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Science
Quarter 1- LIVING THINGS
Module 3: Non-Mendelian Patterns of Inheritance

ALTERNATIVE DELIVERY MODE
ADM

Science – Grade 9
Alternative Delivery Mode
Quarter 1: Living Things Module 3: Non-Mendelian Patterns of Inheritance
First Edition, 2020

Published by the Department of Education
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Undersecretary: Diosdado M. San Antonio

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Printed in the Philippines by _____
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Science
Quarter 1- LIVING THINGS
Module 3: Non-Mendelian Patterns of Inheritance

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Introductory Message

This Self-Learning Module (SLM) is prepared so that you, our dear learners, can continue your studies and learn while at home. Activities, questions, directions, exercises, and discussions are carefully stated for you to understand each lesson.

Each SLM is composed of different parts. Each part shall guide you step-by-step as you discover and understand the lesson prepared for you.

Pre-tests are provided to measure your prior knowledge on lessons in each SLM. This will tell you if you need to proceed on completing this module or if you need to ask your facilitator or your teacher's assistance for better understanding of the lesson. At the end of each module, you need to answer the post-test to self-check your learning. Answer keys are provided for each activity and test. We trust that you will be honest in using these.

In addition to the material in the main text, Notes to the Teacher are also provided to our facilitators and parents for strategies and reminders on how they can best help you on your home-based learning.

Please use this module with care. Do not put unnecessary marks on any part of this SLM. Use a separate sheet of paper in answering the exercises and tests. And read the instructions carefully before performing each task.

If you have any questions in using this SLM or any difficulty in answering the tasks in this module, do not hesitate to consult your teacher or facilitator.

Thank you.

What I Need to Know

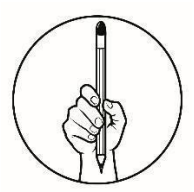
This module was designed and written with you in mind. It is here to help you master the Non-Mendelian pattern of inheritance. The scope of this module permits it to be used in many different learning situations. The language used recognizes the diverse vocabulary level of students. The lessons are arranged to follow the standard sequence of the course, but the order in which you read them can be changed to correspond with the textbook you are now using.

The module focuses on achieving this learning competency:

Explain the different Non-Mendelian Patterns of Inheritance (S9LT-Id-29)

After going through this module, you are expected to:

1. explain the incomplete dominance pattern of inheritance
2. describe codominant traits
3. determine all possible combinations of genes for a specific blood type
4. determine the probability of having a male and female gender
5. explain the sex-linked and sex influenced trait



What I Know

Choose the letter of the best answer. Write your answer on a separate sheet of paper.

1. Which statement is TRUE about incomplete dominance?
   A. It happens when two or more alleles control the inheritance of a character.
   B. It refers to traits that are controlled by genes located on the same-sex chromosomes.
   C. It occurs when two dominant alleles of a contrasting pair are fully expressed at the same time in a heterozygous individual.
   D. It occurs when the phenotype of the offspring is somewhere in between the phenotype of both parents

2. In cattle, roan coat color (mixed red and white hairs) occurs in the heterozygous (Rr) offspring of red (RR) and white (rr) homozygotes. Which cross would produce offspring in the ratio of 1 red: 2 roan: 1 white?
   A. RR x rr
   B. Rr x Rr
   C. RR x Rr
   D. Rr x RR

3. In the ABO blood group system among humans, a man with type AB blood marries a woman with type A blood. What possible blood type might their sons inherit?
   A. Type B or type O
   B. Type A or type O
   C. Type A or type AB
   D. Type A, type B, or type AB

4. Which of the following indicate the number of chromosomes and sex chromosomes of a male?
   A. 46, XY
   B. 48, XY
   C. 46, XX
   D. 48, XX

5. Color blindness is an example of an X-linked trait. Who are the possible carriers of the color-blindness trait?
    A. Men who are homozygous for the trait
    B. Men who are heterozygous for the trait
    C. Women who are homozygous for the trait
    D. Women who are heterozygous for the trait

6. What would be the parent's genotype for color, if a black offspring were produced from two white sheep parent?
    A. Heterozygous.
    B. Homozygous black
    C. Homozygous white
    D. Not enough information was given

7. What type of inheritance is observed when a long radish crossed with round radishes, result in all oval radishes?
    A. Codominance.
    B. Multiple alleles
    C. Complete dominance
    D. Incomplete dominance

8. An extra finger in humans is rare but is due to a dominant gene. When one parent is normal, and the other parent has an extra finger but is heterozygous for the trait, what is the probability that the first child will be normal?
    A. zero percent
    B. fifty percent
    C. twenty-five percent
    D. seventy-five percent

9. Which statement is TRUE in human, concerning a pair of alleles for a gene that controls a single characteristic?
    A. Both genes come from the father
    B. Both genes come from the mother
    C. The genes come randomly in pairs from either the mother or the father
    D. One gene comes from the mother and the other gene comes from the father

10. What are the possible phenotypic outcomes of an organism who is heterozygous for tallness (Tt) mated with a recessive (tt) individual?
    A. 3 tall offspring
    B. 4 tall offspring
    C. 4 dwarfs' offspring
    D. 2 tall, 2 dwarfs' offspring

11. What type of inheritance is expressed by genes located either on X or Y sex chromosomes?
    A. Codominance
    B. Multiple alleles
    C. Incomplete dominance
    D. Sex-linked inheritance

12. What pattern of inheritance is determined by offspring having a series of phenotypes?
    A. Codominance
    B. Multiple alleles
    C. Incomplete dominance
    D. Sex-linked inheritance

13. Which of the following represents an individual who is heterozygous for two genes?
    A. Aabb
    B. AAbb
    C. AaBb
    D. AABb

14. This refers to the family tree showing the inheritance of a trait over several generations.
    A. Pedigree
    B. Karyotype
    C. Dominant
    D. Punnett square

15. Which of the following best describes a genotype with a symbol of Dd?
    A. Dominant
    B. Recessive
    C. Heterozygous
    D. Homozygous

Lesson 1 Non-Mendelian Patterns of Inheritance

In Science 8 modules, you have discussed that cells divide to produce new cells and meiosis is one of the processes producing genetic variations in Mendelian patterns of inheritance. In this module, however, we will explain the different Non-Mendelian patterns of inheritance. Mendelian laws of inheritance have important exceptions. For example, not all genes show simple patterns of dominant and recessive alleles. We will explain them carefully throughout this module.

Here are some key questions for you to ponder after finishing this module:

1. Identify the characters whose inheritance do not conform with predicted outcomes based on Mendel's laws of inheritance.
2. Solve genetic problems related to incomplete dominance, codominance, multiple alleles, and sex-linked traits.
3. Identify the law not strictly followed in the Non-Mendelian inheritance.

What's In

Let us recall your understanding of concepts of Mendel's law of inheritance by predicting the possible offspring on a test cross using a Punnett square:

Red tomato fruit (R) is dominant over yellow fruit (r). In a test cross between a homozygous red tomato fruit plant and a tomato plant that has yellow fruit, what would be the genotypes of the parents?

Genotype: _____
Phenotype: _____

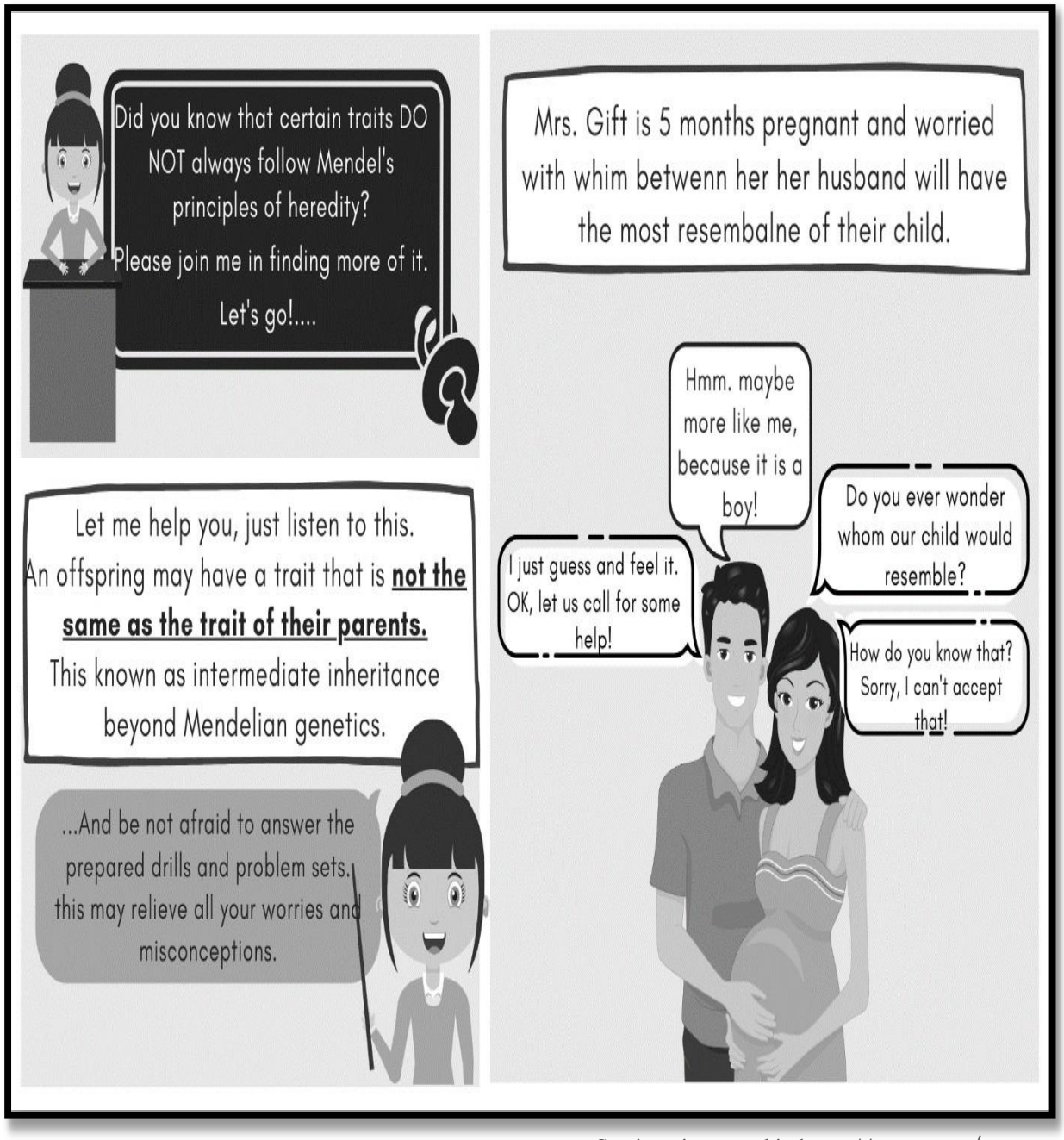
Questions:

a. What are the genotypes of the offspring?
b. What are the phenotypes?
c. If two of the F_1 generation from the above cross were mated, what would be the phenotypes and genotypes of the offspring?

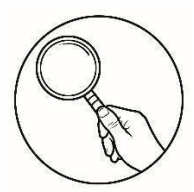
What's New

In your previous lesson on Mendelian patterns of inheritance, you have learned that the dominant gene overpowers the effects of the recessive gene.

Read the comic strip below. Identify the problem that was encountered. Did you ask the same questions? Do you think you can help Mr. and Mrs. Gift in solving their problem?



Comic strip created in https://canva.com/



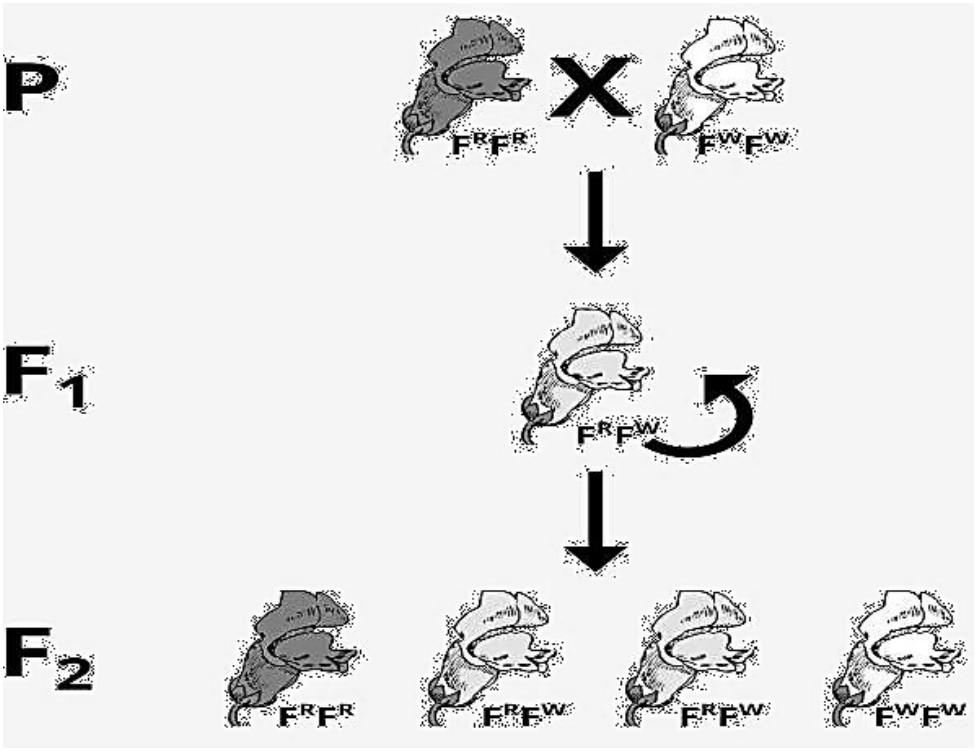
What is It

Non-Mendelian Patterns of Inheritance

A Mendelian pattern of inheritance refers to reproducing organisms sexually. We know that in Mendel's principles of heredity each parent gives one of two possible alleles for a trait. However, Non-Mendelian inheritance is any pattern of inheritance wherein traits do not segregate following Mendel's law. These laws describe the inheritance of traits linked to single genes on chromosomes in the nucleus.

Incomplete dominance. Snapdragon flower is an example of this pattern of inheritance in which both alleles are present resulting in an intermediate phenotype.

- A cross between a homozygous red-flowered plant (F^RF^R) and a homozygous white-flower plant (F^WF^W) will produce offspring with pink flowers (F^RF^W) as shown in the F_1 generation.



Snapdragon Test Cross
Figure from Creative Commons.org

- A cross between two heterozygotes of F_1 generation, however, will result in an F_2 generation with a phenotype of 25% red flowers, 50% pink flowers, and 25% white flowers (phenotypic ratio of 1:2(blended traits):1).

Codominance is a heterozygote condition wherein both traits are present simultaneously, rather than one fully determining the phenotype. A speckled chicken is a good example of dominance.

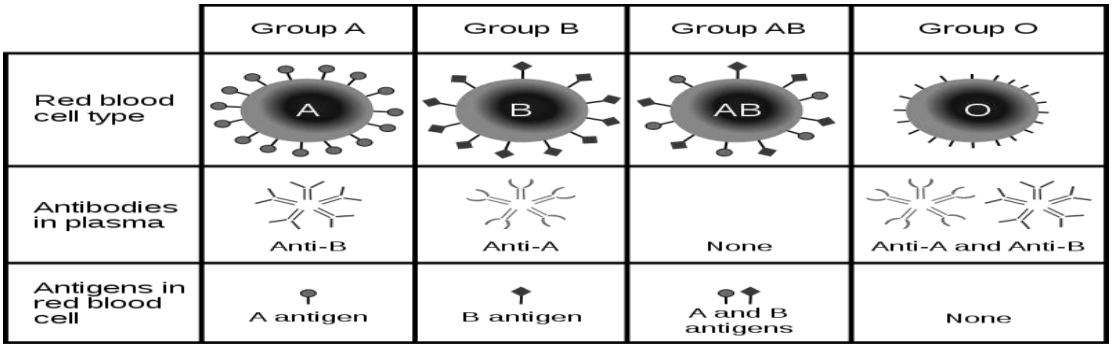
speckled hen

- A cross between a black and white chicken will produce chicken with both black and white feathers. The alleles for black feathers in some varieties of chicken is codominant with the allele for white feathers.

- Another example that shows how the co-dominance pattern of inheritance is determined by genes is in the blood typing in humans. An antigen is a protein- bound to a sugar molecule found on the surface of our red blood cells. A pair of alleles (IA and IB) which controls one group of antigens, help in determining the blood types of an individual.

Table 1. *Summary of phenotypes and genotypes of the blood typing in humans.*

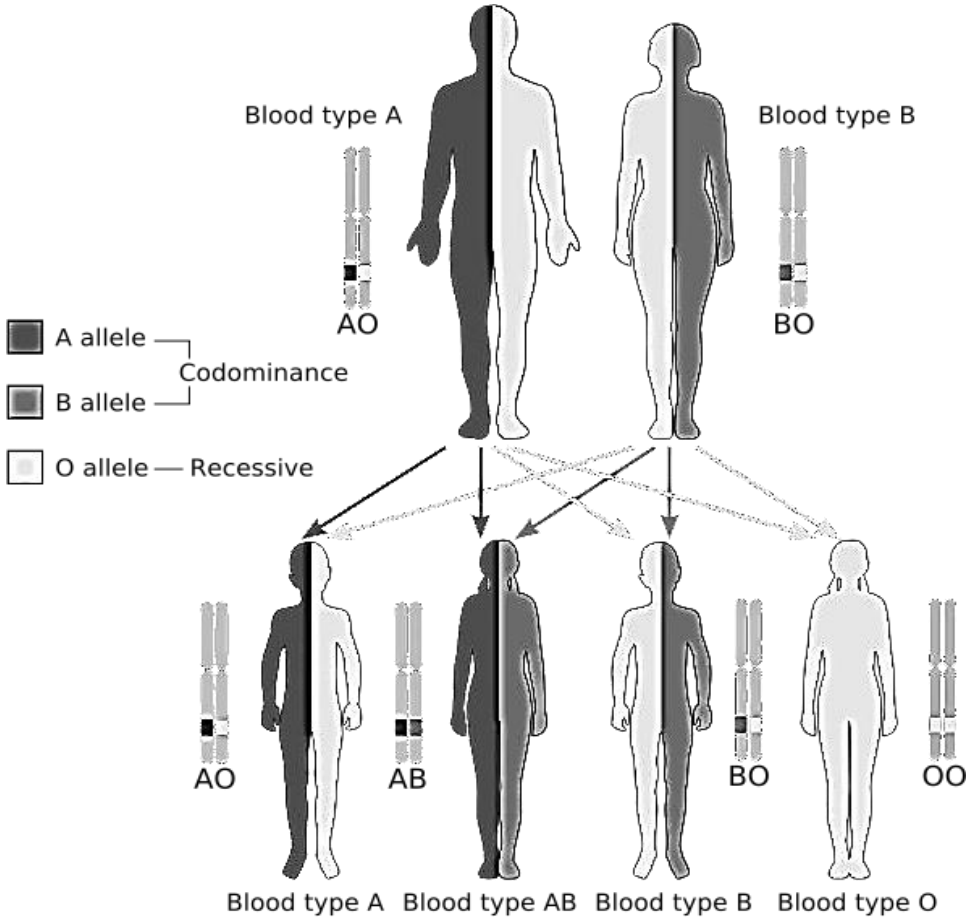
HUMAN BLOOD TYPES				
Phenotype	**A**	**B**	**A** **B**	**O**
Genotype	I^AI^A or I^Ai	I^BI^B or I^Bi	IA IB	ii
Can receive blood from:	O, A	O, B	A, B, AB, and O (universal recipient)	O
Can donate blood to:	AB, A	AB, B	A B	A, B, AB, and O (universal donor)



ABO Blood Types
Figure from Wikimedia Commons

In the heterozygote condition, both I^A and I^B alleles are expressed in the red blood cells that will have the antigens A and B. Three alleles exist in the ABO system: A, B, and O. This result in four blood types: A, B, O, and the blended AB.

Codominance in Human Blood Types
Figure from Creative Commons



Multiple Alleles: (ABO Blood Types)

A single gene that has more than two alleles is called multiple alleles. The ABO blood groups in humans as an example of a gene that has multiple alleles is the one that controls the inheritance. There are four blood group systems A, B, AB, and O.

We know that there are three different alleles for ABO blood types, however, only two are present in an individual at a time.

Table 2. *Allelic Combination of Different Blood Types in Humans*

Resulting Blood Type	Allelic Combination
A	I^AI^A or $I^A i$
B	I^BI^B or $I^B i$
AB	I^AI^B
O	ii

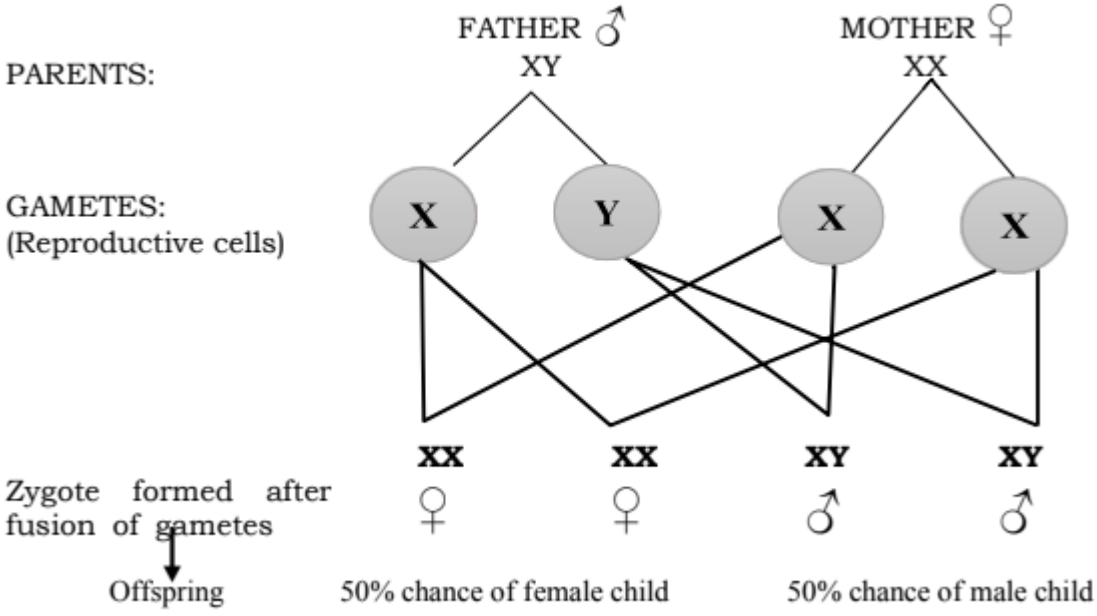
The IA and IB are dominant over the i allele which is always recessive. However, both alleles are expressed equally when the two alleles are inherited together.

Sex Chromosomes and Sex Determination

Most humans have an XY sex-determination that is responsible for the gender characterization of an individual. Sex chromosomes control whether the organism will be a male or a female.

Both males and females have 22 pairs of autosomal chromosomes and a pair of sex chromosomes. Male brings X and Y chromosomes, while both X chromosomes are in females.

A male offspring will be produced when an egg fertilized by a sperm passing on a Y chromosome. Similarly, a female offspring will be a result of a fertilized egg through a sperm carrying an X chromosome. Therefore, there is a fifty-percent probability of having a male and female offspring.



Sex-Related Inheritance

Most of the time, more men in comparison to women are bald while lactation or milk production is common in women but certainly not in men. These are inherited characteristics determined by sex. The following are the three kinds of sex-related inheritance namely, sex-limited, sex-influenced, and sex-linked.

Sex-Linked Genes

Sex-linked genes are genes found either on X or Y chromosomes which are inherited differences among male and a female. Sex-linked traits determined by an X-linked gene when an X chromosome takes control. On the other hand, the so-called Y-linked genes are those located on the Y chromosome.

- **Hemophilia,** an example of an X-linked trait is a rare genetic disorder in which a person lacks enough blood-clotting proteins caused by a change in one of the genes.
  Since this phenomenon is sited on the X chromosome, females identified to have affected two X chromosomes cause the disorder.
  But if there is only one chromosome affected, the female individual is referred to as "carrier" of the disorder.

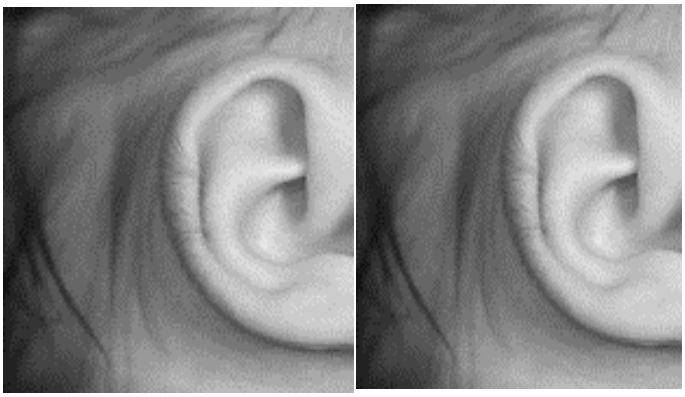
A woman suffering from Hemophilia
Figure from Creative Commons

Color-blindness is another condition of the X-linked trait. These traits will be manifested in females who have two genes of color-blindness. Meanwhile, in males, there is only one gene of the disorder needed to express the phenomenon.

Table 3. *Genotypes and phenotypes in humans*

Genotype	Phenotype
X X	Normal female
X X^C	Normal female, carrier of the gene
X_c X_c	Color-blind female
X Y	Normal male
X^C Y	Color-blind male

Hypertrichosis pinnae auris is a Y-linked trait controlled by a Y chromosome and characterized by hairy ear in which are expressed in males alone. This human condition can be inherited from a father who has the disorder, to his sons who, in turn, will pass it on to their sons.



Hairy Human Ear
Figure from Creative Commons

Sex-Limited Trait

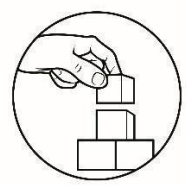
Sex-limited traits are those traits limited to only one sex. **Lactation** is a good example of a sex-limited trait that is exclusively exhibited among females. However, cattle carry genes for lactation on both males and females.

Lactating gene (L) is a dominant gene over the non-lactating recessive gene (l). In female cattle carrying one dominant gene (XXLl), or two dominant genes (XXLL) lactation will be shown. Nevertheless, neither male cattle having dominant genes nor in male cattle that have recessive genes will lactate.

Sex-Influenced Traits

Sex-influenced traits are autosomal traits that are expressed in both sexes but more frequently in one than in the other sex. One classic example of this is **pattern baldness** which is expressed in females but is more often manifested in males.

The gene has two alleles, "bald" (B) and "non-bald" (b), and these genes are highly influenced by the hormones individually. We know that all humans have testosterone, but males have higher level of testosterone than females do. This shows that, although baldness alleles (XY^{BB}, XY^{Bb}, or XX^{BB}) behave like a dominant allele in males, they are recessive in females (XX^{Bb}, XX^{b}).



What's More

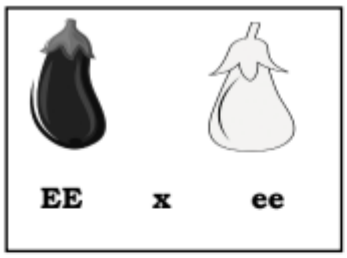
Activity 1: My Incompleteness, Complete Me.

Fill in the Punnett squares with the correct genotypes based on the key pictures that illustrate incomplete dominance. Then answer the following questions. Provide a separate sheet of paper for your answer.

KEY:

		
Purple eggplant (EE)	**Violet eggplant (Ee)**	**White eggplant (ee)**

1.

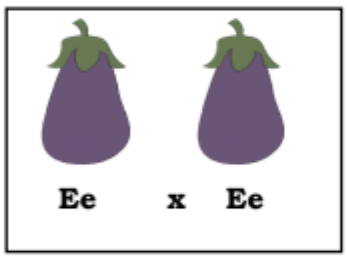


	E	E
e		
e		

A. What percentage of the offspring will have white fruit? _____

B. What percentage of the offspring will have violet fruit? _____

2.

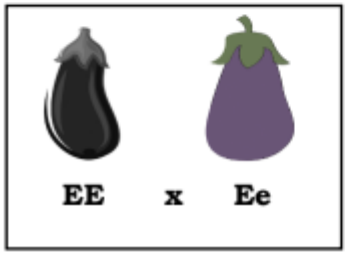


	E	e
E		
e		

A. What percentage of the offspring will have purple

B. What percentage of the offspring will have heterozygous fruit? _____

3.



	E	E
E		
e		

A. What percentage of the offspring will have purple fruit? _____

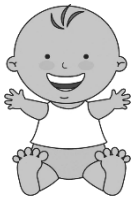
B. What percentage of the offspring will have white fruit? _____

Pictures/Illustrations from Canva.com

Activity 2: Who's My Family?

A fire has occurred in a nearby maternity clinic. The assigned nurse quickly rushed out of the place to secure the newly born babies. Unfortunately, there were some babies without their identification bracelets.

Using your knowledge about codominance inheritance will help bring these babies back to their correct parents.



Pictures/Illustrations from Canva.com

Baby Genotypes:

Baby # 1	Baby # 2	Baby # 3
A	AB	B

- Cruz family are the first set of parents. Mr. Cruz's blood type is B, and his wife's blood type A.
- The second set of parents is Fernandez. Mr. and Mrs. Fernandez both have a B blood type.
- The last set of parents is the Lopez family. Mr. Greg Lopez has an O blood type, and Mrs. Anna Lopez's blood type is A (heterozygous).

Do this task: Make use of Punnett square below to determine the possible genotypes of the newborn babies. Compare the 4 possible genotypes of the three evacuated babies. Write your answer in a separate sheet of paper.

Cruz Family

Fernandez Family

Lopez Family

Guide Questions:

1. Which baby or babies could belong to the Cruz?
2. Which baby or babies could belong to the Fernandez?
3. Which baby or babies could belong to the Lopez?

Based on all the given information above, identify which baby/babies belong to each set of parents?

Parents	**Baby #**
Cruz	
Fernandez	

Activity 3: Where Do I Belong?

The following pictures show the cross between organisms based on their phenotypes. Match each given pair of organisms in Column A with its possible offspring in Column B, then write your answer for the following questions on a separate sheet of paper.

Column A

Column B

1.  Red x  Yellow

A.  Pink

2.  x 

B.  Orange

3.  x  Pink

C. 

4.  Red x 

D.  Mix of brown & white

5.  x 

E.  Mix of pink & white

Pictures/Illustrations from Creative Commons and Wikimedia Commons

Guide Questions:

What are the genotypes of the parent hibiscus flower plant?

What cross will produce the pink flower plant? Support your answer with a Punnett square.

What is the genotype of a dalmatian dog?

Which crosses are an example of an incomplete dominance? Why?

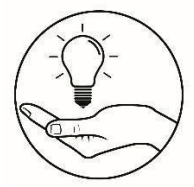
Which crosses are example of codominance? Why?

Activity 4. Linked Together!

Complete the table below to determine the Non-Mendelian patterns of inheritance involved in the formation of the given phenotype of the offspring produced in a cross between a homozygous black fur rabbit and white fur rabbit. Write your answer on a separate sheet of paper.

Genotypes	**Non-Mendelian Patterns of Inheritance**	**Explanation**
1. Gray fur rabbit		
2. Broken fur rabbit (rabbits that have white fur with any color patches or spots).		
3. Chinchilla fur rabbit (brownish, bluish, or gray except on the stomach that has yellowish white color).		

CRITERION	Exemplary (2)	Proficient (1)
Support/ Evidence (x3)	argument is clearly supported by accurate evidence considered credible by the audience; there is sufficient detail to support the main points of the argument	some evidence is provided, but information is not fully explained; important pieces of evidence have not been included some data are relevant or credible but inaccurate
Clarity/ Conciseness (x2)	sentences flow smoothly, are structurally correct, and convey the intended meaning; no wordiness	majority of ideas expressed are awkward, incorrectly constructed, or wordy
Strategy/ Audience	content, structure, and language of argument is geared to intended audience	argument is missing a substantial portion of content required by audience



What I Have Learned

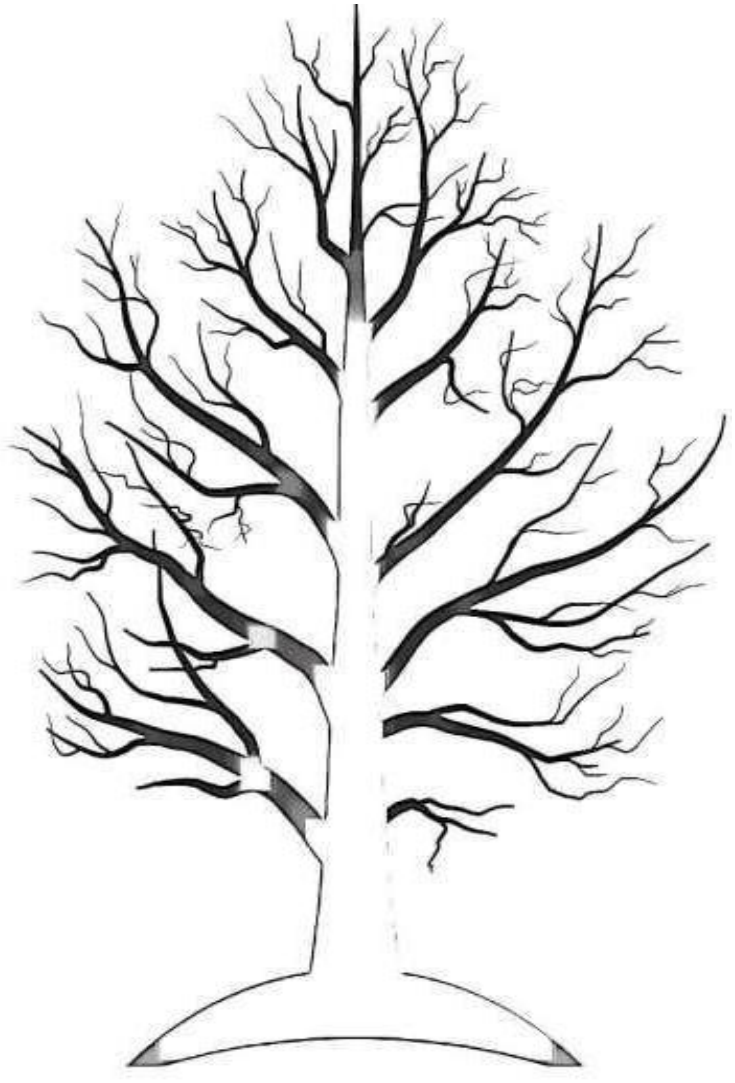
To summarize all your learnings from this module, supply the blanks with words within the box that will complete each sentence. Write your answer on a separate sheet of paper.

Non-Mendelian	Co-dominance	X and Y
Multiple alleles	Incomplete dominance	Forty-six
A, B, AB, O	Recessive	Sex chromosomes
Blood types	Codominant	X chromosome
Sex-influenced	Disorder	Sex-linked

1. The pattern of inheritance in which traits do not segregate under with Mendel's laws is called _____.
2. _____ is a form of intermediate inheritance in which one allele for a specific trait is not completely dominant over the other allele.
3. In _____, both alleles are expressed equally in the phenotype of the heterozygote.
4. _____ refer to a phenomenon of having more than two forms of the same gene in the population.
5. In humans, there are four blood types (phenotypes): _____.
6. _____ is controlled by three alleles: A, B, O.
7. Allele for O is _____, two O alleles must be present for a person to have an O blood.
8. A and B are _____. If a person receives an A allele and a B allele, their blood type is AB.
9. Males have 44 body chromosomes and two sex _____chromosomes. The males determine the sex of their children. Females have 44 body chromosomes and two sex chromosomes, both X. The total number in each cell of an individual is _____. These chromosomes contain genes, which are the factors of heredity.
10. _____ traits are inherited through the _____.
11. Males have only one X chromosome. Thus, if they inherit the affected X, they will have the _____.
12. Females have two _____. Therefore, they can inherit/carry the trait without being affected if it acts in a recessive manner.
13. _____ traits are those that are expressed exclusively in one sex.
14. _____ traits are expressed in both sexes but more frequently in one than in the other sex.

What I Can Do

Make a Family Traits Tree. Identify the traits of the family members from your grandparents up to your present generation. Choose among the traits you will track which are non-Mendelian traits of inheritance, then draw each trait on the leaves of the family tree. Put a mark on those traits that you do not inherit. Explain why chosen traits are under the non-Mendelian pattern of inheritance. Consider the rubrics below. Redraw the family tree in a separate answer sheet.



Picture/Illustration from Canva.com

Scientific Drawings: My Family Traits Tree

CATEGORY	Not Achieved (0 pt)	Partially Achieved (2 pts)	Mostly Achieved (4 pts)	Fully Achieved (6 pts)
Family Tree	There is no family tree/ only one generation of the family that has been shown.	Only two/ generations of the family are shown.	The Family Tree shows two generations.	The Family Tree includes three or more generations.
Genetic Traits	No trait has been chosen/ the trait chosen is not an inherited one.	1 or two traits are shown/ there are weak genetic links to the traits/ the student has confused the traits and cannot follow them along the family tree.	All three traits are genetic and can be traced from the maternal or paternal line.	The students have traced three or more genetic traits/ the traits are inherited in different ways/ the trait can be traced back on both paternal and maternal lines.
Marking on traits do not inherit	No marking is visible for traits not inherited	N/A	N/A	Markings is visible for the traits inherited.
Legend	No legend is used for clearer descriptions of traits of the family members	One legend is used for clearer descriptions of traits of the family members	2 to 3 legends are used for clearer descriptions of traits of the family member	Complete legends are used for clearer descriptions of traits of the family members.
Summary of Traits	No summary of traits has been shown	1 summary of traits is shown.	Two traits have a summary shown and can be traced from the maternal or paternal line.	All three traits have summary shown and can be traced from the maternal or paternal line.

Assessment

Choose the letter of the best answer. Write your answers on a separate sheet of paper.

1. When one characteristic is more strongly inherited than another characteristic, it is said to be.
   A. Dihybrid
   B. Dominant
   C. Recessive
   D. Monohybrid

2. Which genotypes consists of two identical genes for a given character?
   A. Dominant
   B. Recessive
   C. Homozygous
   D. Heterozygous

3. The human sex chromosome for male is _____.
   A. XX
   B. YY
   C. XY
   D. XZ

4. Which of the following is an alternate form of a gene?
   A. Allele
   B. linkage
   C. Genotype
   D. Phenotype

5. The chromosome number of human gametes is _____.
   A. 12
   B. 23
   C. 46
   D. Higher for eggs and sperm

6. Which is NOT an example of incomplete dominance?
   A. A pink flower produced from red and white flowers
   B. A flower that is both red and white produced from red and white flowers
   C. Curly-haired and straight-haired individuals producing wavy-haired offspring
   D. A highly spotted dog and a non-spotted dog producing puppies with a few spots

7. A man heterozygous for blood type A marries a woman heterozygous for blood type B. What is the chance that their first child will have type O blood?
   A. 0%
   B. 25%
   C. 50%
   D. 75%

8. Which best describes the genetic material a person receives from his or her father?
   A. 22 autosomes and an X or Y chromosome
   B. 22 haploid cells and an X or Y chromosome
   C. 23 diploid cells and an X and Y chromosome
   D. pair of homologous chromosomes and an X and Y chromosome

9. Which statement is TRUE about the Punnett squares in A and B?

DIAGRAM A

	B	**B**
B	B B	B B
W	B W	B W

DIAGRAM B

	R	**r**
R	R R	Rr
R	R R	rr

I. In diagram A, white is dominant over black while in diagram B red is dominant over white.
II. Diagram A shows a codominance pattern of inheritance while diagram B shows an incomplete pattern of inheritance
III. In diagram A, the parents produce offspring with a phenotype in which both parental traits appear together while in diagram B, the parents produce offspring with a phenotype that is a blending of parental traits.
IV. Diagram A describes a cross among parents of different phenotypes while diagram B describes a cross between parents of the same

A. I
B. II
C. Both II and III
D. Both II and IV

10. A couple has a colorblind son, but all their daughters have normal vision. What are the genotypes of this couple?

A. X^nX^n and X^nY
B. X^NX^N and X^NY
C. X^NX^n and X^NY
D. X^NX^n and X^nY

11. If an organism has two alleles for a gene that are the same and usually masked by another type of allele, the organism is said to be _____?

B. Heterozygous
C. Generally defective
C. Homozygous recessive
D. Homozygous dominant

12. Baldness is an example of _____.

A. Polygene
B. X-linked gene
C. Holandric gene
D. Sex-influenced trait

13. What inheritance is most likely involved when both parental phenotypes are expressed in the F1 generation?

A. Codominance
B. Multiple alleles
C. Polygenic inheritance
D. Incomplete dominance

14. A polygenic trait is also called _____.

A. X-linked gene
B. Multiple alleles
C. Holandric gene
D. Continuous trait

15. What information can be obtained from a Punnett square?

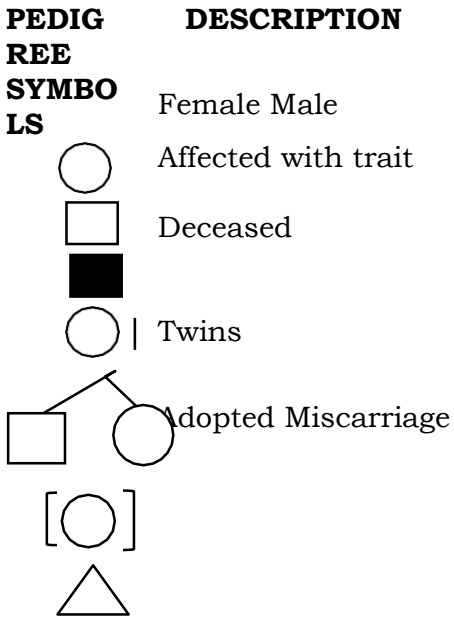
A. Genotype of offspring
B. Phenotype of offspring
C. Phenotypic ratio of offspring
D. All the above information

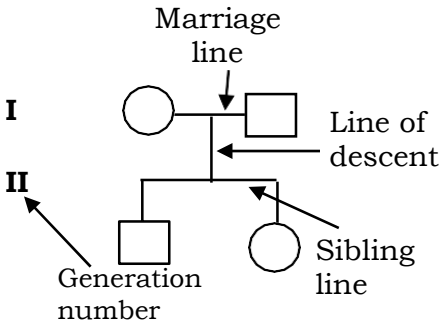
Additional Activities

PEDIGREE ANALYSIS

Pedigree is used to trace a gene as it is passed down throughout a family. This shows the presence or absence of a trait, as it relates to the relationship between parents, offspring, and siblings. Genotypes and phenotypes can be determined by analyzing a pedigree and predict how a trait will be passed on in the future. It is possible to determine how certain alleles are inherited through the information based on a pedigree: whether they are dominant, recessive, autosomal, or sex-linked.

There are common pedigree symbols used in representing family members and relationships as shown





How to Read a Pedigree

- **Determine whether the trait is dominant or recessive.** In a dominant trait, one parent should have the trait. For the recessive trait, neither parent is required to have the trait since they can be heterozygous.
- **Determine if the chart shows an autosomal or sex-linked trait.** As an example, males are more commonly affected than females in X- linked recessive traits. However, both males and females are equally expected to be affected by autosomal traits.

Example: Autosomal dominant trait

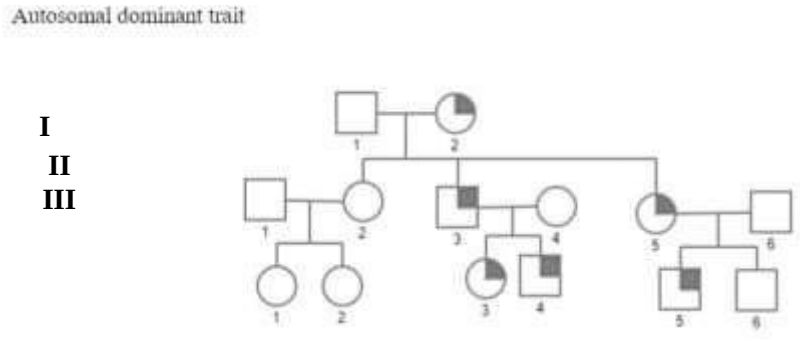


Illustration created in https://progenygenetics.com/

- The allele for freckles (F) is dominant to the allele for no freckles (f) as the diagram indicates the inheritance of freckles in a family.
- At the top of the pedigree is a grandmother (individual 1-2)
- Two of her three children have the trait (individuals II-3 and II-5), and
- Three of her grandchildren have the trait (individuals III-3 and III-5)

Example: X-linked recessive trait

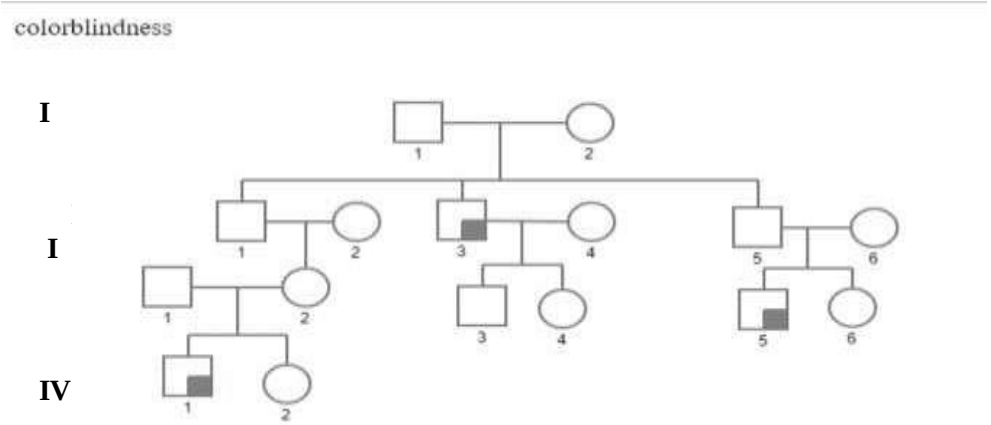


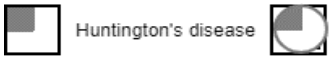
Illustration created in https://progenygenetics.com/

- Colorblindness is a recessive and X-linked trait (X^b). The allele for normal vision is dominant (X^B).
- In the first generation, neither parent has the trait.
- One of their three children (II-3) is colorblind, assumed that the trait is recessive because of the unaffected parents.

The trait appears to affect males more than females.

Let us practice it again! **Analyze the pedigree below to answer the questions that follow.**

Huntington's disease a disorder in which nerve cells in certain parts of the brain waste away, or disintegrate, is passed down through families.



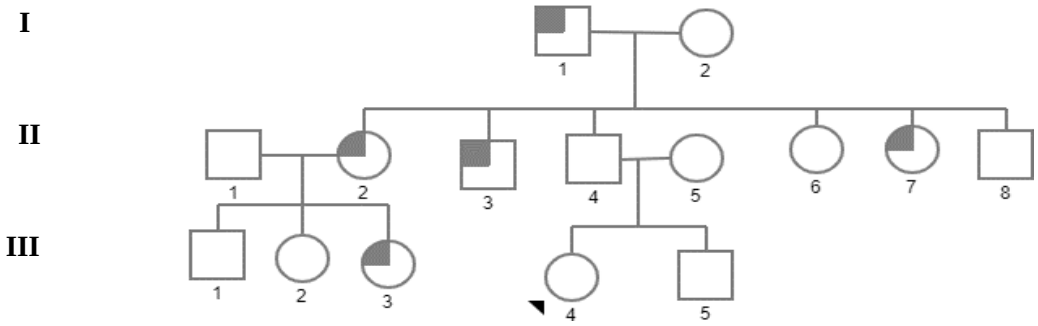


Illustration created in https://progenygenetics.com/

1. What members of the family above are affected with the Huntington's disease? _____

_____

2. There are no carriers for Huntington's disease: you either have it or you do not. Is Huntington's disease caused-by a dominant or recessive trait? _____

_____

3. Identify the genotypes of the following individuals using the pedigree above. (homozygous dominant, homozygous recessive, heterozygous).

   I – 1 : _____
   II – 1 : _____
   II – 3 : _____
   III – 4 : _____

4. How many children did individuals I-1 and I-2 have?

5. How many girls did II-1 and II-2 have? How many have Huntington's Disease? _____

6. How are individuals III-2 and II-4 related? _____
   I-2 and III-5? _____

Answer Key

What I Know

1. D
2. B
3. D
4. A
5. D
6. A
7. A
8. A
9. C
10. D
11. D
12. A
13. C
14. A
15. D

What's In

F_1	R	R
r	Rr	Rr
r	Rr	Rr

F_1 generation	RR, rr
P_1 Genotype	4 Rr
F1 Genotype	All red tomato fruit
F_1 Phenotype	

F_2	R	r
R	RR	Rr
r	Rr	rr

F_2 generation	
F_2 Genotype	1RR: 2Rr: 1rr
F_2 Phenotype	3 red tomato fruit : 1 yellow tomato fruit

What's More

Activity 1

1.

	E	E
e	Ee	Ee
e	Ee	Ee

A. 0% B. 100%

2.

	E	e
E	EE	Ee
E	EE	Ee

A. 25% B. 50%

3.

	E	E
e	Ee	Ee
E	EE	EE

A. 25% B0%

Activity 2

Cruz	A	A
A	AA	AA
B	AB	AB

Fernandez	B	B
B	BB	BB
B	BB	BB

Lopez	A	O
O	AO	OO
O	AO	OO

Guide Questions:

1. # 1 & # 2
2. # 3
3. # 1

Parents	Baby #
Cruz	1 & 2
Fernandez	3

Activity 3

1. B
2. B
3. E
4. A
5. D

Guide Questions:

A. RR x YY

B.

	R	R
W	RW	RW
W	RW	RW

C. bb

D. Incomplete dominance offspring shows a mix of traits from parents.
- Red hibiscus flower x Yellow hibiscus flower
- Red snapdragon flower x White snapdragon flower

E. Codominance offspring shows both parental traits. The traits do not mix.
- Black dog x White dog
- White four o' clock flower x Pink four o' clock flower
- Brown horse x White horse

Activity 4

Genotypes	Non-Mendelian Patterns of Inheritance	Explanation
1. Gray fur rabbit	Incomplete dominance	A cross between a homozygous black (G) fur rabbit and white (g) fur rabbit produced a 100 % gray (Gg) fur offspring. A blend of color coat traits in rabbits were expressed on the offspring.
2. Broken fur rabbit	Codominance	A breed on a homozygous solid Spot (En) to a homozygous Charlie (en) to produce of a 100% heterozygous broken fur rabbit offspring. The two traits for coat color in rabbits were manifested.
3. Chinchilla fur rabbit	Multiple Alleles	Both parent rabbit with chinchilla fur produced 3 chinchilla fur rabbit and an albino fur rabbit. Shows inheritance by multiple alleles for a single gene.

Assessment

1.	B	10. C
2.	C	11. C
3.	C	12. D
4.	A	13. A
5.	C	14. B
6.	B	15. D
7.	C	
8.	A	
9.	C	

What I have Learned

1. Non-Mendelian
2. Incomplete dominance
3. Codominance
4. Multiple Alleles
5. A, B, AB, O
6. Blood type
7. Recessive
8. Codominant
9. X and Y chromosome
10. Sex-linked; X chromosome
11. Disorder
12. Two X chromosome
13. Sex-limited
14. Sex-influenced

Additional Activities

1. I-1, II-2, 3, 7, & III-3
2. Dominant
3. Hh – heterozygous
   hh – homozygous recessive
4. 6
5. 2, 1
6. Niece, Uncle, Grandmother, Grandson

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