ the *(darker/lighter)* the skin color.

3. What is the probability of the couple to have a child with very light skin? _____
   To have very dark skin? _____

What do you think is the effect of this pattern of inheritance to the diversity of skin color in the human population?

_____
_____
_____

Key Concepts

In polygenic pattern of inheritance, many genes control a trait, each usually contributing a little to the expression of the phenotype. Although there are dominant and recessive genes, the overall phenotype of the organism is a result of the complex interaction of these genes and with the environment. The resulting phenotypes are a continuous gradient, which when graphed form a bell-shaped curve with the dominant and recessive traits at the extreme ends of the curve.

In the case of skin color, the more dominant genes present in the genotype, the more melanin is produced, the darker the skin color especially when exposed to light.

This pattern of inheritance is responsible mostly for the diversity of organisms on earth. This explains why humans differ in height, weight, intelligence quotient or IQ and skin color. No two plants produce exact size and number of leaves or grains.

Direction: Analyze and solve the word problems below.

1. Pink-flowered plant is crossed with a red-flowered plant of the same kind. This plant exhibits codominance. What are the possible genotypes and phenotypes of the next generation? Solve using Punnet square.

2. Mr. Chang has blood type B while his wife has type A. Mr. Chang told his wife that their son, Yuan with blood type O is not his child. As a student of Biology and has taken up Genetics, how would you answer and explain to Mr. Chang that indeed Yuan is his son? Use Punnet square to prove your point.

3. What is the probability that a man with blood type AB and a woman with blood type O will have a child with blood type AB? Use Punnet square to solve the problem.

Congratulations, you have finished Lesson 2 of this module.

For more detailed information and explanation, you can access the suggested internet links if you can.

Internet links:

1. Multiple gene (polygenic) inheritance
   https://www2.palomar.edu/users/warmstrong/lmexer5.htm
2. Polygenic Inheritance of Traits Like Eye Color and Skin Color
   https://www.thoughtco.com/polygenic-inheritance-373444
3. Non-Mendelian Genetics Practice Packet

I have learned that...

_____
_____
_____
_____

I wish to ask my teacher about...

_____
_____
_____
_____

ANSWER KEY

TRY THIS

6. B
7. B
8. A
9. C
10. C

A REVIEW

1. Mendelian Pattern of inheritance
2. dominant trait

3. F_2 generation
4. No

INCOMPLETE DOMINANCE

1. pink color
2. the phenotype is the intermediate characteristic of the phenotype of the parents
3. pink = Rr, red = RR, white = rr
4. other examples: chicken with blue feathers, tail lengths in dogs

DO THIS

1.

	R	r
R	RR	Rr
r	Rr	rr

	genotypes	phenotypes
	RR-1	Red - 1
	Rr - 2	Pink - 2
	rr - 1	White - 1
ratio	1:2:1	1:2:1

CODOMINANCE

1. The offspring display both the characteristics of the parents.
2. No

DO THIS

1. a = RR, b = rr, c = Rr

	R	R
R	RR	RR
r	Rr	Rr

2.

	genotypes	phenotypes
	RR-2	Red - 2
	Rr - 2	Combo- 2
ratio	2:2	2:2

	genotypes	phenotypes

	r	r
R	Rr	Rr
r	rr	rr

	Rr - 2	Combo -2
	Rr - 2	White - 2
ratio	2:2	2:2

3.

	R	r
R	RR	Rr
r	Rr	rr

	genotypes	**phenotypes**
	RR-1	Red fur – 1
	Rr - 2	Roan - 2
	rr - 1	White fur - 1
ratio	1:2:1	1:2:1

4.

	A	B
A	AA	AB
B	AB	BB

	genotypes	**phenotypes**
	AA - 1	Type A - 1
	AB - 2	Type AB - 2
	BB - 1	Type B - 1
ratio	1:2:1	1:2:1

5.

MULTIPLE ALLELISM

EXPLORE

1. THREE (A, B, O)
2. SIX
3. FOUR
4. BOTH ARE DOMINANT
5. O

DO THIS

3. AA x AO

	A	A
A	AA	AA
O	AO	AO

	genotypes	**phenotypes**
	AA - 2	Type A - 2
	AO - 2	Type A - 2
ratio	2:2	4:0

4. AB X O

	A	B
O	AO	BO
O	AO	BO

	genotypes	phenotypes
	AO - 2	Type A - 2
	BO - 2	Type B - 2
ratio	2:2	2:2

EXPLORE

1. SEVEN SHADES
2. a. darker
   b. darker
   c. darker
3. very light skin = 1/64, very dark skin = 1/64

EXPRESS YOUR VIEWS

Polygenic pattern of inheritance produces different shades and hues of colors of the skin so that there are several phenotypes among humans in the population around the world.

APPLY WHAT YOU HAVE LEARNED

1. **Rr x RR**

	R	r
R	RR	Rr
RR	RR	Rr

	genotypes	phenotypes
	RR - 2	Red - 2
	Rr - 2	Pink - 2
ratio	2:2	2:2

2. Mr. Chang – type B
   Mrs. Chang – type A
   Yuan – type O

	B	O
A	AB	AO
O	BO	OO

Yuan's blood type

3. **AB X O**

   ANSWER: ZERO POSSIBILITY

	A	B
O	AO	BO
O	AO	BO

REFERENCES

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