



LESSON 4:

Heredity: *Chromosomes, Crossing & Probability*

7TH & 10TH GRADE

**Minnette Rodríguez Harrison
María L. Ortiz Hernández**

January 2020

INTRODUCTION

The *Genomic Logic for Underlying Morphological Divergence (EPSCoR)* project aims to bring science-related learning experiences to schools. This lesson is the fourth of five designed to facilitate learning about the concepts of natural selection (lesson 1), adaptation (lesson 2), evolution (lesson 3), heredity (lesson 4) and gene expression (lesson 5). These lessons will serve as a tool for the trainer or professional in charge of teaching (teacher, professor, among others). For participants, they can be teachers (as part of their professional development) or students.¹

In this fourth lesson, the instructors or teachers of the Biological Sciences (7th grade) and Biology (10th grade) courses, and their participants, will actively participate in some activities where they will understand the principles of heredity, highlighting the concepts of chromosomes, crosses, and probability.

This lesson includes:

- ✓ Scientific background of the concepts
- ✓ Glossary
- ✓ Alignment of the content to the standards, expectations, and specificities of the Department of Education of Puerto Rico (DEPR)
- ✓ Educational Process
- ✓ Detailed activities to carry out in the classroom.

SUBJECT:	Science (Biological Sciences/Biology)
LEVEL:	Intermediate - Advanced/ 7th – 10th grade
PRIMARY CONCEPTS:	genetics, inheritance, Punnett square, chromosomes, chromosomal mutations
SECONDARY CONCEPTS:	genetic changes, genetic variations

PRIOR KNOWLEDGE: phases of mitosis and meiosis

SPECIFIC LEARNING OBJECTIVES

Throughout the lesson, participants will:

- 1) describe the structure of chromosomes.
- 2) identify the human karyotype and compare it with other species.
- 3) define what a chromosomal mutation is and the types of chromosomal mutations.
- 4) compare the number of chromosomes in humans (normal) with the number of chromosomes when a chromosomal mutation occurs.
- 5) define what probability is.
- 6) identify the genotype and phenotype in different crosses.

Continuous assessment

Throughout the activity, the instructor or teachers will be making observations as they move between the working groups, when participants discuss and when they present their answers to the questions. This allows them to assess the participants' learning.

STANDARDS, EXPECTATIONS AND SPECIFICITIES 7th GRADE – SCIENCE

Standard(s): Interactions and Energy

Area of expertise: Growth, development, and reproduction of organisms

Expectation: B.CB1 From molecules to organisms: Structures and processes

Indicators

EI.B.CB1.IE.2 Evaluate how environmental and genetic factors influence the growth of organisms. Understand how scientists use genetic knowledge to predict offspring. *Examples of local environmental conditions may include the availability of food, light, space, and water. Examples of genetic factors may include breeding large livestock and the types of grasses that affect the growth of organisms. Examples of evidence may include drought affecting plant growth, the use of fertilizers that accelerate plant growth, different seed varieties growing at different rates under different conditions, and fish growing larger in larger ponds as opposed to the growth of the same fish in confined spaces.*

Standard(s): Conservation and change

Area of expertise: Growth, development, and reproduction of organisms

Expectation: B.CB3 Inheritance and variations in characteristics

Indicators

EI.B.CB3.CC.1 Explain why structural changes in genes (mutations) located on chromosomes can affect proteins and cause beneficial, harmful, or neutral changes in the structure and function of the organism.

EI.B.CB3.CC.2 Build a model to explain why asexual reproduction results in offspring with identical genetic information and why sexual reproduction results in offspring with genetic variation. *The emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause-and-effect relationships in the transmission of genes from parents to offspring, which result in genetic variations.*

STANDARDS, EXPECTATIONS AND SPECIFICITIES 10th GRADE – SCIENCE

Standard(s): Conservation and change

Area of expertise: Inheritance and variations in characteristics

Expectation: B.CB3 Inheritance and variations in characteristics

Indicators

ES.B.CB3.CC.1 Formulate and defend an evidence-based statement that genetic and hereditary variations can result from: (1) new genetic combinations through the process of meiosis, (2) viable errors that can occur during DNA replication, and/or (3) mutations caused by environmental factors. *The emphasis is on using data to support arguments about the different ways in which mutations can occur.*

ES.B.CB3.CC.2 Apply statistical and probability concepts to explain the variation and distribution of visible characteristics in the population. *The emphasis is on using mathematics to describe the probability and presence of characteristics related to genetics and environmental factors, as well as representing phenotypic and genotypic ratios in different genetic crosses.*

ES.B.CB3.CC.3 Recognize and explain that multicellular organisms develop from a single zygote and that the resulting phenotype will depend on the genotype that was established at the time of fertilization.

ES.B.CB3.CC.4 Explain the importance of continuity of life through the action of genes, hereditary patterns, reproduction in organisms, and cell reproduction.

BACKGROUND

Members of a family tend to share physical traits (like eye color, skin color, and the shape of the face) with one or both parents. These traits pass from the parents to their offspring; in other words, they are inherited.

Human beings have somatic and germ cells. Germ cells are those that form gametes. Unlike somatic cells that have two sets of chromosomes (a set inherited from each parent = $2n$), gametes have a unique copy of each chromosome. Given the genetic composition of these cells, they are known as haploid cells (n). Therefore, human gametes contain 23 chromosomes. Only gamete DNA is transmitted to the offspring of an organism. DNA is the genetic material present in all organisms, and it is stored inside chromosomes in the cell's nucleus. Each pair of cell chromosomes is known as a pair of homologous chromosomes. Homologous chromosomes are two chromosomes, one inherited from the mother and the other one from the father. Both have the same general appearance and have copies from the same gene, although the information in the genes can differ.

Genetic crossing is the product of the mating between two organisms, in most cases from the same species. Two gametes fuse during fertilization so that the resulting organism has two copies of each gene, one from each parent. A gene is a piece of DNA that carries a set of instructions to a cell for it to make a determined protein or ribonucleic acid (RNA). Genes contain genetic information, which varies from one organism to the other due to different alleles existing in a population. An allele is any of the variants or versions of a gene that could occur. The term "homozygous" describes two equal alleles, while the concept "heterozygous" describes different alleles in the same locus or place of the chromosome.

When describing homozygous or heterozygous allele pairs, we are talking about the real genetic composition of an organism, denominated as genotype. On the other hand, real physical characteristics or traits of an organism compose its phenotype.

On occasion, only one of the alleles will influence the trait. As demonstrated by Mendel's results, in some cases an allele can be dominant over another. We can say that a dominant allele is the allele that expresses if there are two different alleles or two dominant alleles. A recessive allele is the allele that expresses itself only if two recessive copies are paired. The combination of alleles, or the genotype of an organism, tends to be represented as a set of letters. Capital letters represent the dominant allele, and lowercase letters represent the recessive alleles. As each cell of the body contains two chromosomes, each with copies of the same gene, two letters are needed to represent the alleles of a pair.

Each gamete contains an allele for each trait in the organism's DNA. Punnett discovered a relationship between parents' gametes and the genotype of their offspring, which he used to develop a simple chart known as the Punnett Square. It allows us to predict all the possible genotypes of the descendants that result from a specific crossing. The crossing that examines a trait from the organism is a monohybrid crossing. There are three basic monohybrid crossings: homozygous-homozygous crossing, heterozygous-heterozygous crossing, and heterozygous-homozygous crossing. On the other hand, dihybrid crossing examines the inheritance of two traits.

DNA has the code from which proteins that form the body's structure and carry out vital functions are made. Changes in DNA are known as mutations. Mutations can be genetic (changes in the sequence of one gene that occur during DNA replication) or chromosomal (changes in chromosome segments or whole chromosomes that occur generally during the processes of mitosis or meiosis). Some of the more common chromosomal mutations are translocation (a chromosome segment passes to another non-homologous chromosome) and non-disjunction mutations (these occur when one or more homologous chromosomes do not separate during meiosis' anaphase). Some examples of nondisjunction mutations are Down Syndrome and Klinefelter Syndrome.

GLOSSARY

Allele —any of the variants or versions of a gene that may happen in a specific locus.

Aneuploidy —change in chromosomal number (for example, 23 in humans)

Centromere - cellular structure that joins two sister chromatids of a chromosome.

Chromatid —It is the half of a chromosome

Chromosome - long and continuous DNA filament formed by numerous genes and that stores genetic information.

Chromosomal mutation —a kind of mutation in which a chromosomal segment is transferred to a position in the same or another chromosome

Chromosomal mutation by disjunction —these mutations could be due to eliminations, insertions, inversions, or translocations.

Chromosomal mutation by nondisjunction —these mutations could be due to trisomy, triploidy, or monosomy.

Crossing —mating of two organisms.

Dihybrid crossing —crossing between two organisms that involves two different characteristics or traits.

DNA, deoxyribonucleic acid - molecule that stores genetic information of all organisms.

Gene —it is a piece of DNA that provides a set of instructions to a cell for it to make a determined protein or RNA (ribonucleic acid) molecule. Each gene has a specific location (locus) in a pair of homologue chromosomes.

Genotype = set of all coded traits in the genetic information of an organism.

Homologous chromosomes —chromosomes of the same length, aspect, and gene sequence, although alleles from one or another chromosome can be different.

Karyotype —organization, on a square, of the chromosome that an individual possesses; useful to locate aneuploidies in humans, like Down syndrome.

Monohybrid crossing —crossing between two organisms that only involves a pair of different traits.

Phenotype —the set of all physical characteristics of a determined organism that result from the interaction of its genotype and the environment.

Probability —the possibility that a particular event may occur.

Punnett square - prediction model of all possible genotypes that could be obtained from a determined crossing or mating.

LEARNING PROCESS

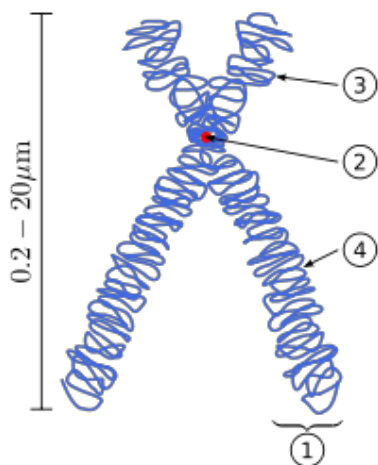
This capacitation has been divided into Part A and Part B. Each of these contains beginning, development, and closure activities for the better understanding of the educative process.

PART A HEREDITY : *GETTING TO KNOW CHROMOSOMES*

BEGINNING

During this part participants' previous knowledge about the concepts to be developed is explored. This will let the instructor recognize misconceptions that participants may have and ensure that they can be corrected during the educational process.

1. Present the illustration of a chromosome for the participants to identify its structure (see Image A). The instructor can place the image of the chromosome in a *PowerPoint* presentation or in a picture on the whiteboard.
2. The participant will identify through socialized discussion the structures that form the chromosome: *centromere*, *chromatid*, *gene*, *allele*, and *DNA*. Then, the definitions will be given.
3. Through the use of *PowerPoint* the relationship of the chromosome in the process of heredity is discussed. That is, it is explained that the chromosome contains the molecule that stores the genetic information that is inherited from parents to children.



1 = chromatid, 2 = centromere,
3 = short arm, 4 = long arm

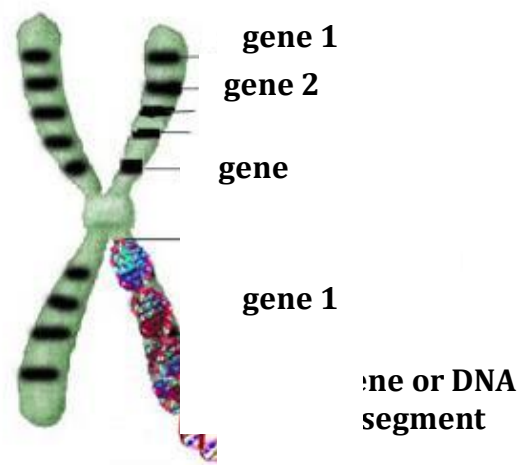


Image A

DEVELOPMENT

ACTIVITY #1: HUMAN KARYOTYPE

Worksheet #1

- 1) The instructor hands out the chromosome model from Worksheet #1 for participants to cut and complete Worksheet #2. It is expected that participants establish that sexual chromosomes are different among themselves; feminine is X and masculine is Y.
 - Worksheet #3 will be used to distinguish chromosome characteristics in humans (karyotype). This worksheet will appear in the *PowerPoint* presentation.
- 2) Show a table with karyotype examples from different species in the *PowerPoint* presentation (see Table #1).

Table #1: Karyotypes of different species

Organisms	Number of chromosome pairs (gametes, n)	Number of chromosomes (2n)
human	23	46
gorilla	24	48
dog	39	78
fruit fly	4	8
bee	8	16
Butterfly (<i>Heliconius sp.</i>)	21	42
cabbage	9	18
potato	24	48
corn	10	20

Consulted references: Libros Biología La Dinámica de la Vida de McGraw Hill, p. 299, Senior Biology 1 de BioZone, p. 153

Using Table #1 as reference, the instructor will ask:

- a. How many pairs of chromosomes do human beings have?

Expected answer: 23 chromosome pairs

- b. What information does the table present?

Expected answer: The participants indicate that each species has different numbers of chromosome pairs.

- An example from the table can be given for participants to indicate the number of chromosome pairs of that species.
- It is expected that some participant will ask what the number of chromosomes (2n) in the table means (see column 3 of Table #1). The instructor must explain that each pair of chromosomes is composed of a pair of *homologous chromosomes*, one that comes from the mother and another from the father.

- 3) The instructor must explain that each species has a different number of chromosomes and that this is what we call a karyotype.

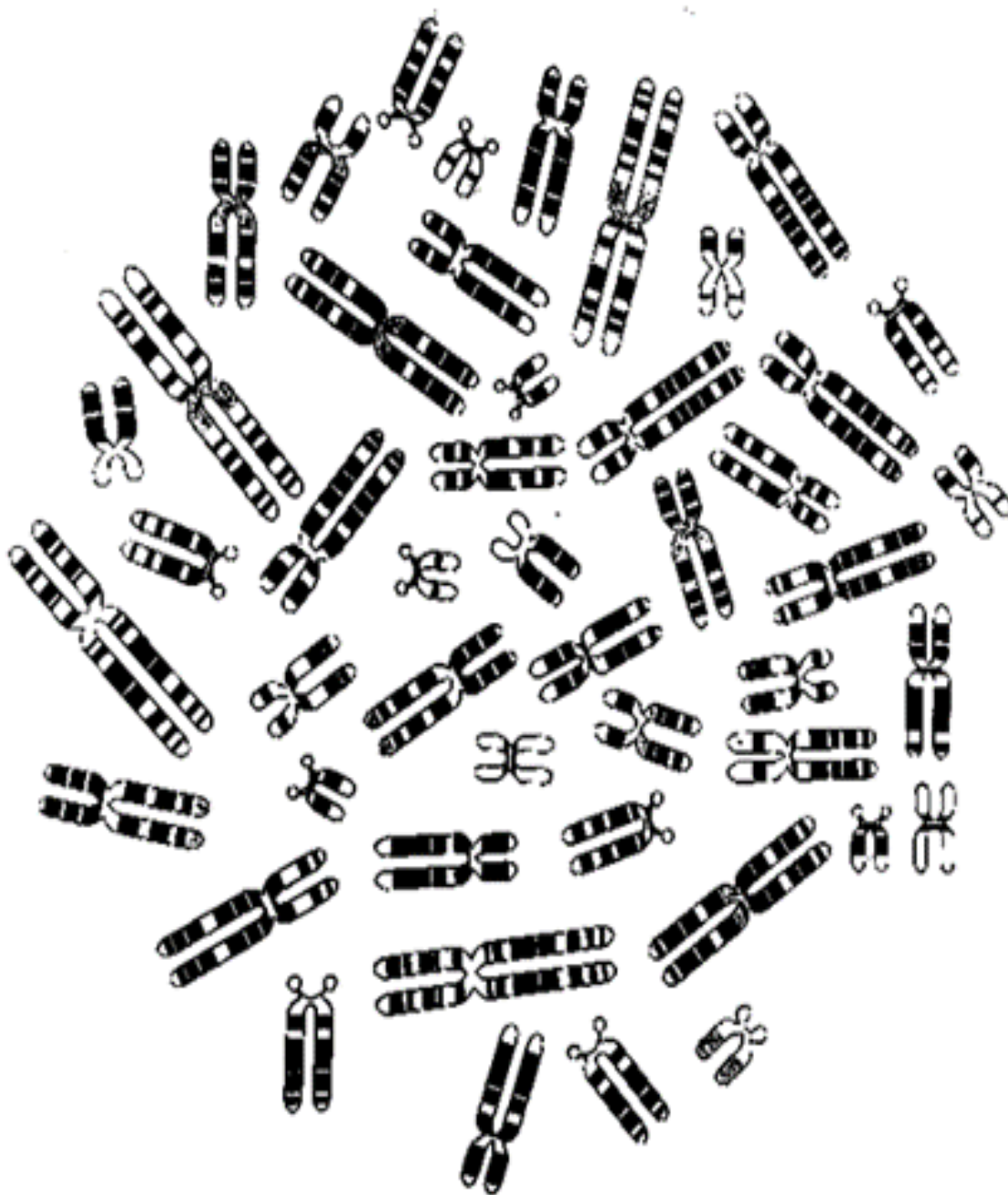
- 4) The class is divided into groups of four participants, and the human karyotype with some *chromosomal mutation* will be handed to each group (Worksheet #4). Participants are not told that there is a chromosomal mutation; they are simply instructed to observe the human karyotype that is being handed out.
 - Worksheet #4^a presents the karyotype of a human with *Down syndrome*, Worksheet #4b presents *Turner syndrome*, and Worksheet #4c presents *Klinefelter syndrome*.
- 5) The group will compare the image that was handed out (Worksheet #4) to the image that they previously worked with (Worksheet #3).
 - It is expected that participants observe that there are changes in the number of chromosomes in the human karyotype that was last handed to them.
- 6) The instructor asks the participants to point out the differences and similarities that are shown in the images.
- 7) It is expected that participants that have the *Down syndrome* image show that there are three chromosomes in position 21, that those who have the *Turner syndrome* image indicate that there is an X chromosome in position 23, and that those who have the *Klinefelter syndrome* image will have three chromosomes in position 23 (XXY).
- 8) The instructor asks the participants if they know the name that is given to the changes that occur in karyotypes.
- 9) If participants do not indicate the concept, the instructor will proceed with the *PowerPoint* presentation to define the concept of *chromosomal mutations* and the types of chromosomal mutations (by disjunction and nondisjunction).
 - **Chromosomal mutation** = a kind of mutation in which a chromosomal segment is transferred to a position in the same or another chromosome
 - **Chromosomal mutation by disjunction** = these mutations could be due to eliminations, insertions, inversions or translocations.
 - **Chromosomal mutation by nondisjunction** = these mutations could be due to trisomy, triploidy, or monosomy.

ACTIVITY #1: *HUMAN KARYOTYPE*

Worksheet #1

Instructions:

- 1) Cut the chromosomes. Create as many pairs between them as you can.
- 2) Paste the chromosomes on Worksheet #2.
- 3) Use Worksheet #3 as a reference.



ACTIVITY #1: *HUMAN KARYOTYPE*

Worksheet #2

Instructions:

1) Paste chromosomes from Worksheet #1 in the corresponding spaces.

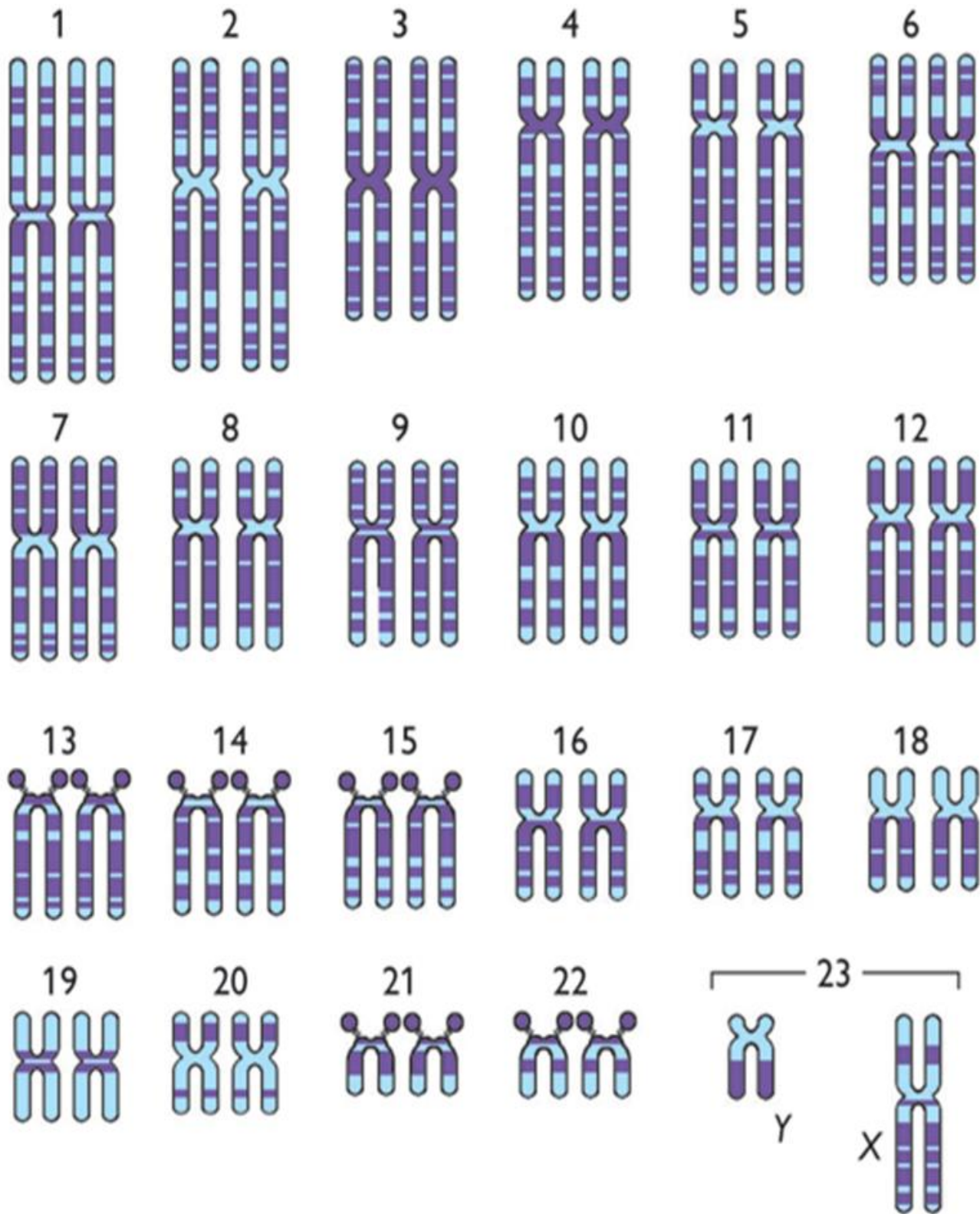
1	2	3	4	5

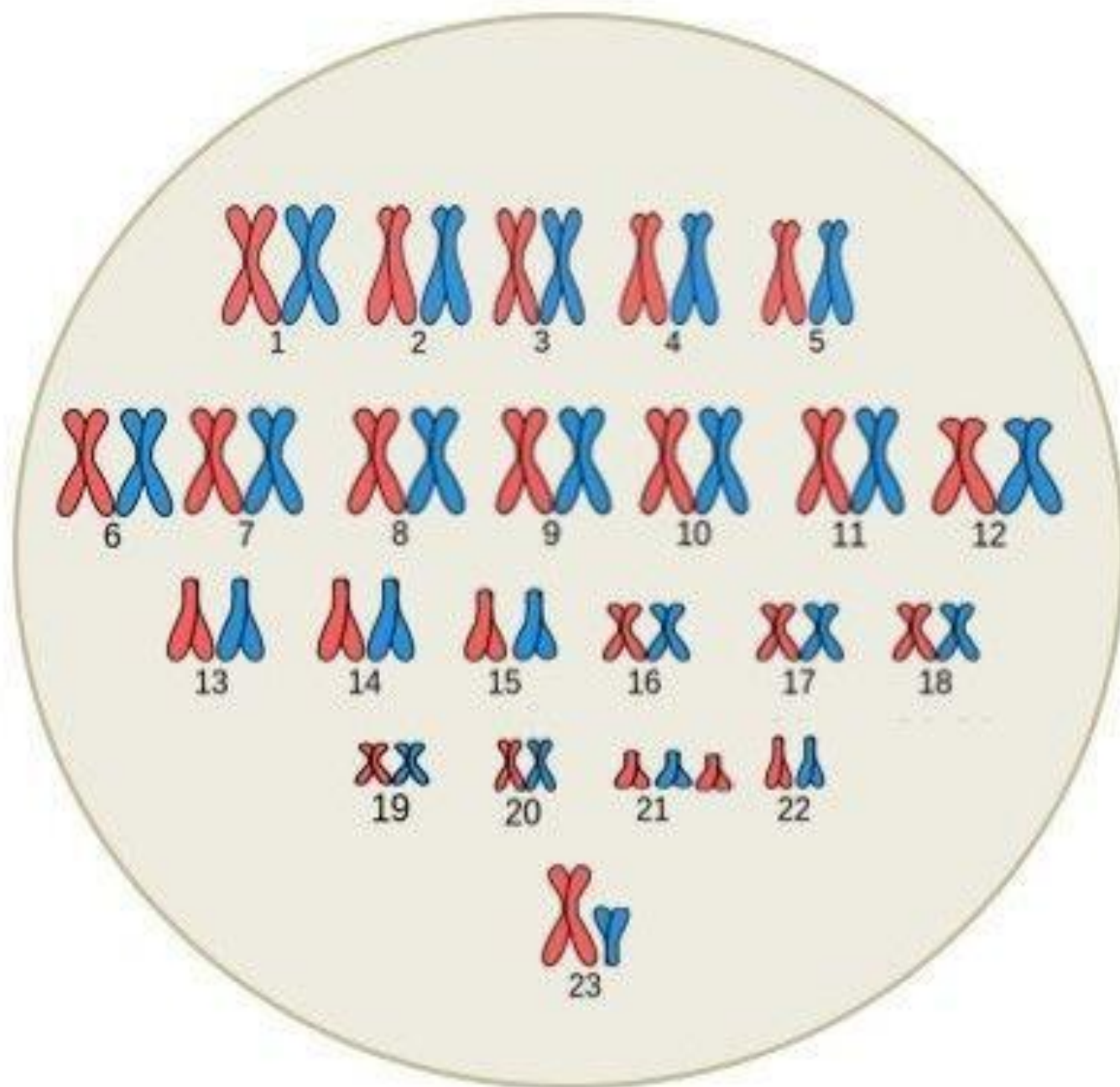
6	7	8	9	10	11	12
13	14	15		16		17
						18

19	20	21	22	Sexual chromosomes	

ACTIVITY #1: HUMAN KARYOATYPE

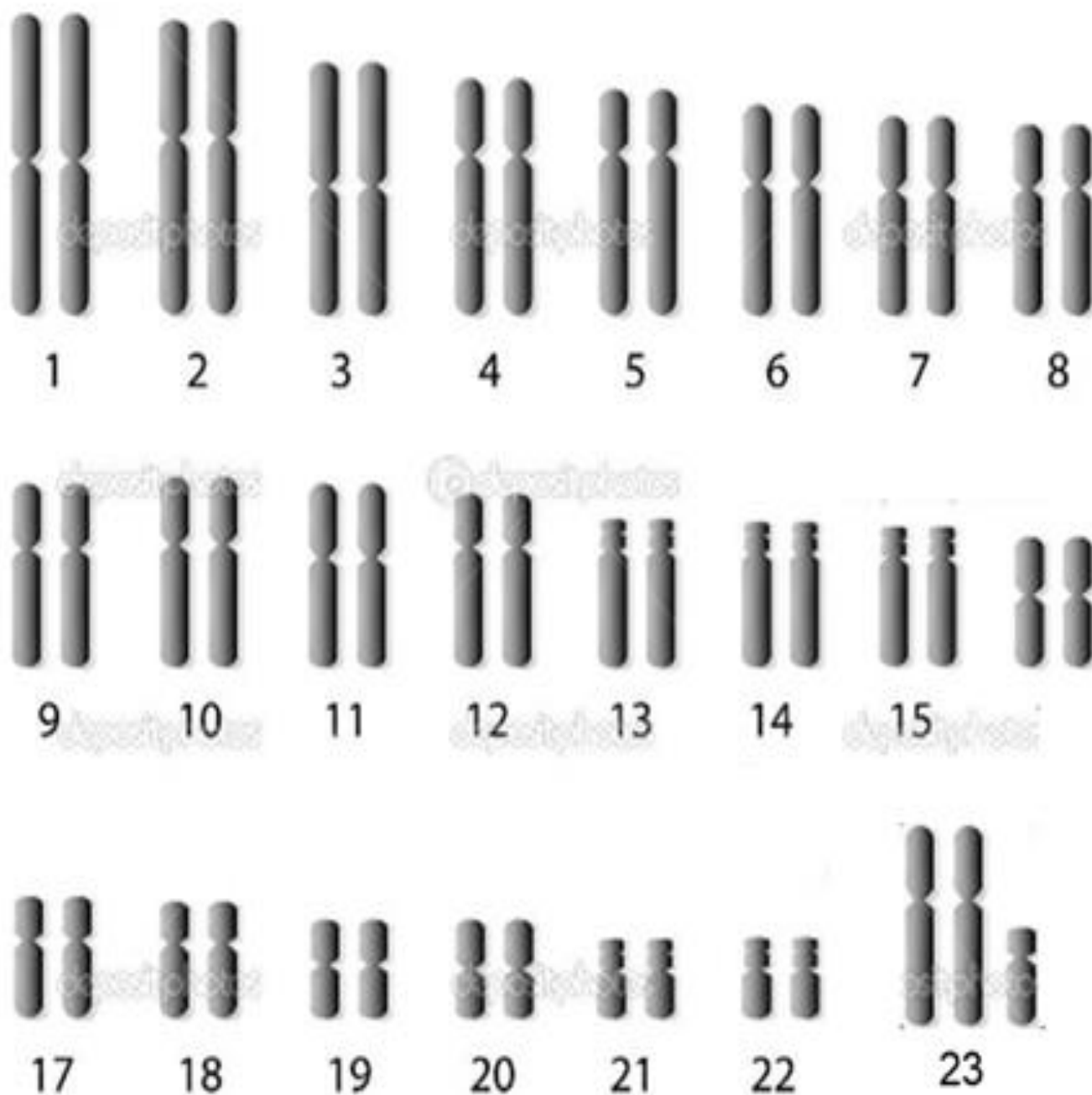
Worksheet #3

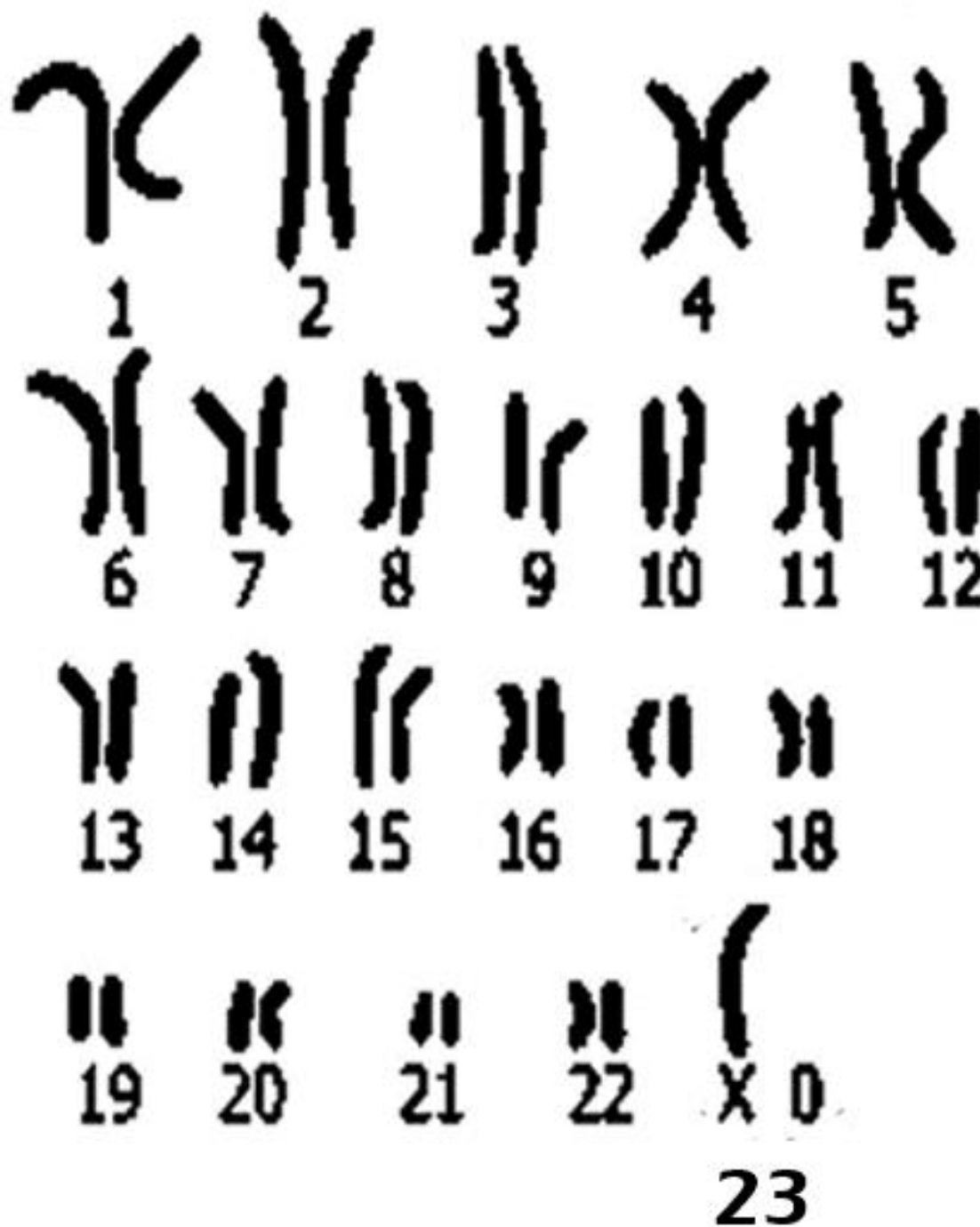




ACTIVITY #1: HUMAN KARYOTYPE

Worksheet #4b





CLOSURE

- 1) In socialized discussion, the instructor will finish the class with the following question:
“We already know that chromosomes have genes or inheritable traits. *How do you think these traits can be passed from generation to generation?*”

Expected answer: when sexual reproduction occurs, traits from both parents are passed on to their offspring (children) and so on.

PART B HEREDITY: *CROSSING AND PROBABILITY*

BEGINNING

- 1) The instructor explores the concept of *probability*, through the brainstorming technique.
Use *PowerPoint* presentations to briefly explain the concept of probability.
- 2) Activity #2 will be carried out in cooperative groups.

ACTIVITY #2: HOW ARE PROBABILITY LAWS APPLIED?

Worksheet # 5

Materials:

2 identical coins

Steps to follow:

- 1) In work groups of 4 participants, you will toss two coins to the air at the same time. One of your group's coworkers will write down the results in the data chart on the worksheet below the respective columns: **Heads/Heads, Heads/Tails, Tails/Tails**.
- 2) An example is included on Worksheet #5.
- 3) First, toss both coins 10 times. Write down the results in Data chart #1A.
- 4) Repeat the same procedure tossing the coins 20 times. Write down the results on Data chart #1B.
- 5) Lastly, toss the coins 30 times. Write down the results on Data chart #1C. For each series of tosses, determine the ratio of heads/heads, heads/tails, tails/tails. Write down the total of your results on Table #2 (summary).
- 6) Imagine that the coins represent traits for living beings that reproduce sexually. A coin represents the possible variants of a trait that comes from the mother, and the other one is a possible variant of the same characteristic that comes from the father. Follow the legend. To substitute the results from Table #2 and write them down on Table #3.
- 7) Answer the analysis questions.

ACTIVITY #2: HOW ARE PROBABILITY LAWS APPLIED?

Worksheet #5

Table #1A: Results after tossing the coins 10 times

Toss	Heads/Heads	Heads/Tails	Tails/Tails
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
Total			

Table #1B: Results after tossing the coins 20 times

Toss	Heads/Heads	Heads/Tails	Tails/Tails
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
Total			

Table #1C: Results after tossing the coins 20 times

Toss	Heads/Heads	Heads/Tails	Tails/Tails
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			
Total			

Table #2: Ratio of the results after tossing the coins

Toss	Heads/Heads	Heads/Tails	Tails/Tails
10			
20			

30			
----	--	--	--

Table #3: Results after tossing the coins (*living being traits where letter t represents the height of the plant*)

Toss	TT	Tt	tt
10			
20			
30			

Legend:

T = heads, **t** = tails

TT = heads/heads, **Tt** = heads/tails, **tt** = tails/tails

Analysis questions:

- 1) When you tossed 2 coins 30 times, what combination was more frequent: heads/heads, heads/tails, or tails/tails? What was the ratio for heads/heads, heads/tails, and tails/tails?
- 2) When you tossed the coins that represented the traits for being tall or being short, what was the ratio for TT, Tt and tt in 10 tosses? And in 30 tosses?
- 3) If we imagine that the coins represent the traits of plants, from the results written down for the 30 tosses, what is the ratio for tall plants to short plants?

NOTE: It is expected that participants could present some difficulty when answering these questions, since none of the concepts related to genetics have been discussed yet.

Example of how to complete the tables

In an experiment, Ana obtained the following results after tossing the coins 10 times:

Table #1: Results after tossing the coins 10 times

Toss	Heads/Heads	Heads/Tails	Tails/Tails
1		X	

2			X
3		X	
4			X
5			X
6			X
7			X
8	X		
9	X		
10		X	
Total	2	3	5

Example:

Table #2: Ratio of results after tossing coins

Toss	Heads/Heads	Heads/Tails	Tails/Tails
10	2/10	3/10	5/10

DEVELOPMENT

- 1) In a guided lesson, the instructor will refer to Worksheet #6 and will start the discussion with the participants.

The Dynamic will be guided by questions and answers. **Worksheet #6: Mendel and crossings** will be used to discuss the concepts of probability, alleles, crossing, monohybrid crossing and dihybrid crossing, genotype, and phenotype. Worksheet #6 will be completed during socialized discussion. See next the instructions for the *GUIDED LESSON USING POWERPOINT AND WORKSHEET #6*.

GUIDED LESSON USING POWERPOINT AND WORKSHEET #6

- 1) The instructor indicates to the participant that in Worksheet #6, the coins have been substituted by letters that represent the alleles that code for the characteristics of living beings.
- 2) **Question:** What can you notice in the used letters? Are they the same or different?

Expected answer: It is expected for participants to indicate that those are the same letters, but that they are represented in uppercase and lowercase.

3) Now, instead of using the table in Worksheet #6, let us place the letters in a square. These letters represent the gametes joining during fecundation. The instructor shows the image of the Punnett square in the PowerPoint presentation without saying what it is called.

4) **Question:** Does anyone know what this square is called?

Expected answer: A participant could mention the concept "Punnett square." If the concept does not arise, at that moment the instructor will use the PowerPoint presentation to explain facts about Mendel's work and what a Punnett square is. The instructor will explain how the letters (which represent the alleles) are placed in the square so as not to generate alternate concepts. Remember to explain that the square is divided into 4. Thus, it is $\frac{1}{4}$ or 25%. Then, the instructor will hand out Worksheet #6.

5) The instructor will instruct the participants to observe Punnett square #1 in Worksheet #6.

6) **Question:** What did we say that the letters that appear in the Punnett square represent?

Expected answer: It is expected that participants indicate that they represent the alleles that are in an individual's gametes.

7) **Question:** What letters will remain in squares #1, #2, #3, and #4?

Expected answer: It is expected for participants to indicate that in square #1 the letters TT will remain, in squares #2 and #3 the letters Tt will remain, and the letters tt will remain in square #4.

8) **Question:** If we already know that each small square represents 25% of a total of 100%, what percentage is present in each combination of letters/alleles?

Expected answer: It is expected for participants to indicate 25% TT, 50% Tt, and 25% tt.

9) The instructor will instruct the participants to place the answers in the table in Worksheet #6. Using PowerPoint, the instructor will explain that we are diploid ($2n$) organisms and will show an image of the meiosis process.

10) **Question:** Do you know what the genetic traits that are represented with uppercase and lowercase letters are called? What about those that are represented with two equal letters?

Expected answer: Participants might not know the answer. The instructor will proceed to indicate that the traits that are represented by uppercase letters are known as dominant traits (dominant homozygote), that those that are represented by lowercase letters are known as recessive traits (recessive homozygote), and that those that are represented by both

uppercase and lowercase are known as hybrids or heterozygotes. These traits —dominant homozygote, recessive homozygote, and hybrid are known as genotypes.

11) **Question:** With the information that we have up to this point, what % of plants are tall?

Expected answer: It is expected for participants to indicate that 25% of plants are tall (TT), and, possibly, some may indicate 75% (25% TT + 50% Tt), which would be the correct answer.

12) **Question:** Then, what % of plants are short?

Expected answer: It is expected for participants to indicate that 25% of plants will be short (tt).

13) **Question:** Do you know what the physical traits that are represented in uppercase and lowercase letters are called? What about those that are represented with both types of letters?

Expected answers: Participants might not know the answer. The instructor will proceed to indicate that these combinations that represent physical traits are called phenotypes.

14) The instructor will instruct the participants to complete the table in Worksheet #6.

ACTIVITY #2: MENDEL AND CROSSINGS

Worksheet #6

Instructions:

- 1) Follow the instructions of the instructor. Complete the square and table during socialized discussion.

A. Complete the crossing presented below:

X	T	t
T	1	2
t	3	4

Legend:

T = _____

t = _____

B. Observing the square in part A, *following the socialized discussion*, complete the table. **In the provided lines, write another name for genetic traits and physical characteristics: see PowerPoint.**

Genetic traits _____	%	Physical characteristics _____	%
TT			
Tt			
tt			

- 2) Individually, participants will complete **Worksheet #7: Pairing of two organisms**, to solve the crossing exercises.

KEY

GUIDED LESSON USING POWERPOINT AND WORKSHEET #6

ACTIVITY #2: MENDEL AND CROSSINGS

Worksheet #6

Instructions:

- 1) Follow the instructions of the instructor. Complete the square and table during socialized discussion.

A. Complete the crossing presented below:

X	T	t
T	1 TT	2 Tt
t	3 Tt	4 tt

Leyenda:

T = tall plants

t = short plants

B. Observing the square in part A, following the socialized discussion, complete the table. In the provided lines, write another name for genetic traits and physical characteristics: see PowerPoint.

Genetic traits <u>genotype</u>	%	Physical characteristics <u>phenotype</u>	%
TT	25	Tall plants	75
Tt	50	Tall plants	
tt	25	Short plants	25

ACTIVITY #3: PAIRING OF TWO ORGANISMS**Worksheet #7**

A. Complete the following monohybrid crossing:

x A a

A		
A		

Observing the monohybrid crossing, complete the table:

Genotype	Ratio	%	Phenotype	Ratio	%

B. CHALLENGE: Dihybrid crossing

X BL BI bL bl

BL				
BI				
bL				
bl				

Alleles (legend)
B = white mouse
b = black mouse
L = long hair
l = short hair

Observing the dihybrid crossing, complete the table:

Genotype	Ratio	%	Phenotype	Ratio	%

KEY

A. Complete the following monohybrid crossing:

x	A	a
A	AA	Aa
A	AA	Aa

Observing the monohybrid crossing, complete the table:

Genotype	Ratio	%	Phenotype	Ratio	%
AA	2/4	50	White flowers	4/4	100
Aa	2/4	50	White flowers		

B.CHALLENGE: Dihybrid crossing

x **BL** **BI** **bL** **bl**

BL	BBLL	BBLI	BbLL	BbLI
BI	BBLI	BBII	BbLI	BbII
bL	BbLL	BbLI	bbLL	bbLI
bl	BbLI	BbII	bbLI	bbII

Alleles (legend)

B = white mouse

b = black mouse

L = long hair

I = short hair

Observing the dihybrid crossing, complete the table:

Genotype	Ratio	%	Phenotype	Ratio	%
BBLL	1/16	6%	White, long hair	9/16	56%
BBLI	2/16	13%	White, long hair		
BbLL	2/16	13%	White, long hair		
BbLI	4/16	25%	White, long hair		
BBII	1/16	6%	White, short hair	3/16	19%
BbII	2/16	13%	White, short hair		
bbLL	1/16	6%	Black, long hair	3/16	19%
bbLI	2/16	13%	Black, long hair		
bbII	1/16	6%	Black, short hair	1/16	6%

CLOSURE

ACTIVITY #4: DESCRIBING MY PHENOTYPE AND GENOTYPE

Worksheet #8

Instructions:

- 1) Individually, using the descriptions and letters to represent human characteristics, determine your genotype and phenotype. Write your data in table #1. **Remember to write the alleles to identify the characteristics and the expressed allele for each one. Look at the example given by the instructor.**
- 2) Select a partner from the group. Then, using the Punnett square, perform a monohybrid crossing of their phenotype and yours for the characteristic of the **thumb**. Perform this same step but with the other characteristics. Determine the genotype and phenotype of your offspring #1. **Remember that each characteristic has 2 alleles; select one of the two to perform your crossing. Write the data in table #2.**
- 3) Repeat step #2 with another colleague from your class. These collected data will represent the phenotype and genotype of your offspring #2. Write the data down in table #3.

Example:

Table #1: Describing my phenotype and genotype

Your traits	Thumb		Earlobes		Cleft Chin		Use of hand (left/right)		Closing of hand	
	Alleles	Expressed allele	Alleles	Expressed allele	Alleles	Expressed allele	Alleles	Expressed allele	Alleles	Expressed allele
phenotype	Normal thumb/ thumb with extension	normal thumb- recessive	Separated earlobe/ Joined earlobe	Separated earlobe - dominant	Cleft chin/ Normal chin	Normal chin recessive	right/ left	right dominant	Left finger up/ Right finger up	Left finger up dominant
genotype	Hh	h	Ff	F	Dd	d	Rr	R	Cc	C

Data tables:

Table #1: Describing my phenotype and genotype

Your traits	Thumb		Earlobes		Cleft Chin		Use of hand (left/right)		Closing of hand	
	Alleles	Expressed allele	Alleles	Expressed allele	Alleles	Alleles	Expressed allele	Alleles	Expressed allele	Alleles
phenotype										
genotype										

Table #2: Phenotype and genotype offspring #1

Offspring #1	Thumb	Earlobes	Cleft Chin	Hair in the middle of the finger	Use of hand (left/right)	Closing of hand
phenotype						
genotype						

Table #3: Phenotype and genotype offspring #2

Offspring #2	Thumb	Earlobes	Cleft Chin	Hair in the middle of the finger	Use of hand (left/right)	Closing of hand
phenotype						
genotype						

Analysis questions:

- 1) According to your data in Table #1, compare your expressed alleles and indicate if they coincide or not with the dominance of the used characteristics.

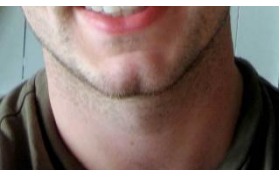
Expected answer: Yes or no, it may vary.

- 2) If one of your expressed characteristics did not coincide with its dominance, explain what could cause your alleles to express that way.

Expected answer: Both alleles are recessive.

Examples of Human Genotypes

Use of hand		Closing of hands	
Dominant	Recessive	Dominant	Recessive
			
Phenotype: Right hand	Phenotype: Left hand	Phenotype: Left finger up	Phenotype: Right finger up
Allele: R	Allele: r	Allele: C	Allele: c

Thumb hyperextension		Cleft chin	
Dominant	Recessive	Dominant	Recessive
			
Phenotype: Extended thumb	Phenotype: Normal thumb	Phenotype: Cleft chin	Phenotype: Normal chin
Allele: H	Allele: h	Allele: D	Allele: d

Earlobes	
Dominant	Recessive
	
Phenotype: Separated earlobe	Phenotype: Joined earlobe
Allele: F	Allele: f

Additional activity to review concepts

- 1) Individually, complete **Worksheet #9: Crosswords: *What my future says***, to review the learned concepts. The concepts reviewed in the crosswords puzzle are defined in the glossary. En forma individual, completar la **Hoja de Trabajo #9: *Crucigrama: Lo que dice mi futuro***, para repasar los conceptos aprendidos. Los conceptos repasados en el crucigrama aparecen definidos en el glosario.

Instructions:

A. Complete the crosswords puzzle to review the studied concepts.

1

2

3

4

5

6

7

8

9

10

11

12

13

14

Horizontal	Vertical
------------	----------

2. It is a long and continuous DNA filament formed by numerous genes and that stores genetic information. 4. The set of all physical characteristics of a determined organism that result from the interaction of its genotype and the environment is known as _____. 5. Chromosomes of the same length, aspect, and gene sequence, although alleles from one or another chromosome can be different. 7. It refers to a kind of mutation in which a chromosomal segment is transferred to a position in the same or another chromosome. 11. The _____ crossing is known as the crossing between two organism that only involve a pair of different traits. 13. It is the molecule that stores genetic information of all organisms. 14. It is a piece of DNA that provides a set of instructions to a cell for it to make a determined protein.	1. The set of all coded traits in the genetic information of an organism is known as _____. 2. It is the cellular structure that joins two sister chromatids of a chromosome. 3. It is the organization, on a square, of the chromosome that an individual possesses; useful to locate aneuploidies in humans, like Down syndrome. 5. mating of two organisms. 6. An _____ is any of the variants or versions of a gene that may happen in a specific locus. 8. The half of a chromosome is called _____. 9. It is the possibility that a particular event may occur. 10. It is a prediction model of all possible genotypes that could be obtained from a determined crossing or mating. 12. The _____ crossing is known as the crossing between two organisms that involves two different characteristics or traits.
--	---

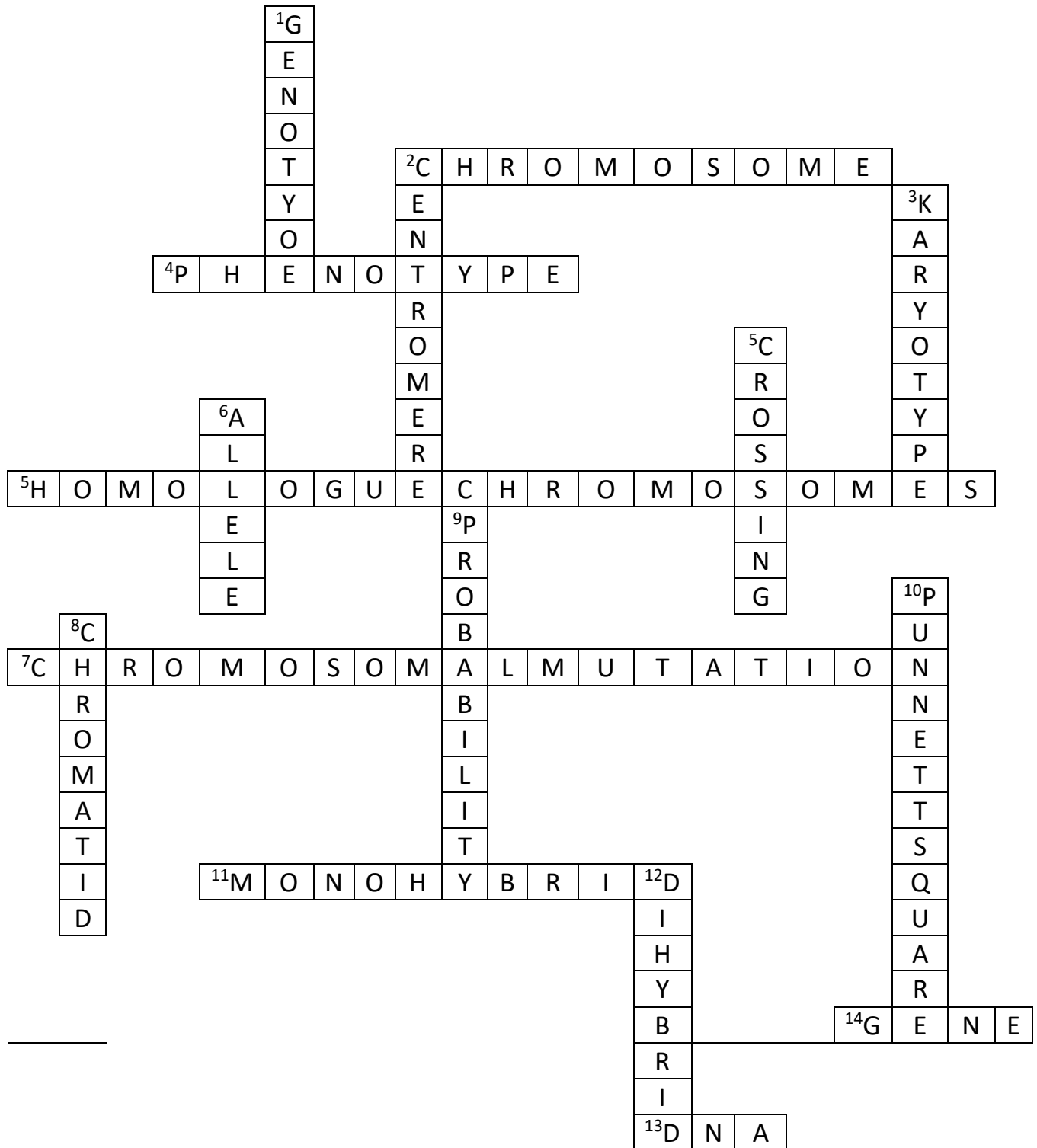
Crosswords: What my future says

KEY

Worksheet #9

Instructions:

A. Complete the crosswords puzzle to review the studied concepts.



BIBLIOGRAPHY

La Dinámica de la Vida, McGraw Hill, p. 299,

Senior Biology 1, BioZone, p. 153

HMH Dimensiones de las Ciencias: Biología, Houghton Mifflin Harcourt Publishing Company, 2018, p. 305 – 349.