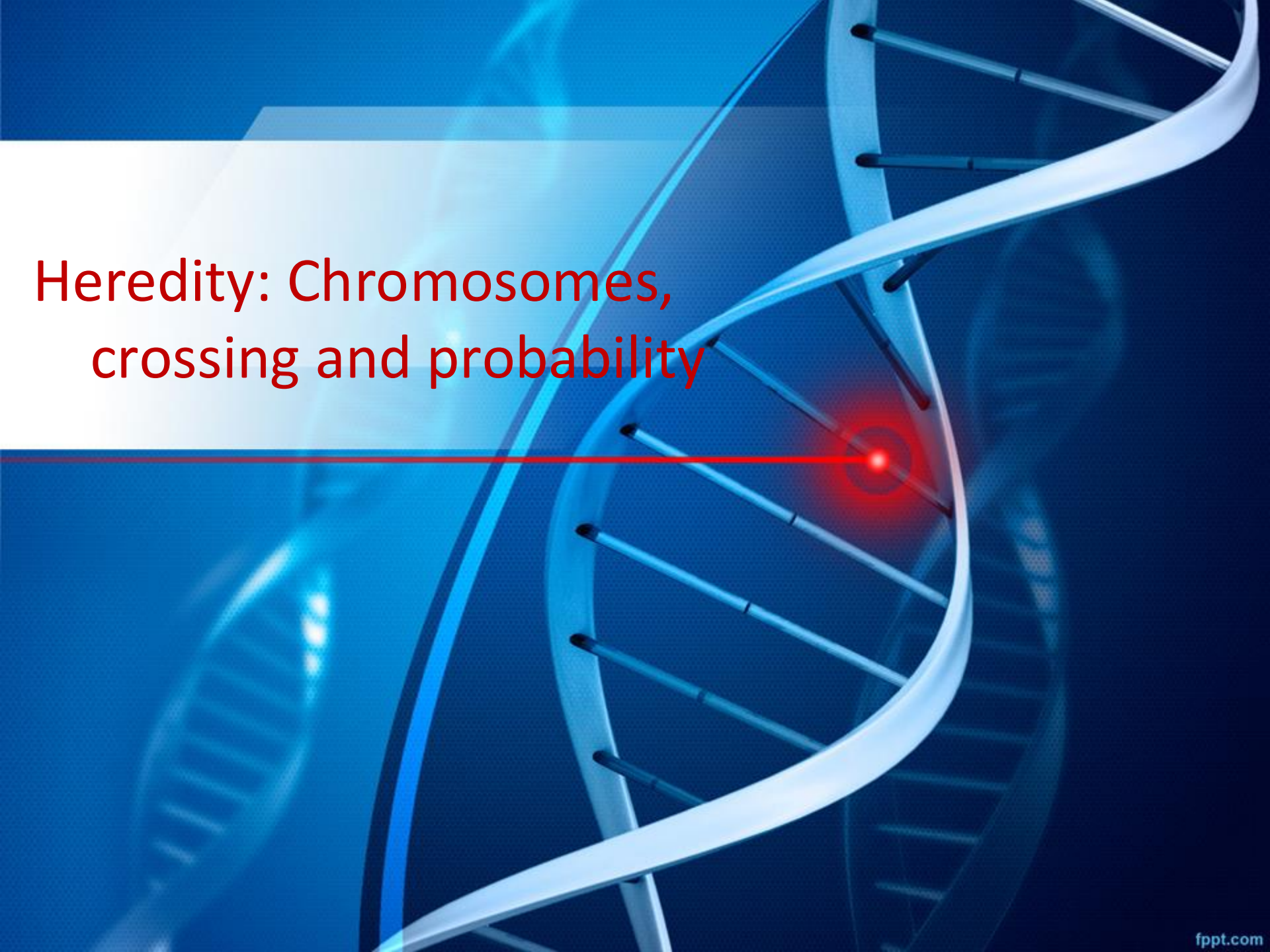
Heredity: Chromosomes, crossing and probability



LEARNING OBJECTIVES

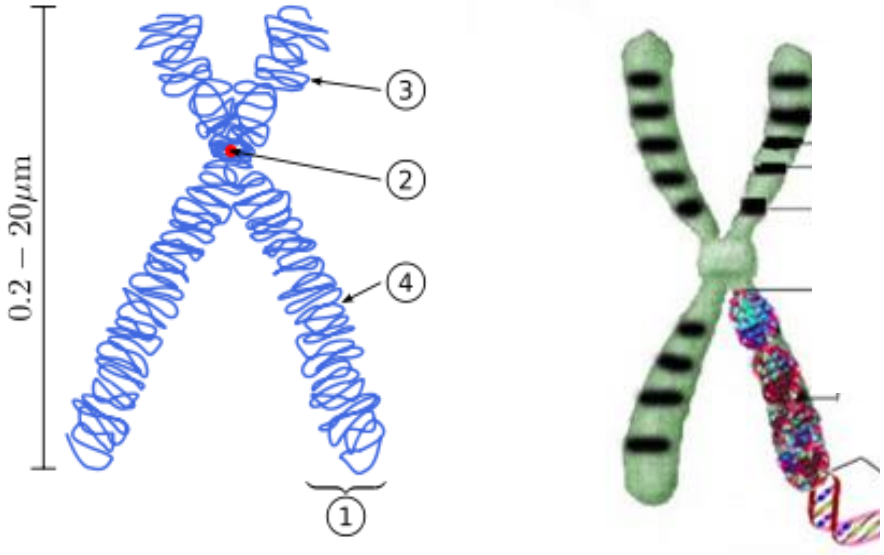
Throughout this activity, the participant will:

- describe the structure of chromosomes.
- identify the human karyotype and compare it to other species'.
- define what is chromosomal mutation and the kinds of chromosomal mutations.

LEARNING OBJECTIVES

- compare the number of chromosomes in the (normal) human being with the number of chromosomes when a chromosomal mutation occurs.
- define what is probability.
- Identify the genotype and phenotype in various crossings.

Identify the structures of a chromosome



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

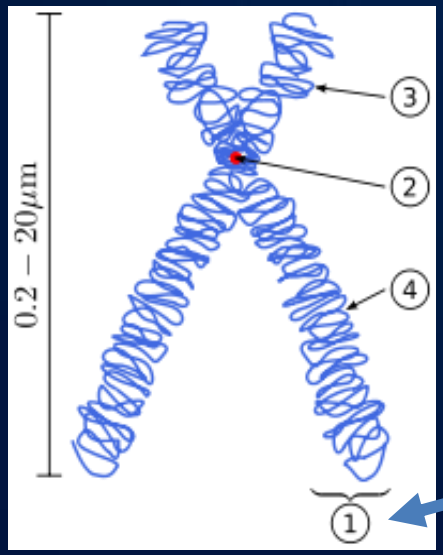
Vocabulary

- **chromosome** = long and continuous DNA filament formed by numerous genes and that stores genetic information.
- **centromere** = cellular structure that joins two sister chromatids of a chromosome.
- **chromatid** = it is the half of a chromosome.

Vocabulario

- **gene** = it is a piece of DNA that provides a set of instructions to a cell for it to make a determined protein or ARN (ribonucleic acid) molecule. Each gene has a specific location (locus) in a pair of homologous chromosomes..
- **allele** = any of the variants or versions of a gene that may happen in a specific locus
- **ADN (deoxyribonucleic acid)** = molecule that stores genetic information of all organisms.

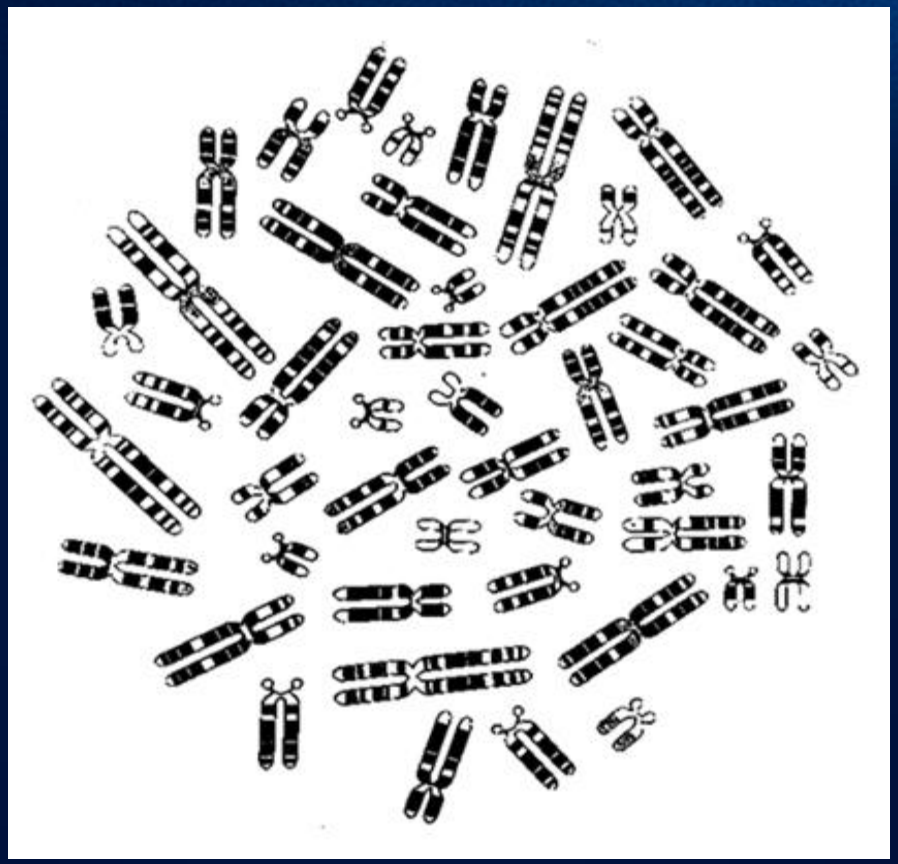
Relationship of the chromosome in the process of heredity



Chromatin

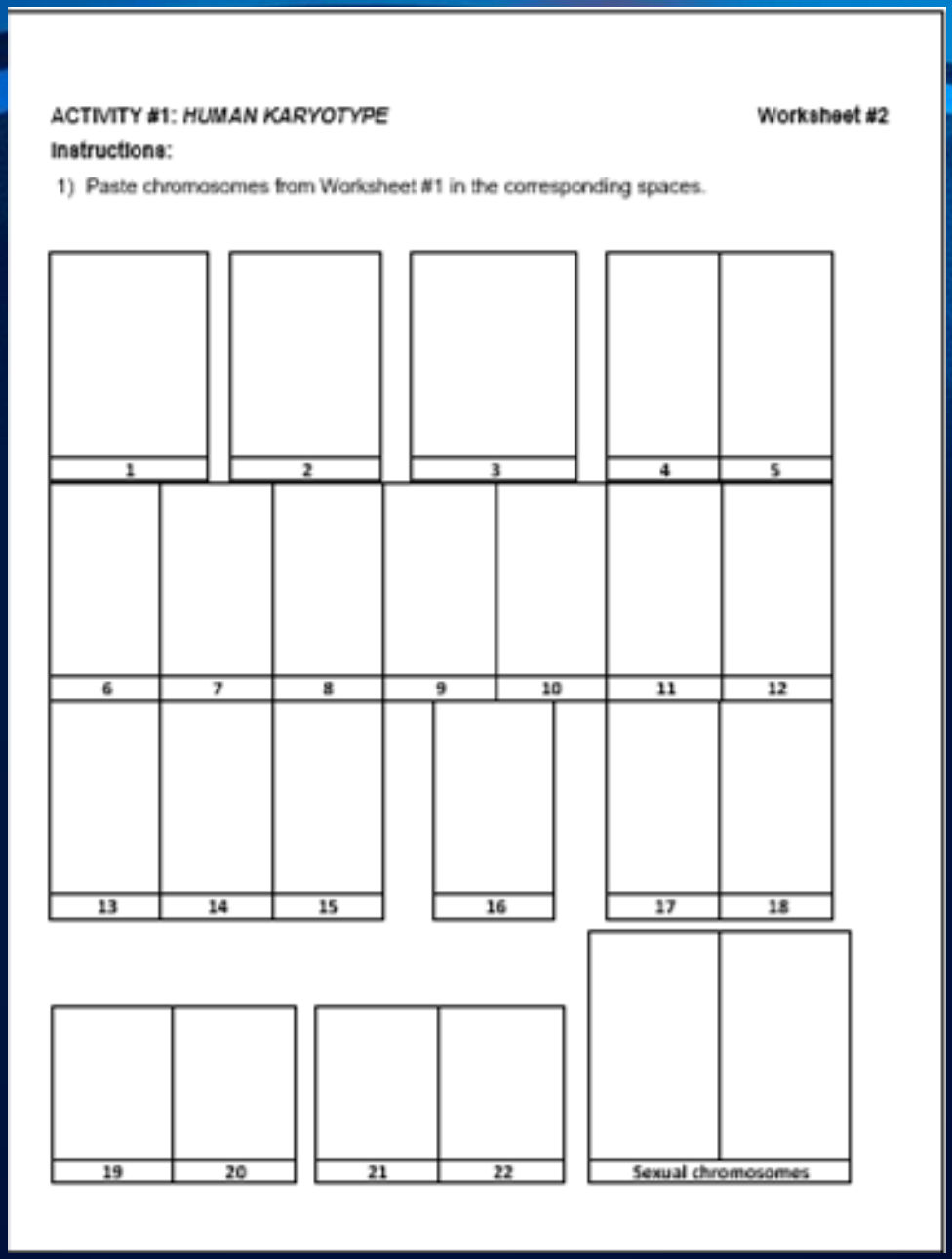
- Contains the molecule that stores genetic information that is inherited from parents to offspring.

Worksheet #1



- Cut the chromosomes. Create as many pairs as possible between them.
- Paste the chromosomes in Worksheet #2.
- Use Worksheet #3 as reference.

Hoja de Trabajo #2



ACTIVITY #1: *HUMAN KARYOTYPE* Worksheet #2

Instructions:

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

1 2 3 4 5

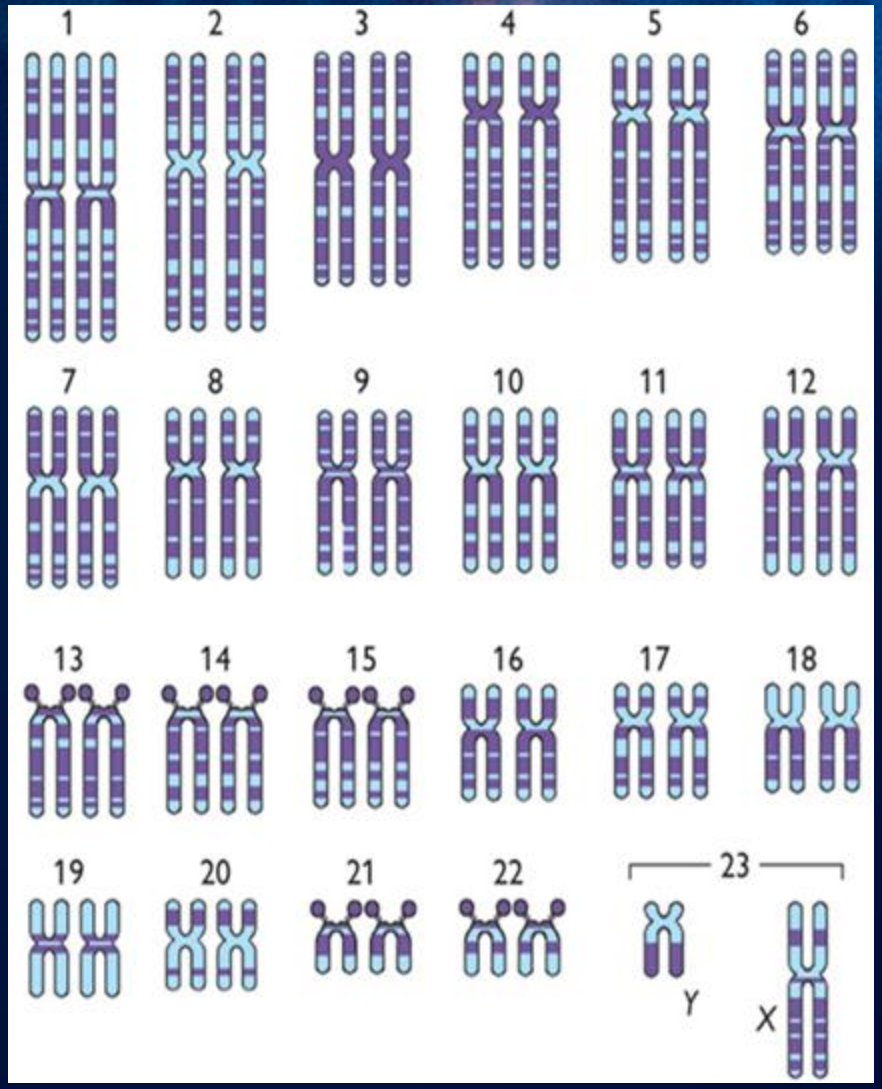
6 7 8 9 10 11 12

13 14 15 16 17 18

19 20 21 22 Sexual chromosomes

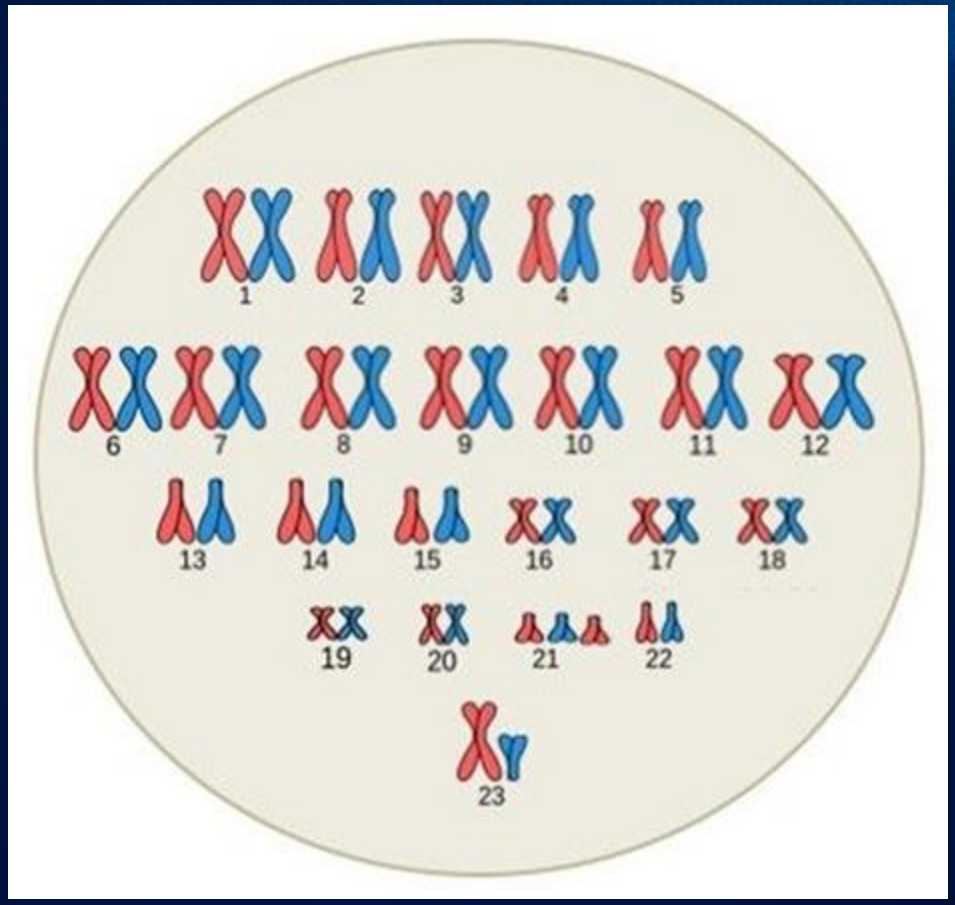
- Paste the chromosomes that you cut from Worksheet #1 in this sheet.

Worksheet #3



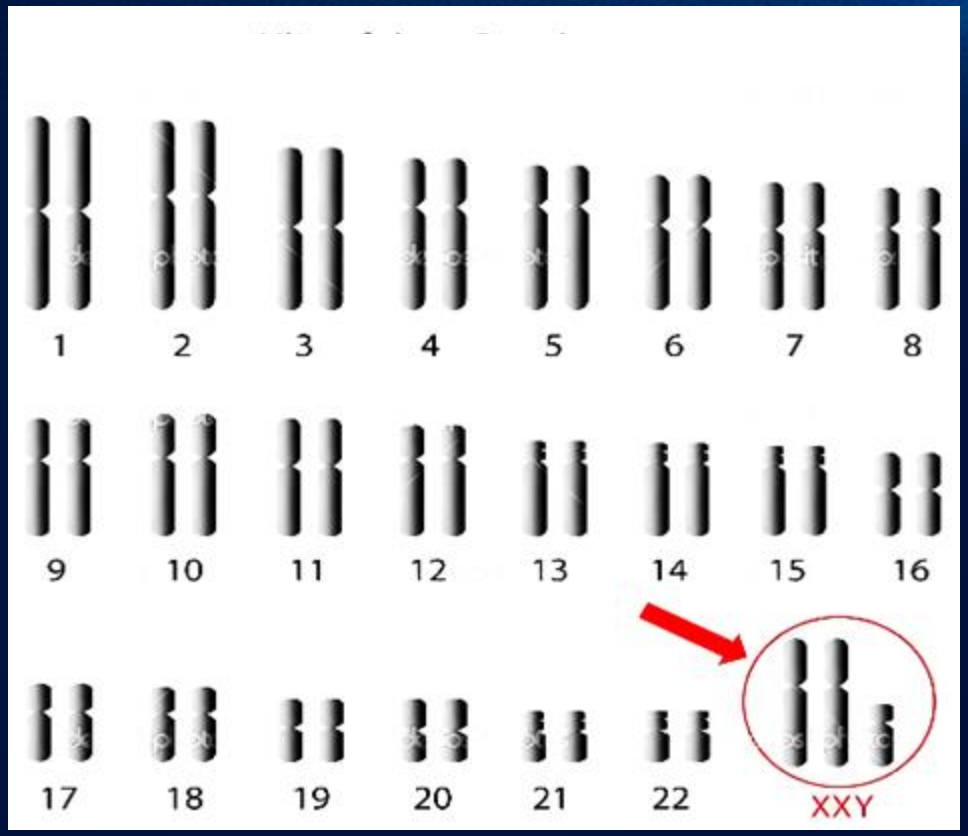
- **Activity #1: *Human Karyotype***

Worksheet # 4a



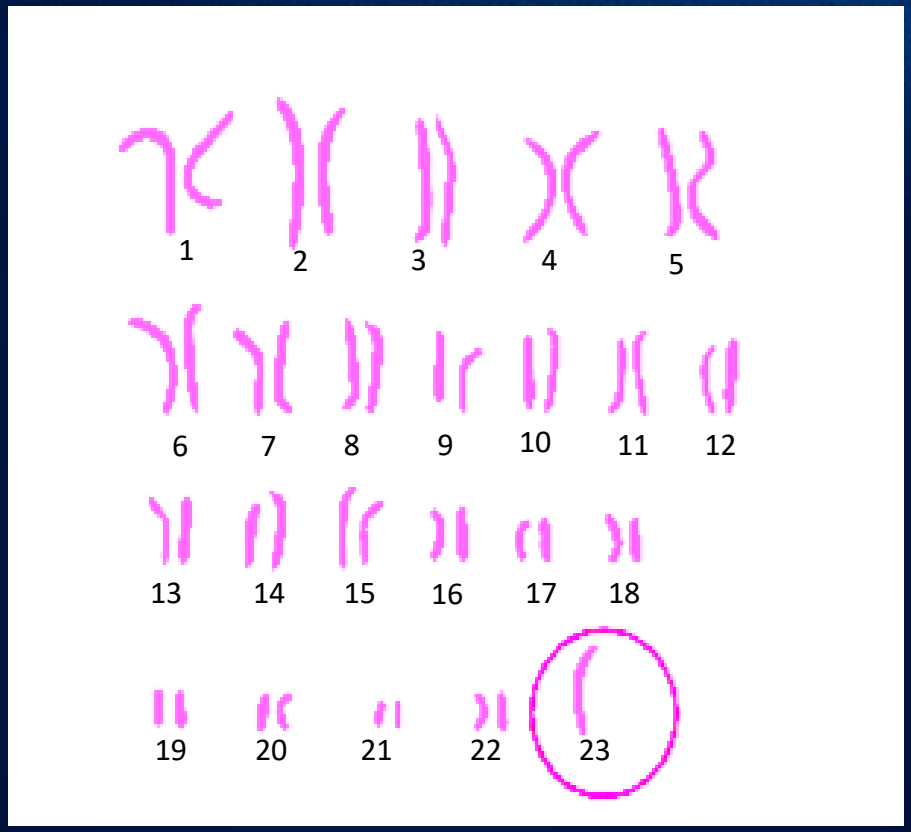
- **Human karyotype of Down Syndrome**

Worksheet #4b



- **Human karyotype of Klinefelter Syndrome**

Worksheet #4c



- Human karyotype of Turner Syndrome

Tabla #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 (*Heliconius sp.*)	21	42
cabbage	9	18
potato	24	48
corn	10	20

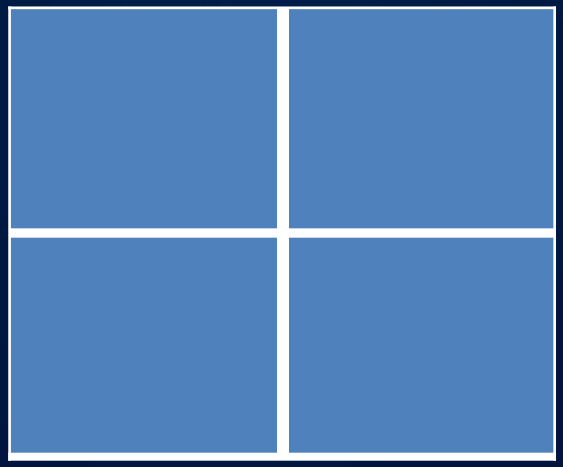
PART B Heredity: *Crossings y Probability*

- Probability
  - Branch of mathematics
  - It is the possibility that a result may occur
    - For example: that a dog may be born with black fur

GUIDED LESSON
Worksheet #2

What is this square called?

X



- It is called the Punnett Square in honor to British scientist R.C. Punnett.
- The Punnett model tracks the alleles that each parent can donate; in this way the results of crossings can be predicted.

Gregor Mendel and heredity

- What is known today about heredity comes from the works carried out in the mid-19th century by the Austrian monk, Gregor Mendel.

- Mendel chose to work with pea plants because they reproduced quickly and could control their pollination easily.

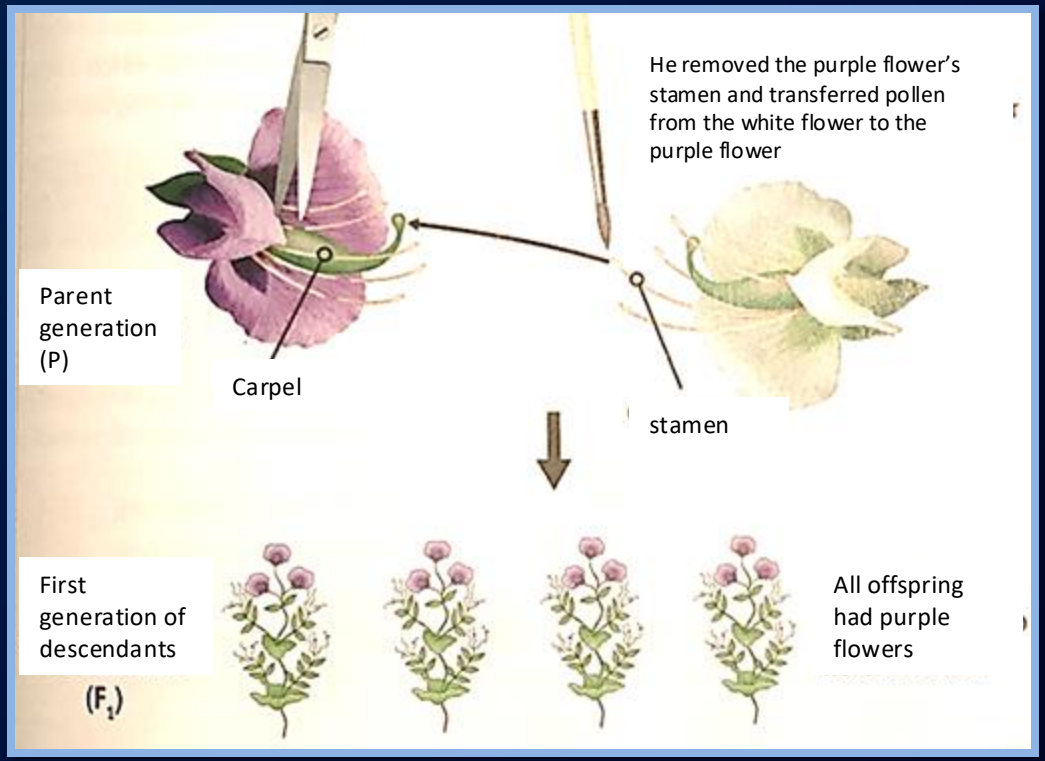
Mendel worked with seven traits present in pea plants

Color of the flower	Position of the flower	Color of the seed	Shape of the seed	Shape of the pod	Color of the pod	Length of the stem
						
purple	axial	yellow	smooth	inflated	green	tall
						
white	terminal	green	wrinkled	outlined	yellow	short

Gregor Mendel and heredity

- Mendel began to work with purebred pea plants as the parent generation.
- A purebred plant means that if a plant with purple flowers self-fecundates, the offspring will have purple flowers only.
- In his experiments, Mendel controlled reproduction to prevent self-pollination of the pea plants.

Mendel controlled self-fecundation by removing the masculine parts from flowers and then fecundated the feminine parts.



Mendel's crossings

- In this image, Mendel's experimental crossings can be observed.
- In the first one, he crossed a purebred white flowered pea plant with a purebred purple flowered pea plant. Both plants are the parents (P).
- F1 plants are the first filial generation of P plants.

Mendel's second experiment

In the second experiment, Mendel let F1 plants self-fecundate. This means he did not control pollination.

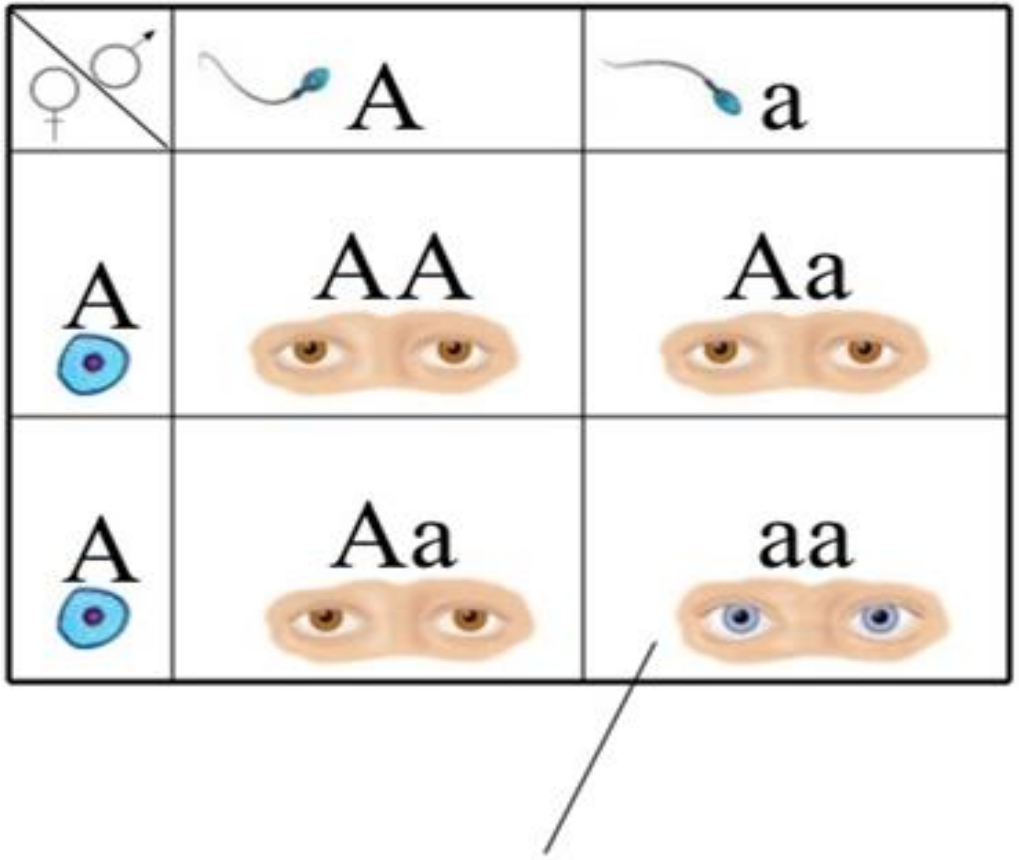
Although both F1 plants were purple, their progeny (F2) had a set of different traits.

Gregor Mendel

- Mendel concluded that traits can be inherited as separate “factors,” or independent units, that can be passed from parents to offspring.

¿Cómo se transmiten los genes?

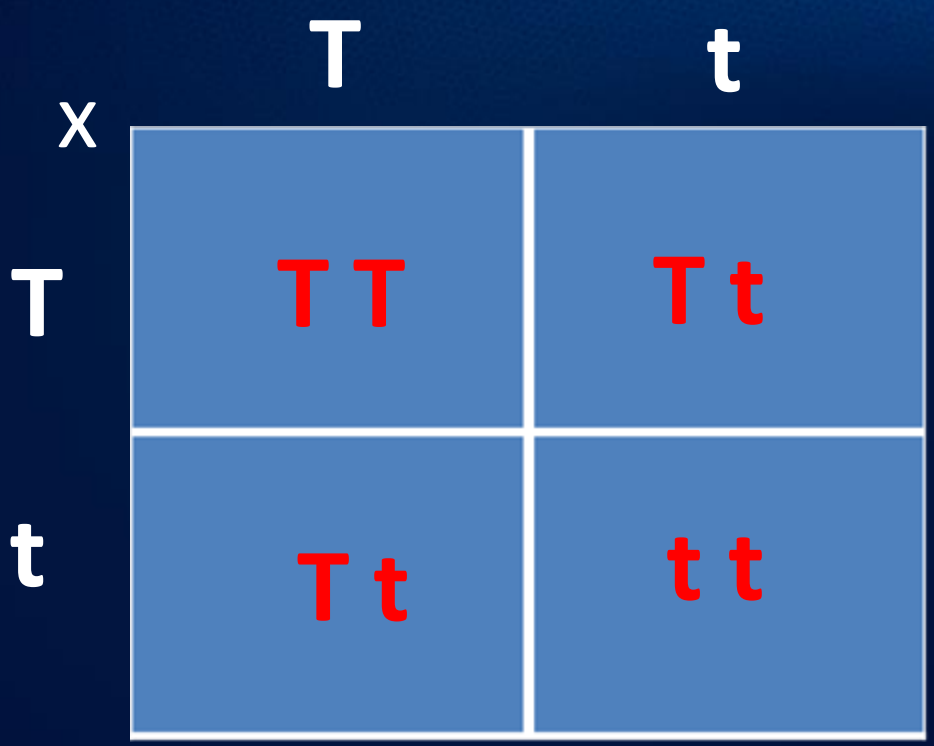
This is another way to represent the possible combinations among male and female gametes



Punnett Square

A boy with blue eyes can be born from parents with brown eyes if an **a** ovule combines with an **a** spermatozoon.

Worksheet #3



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 characteristics of living beings (alleles).

What letters will remain in squares #1, #2, #3, and #4?

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

Worksheet #3

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

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

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

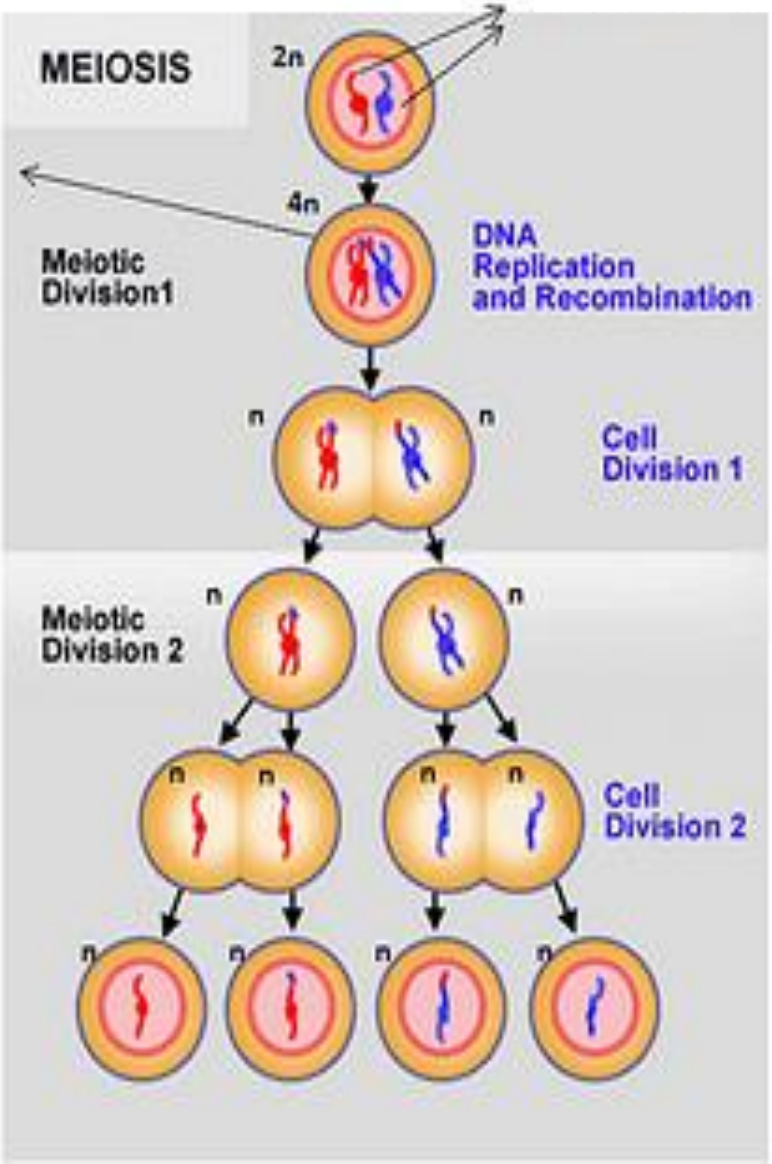
Meiosis

Pair of homologous chromosomes. One comes from the mother and one comes from the father.

Pair of duplicated homologous chromosomes = *bivalents or tetrads*

In this stage, the crossing-over of homologous chromosomes occurs.

Only between a chromatid of a pair of homologue chromosomes and a chromatid from the other pair.



Separation in the level of a pair of homologous chromosomes. Random segregation.

Separation of sister chromatids. Reduction of genetic material by half. Random segregation.

GUIDED LESSON
Worksheet #2

Do you know how the genetic traits that are represented with uppercase and lowercase letters are called? What about those that are represented with both equal letters?

GUIDED LESSON
Worksheet #2

With the information that we have up to this point, what % of plants are tall?

GUIDED LESSON
Worksheet #2

Then, what % of plants are short?

Expected answer:

It is expected for participants to indicate that 25% of plant will be short (tt).

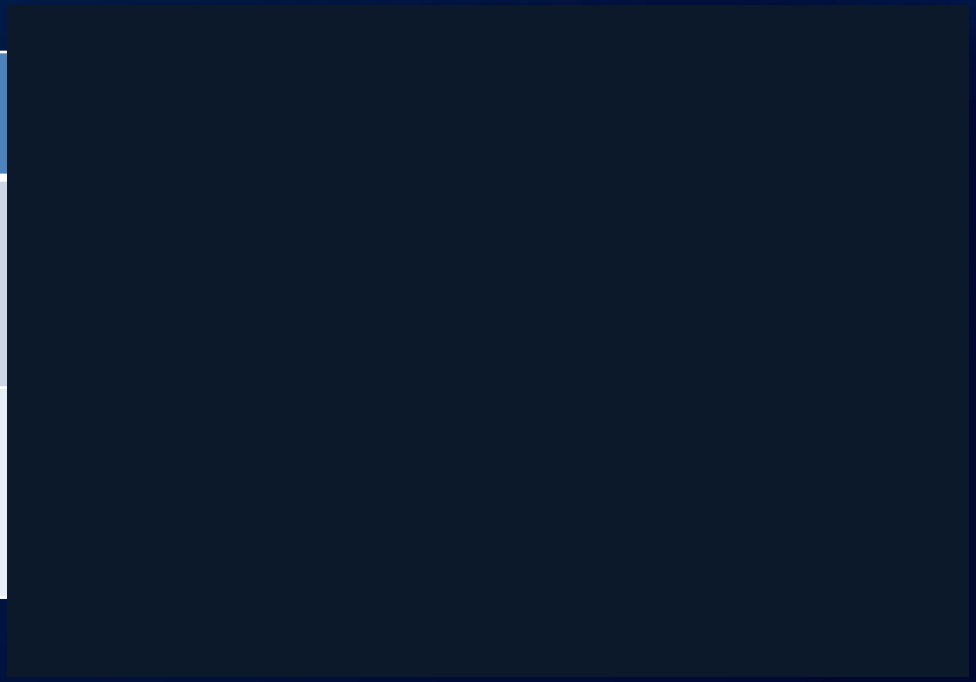
Do you know how the physical traits that are represented in uppercase and lowercase letters are called? What about those that are represented with both types of letters?

Worksheet #3

Pairing of two organisms

A. Complete the following monohybrid crossing

x	A	a
A		
A		



Worksheet #3

Observing the monohybrid crossing, complete the table:

Genotype	Ratio	%	Phenotype	Ratio	%

B. CHALLENGE: Dihybrid crossing

Worksheet #3

x	BL	Bl	bL	bl
BL	BBLL	BBLl	BbLL	BbLl
Bl	BBLl	BBll	BbLl	Bbll
bL	BbLL	BbLl	bbLL	bbLl
bl	BbLl	Bbll	bbLl	bbll

Alleles (legend)

B = white mouse

b = black mouse

L = long hair

l = short hair

Worksheet #3

Observing the dihybrid crossing, complete the table:

Genotype	Ratio	%	Phenotype	Ratio	%
BBLL	1/16	6%	White, long hair	9/16	56%
BBLl	2/16	13%	White, long hair		
BbLL	2/16	13%	White, long hair		
BbLl	4/16	25%	White, long hair		
BBll	1/16	6%	White, short hair	3/16	19%
Bbll	2/16	13%	White, short hair		
bbLL	1/16	6%	Black, long hair	3/16	19%
bbLl	2/16	13%	Black, long hair		
bbll	1/16	6%	Black, short hair	1/16	6%

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

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

Examples of human genotypes