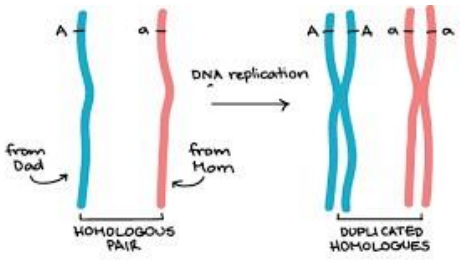
Chap.2: Transmission of genes and genetic recombination

- Hereditary traits are transmitted from parents to offsprings by meiosis and fertilization. These traits are controlled by genes that are linearly arranged on chromosomes.
- What does the result reveal in doc.a page 42?
  - The nucleus transmits the black color to the baby while the cytoplasm and uterus have no effect on that.
- Derive a suitable conclusion.
  - The genetic information is located inside the nucleus.
- Monohybrid Cross or monohybridism: is the cross-breeding between 2 individuals of same species belonging to pure races that differ in sexes and in one allelic character. The offsprings obtained are called hybrids of F_1: "First Filial generation"
- Allelic character: is a general allelic hereditary trait in a species.

  Example:
  - Color of eyes of humans
  - Color of skin in humans
  - Blood group in humans
  - Color of fur in rabbits
  - Length of wings in drosophila



Each allelic trait is represented by 2 alleles, on a pair of homologous chromosomes of an individual.

The 2 alleles may be similar or different that correspond to a gene of this character.

- Gene: is a version of 2 alleles in a pair of homologous chromosomes in any individual
  - If the 2 alleles are **similar**, they are said to be **homozygous** or **pure** or **true-breeding**.
  - If the 2 alleles are **different**, they are said to be **heterozygous** or **hybrid**.
  - The allelic trait has many different alleles in a population but it has 2 alleles in an individual.

Allelic character	**Alleles**
1. Blood group in humans	A, B, O
2. Length of wings of drosophila	Long, short, vestigial, intermediate
3. Color of eyes of humans	Black, blue, brown, green,…

- **Representation of alleles**:

  Symbol of alleles: They are represented by alphabetical letters

  a. A capital letter for dominant or codominant alleles

  b. A small letter for recessive alleles

  Example: in humans:
  - Right –handed allele dominates left-handed allele
  - Alleles of blood groups A and B dominate allele O and codominant with respect to each other.

  Symbol of alleles :

  "R" for right –handed allele

  " l" for left-handed allele

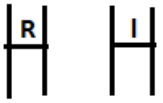
  "A" for blood group A

  "B" for blood group B

  "O" for blood group O
- **Genotype of an individual**: It is represented by 2 alleles of same allelic character on a pair of homologous chromosomes.

i)If they are similar: RR or ll, they are said to be homozygous individual

ii)If they are different; Rl, the genotype is hybrid



Same level and Same location

- **Phenotype:** is the expression of the genotype in an individual.
  It is represented by [R] or Right-handed
  [l] or Left-handed

  Application: Monohybrid cross

  - Dominant-Recessive
  - Gene is autosomal

  Example: **A cross is done between 2 pure races of rabbits : a male having normal paws and a female having deformed paws. All obtained rabbits were having normal paws.**

  Conclusion: - Normal paws allele is dominant, since all F1 have normal paws
  -Deformed paws allele is recessive
  The obtained rabbits are called hybrids of F1

  Symbol of alleles: "N" for normal paws
  "d" for deformed paws

Phenotype: ♂ [N] pure x ♀ [d] pure

1) Genotype : of parents NN x dd

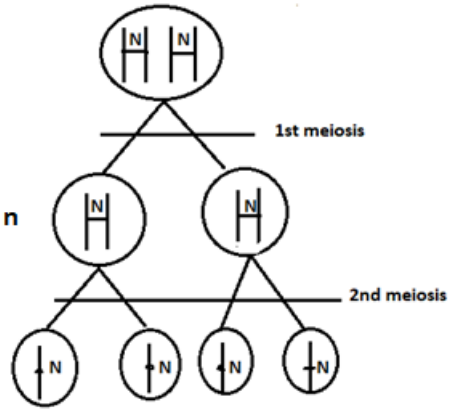
2) Gametes of : P ♂(N) ♀(d)

100% 100%

3) Table of fertilization or Punnet square or table of cross:

♀ \ ♂	N 100%
d 100%	Nd 100% (F1)

Segregation of gametes during meiosis:



4) **Analysis of table of cross**:

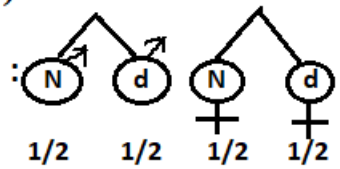
- One genotype: 100 %

- One phenotype: [N] 100%

- **Factorial analysis of self -fertilization of F1(self cross): F_1 x F_1(Parents) → F_2 (Offsprings)**

i) **Genotype of parents (F1):** ♂ **Nd** **x** ♀ **Nd**

ii) ⚷ **of parents** :



iii) **Punnet square table:**

♀ \ ♂	**N** ½	d ½
N ½	NN ¼	Nd ¼
d ½	Nd ¼	dd ¼

iv)**Analysis of table:**

3 genotypes: ¼ NN

½ Nd

¼ dd

2 phenotypes: **¼** [d]

¾ [N]

F_1 x recessive → 2 equal phenotypes: ½ [D], ½ [r]

♀ \ ♂	N 1/2	d 1/2
d 1	Nd 1/2	dd 1/2

♀ ♂

Genotype of P : Nd x dd → ½ [N] ; ½ [d]

Laws of Mendel

1st Law of Mendel: " Law of homogeneity"in F1:All individuals of F1 have same genotype and same phenotype

2nd Law od Mendel : Law of heterogeneity in F2: Individuals in F2 resulting from the cross (self-fertilization of F1) have different phenotypes and different genotypes

3rd Law of Mendel: Law of segregation The gamete must not hold 2 or more alleles for the same allelic character. It carries **only one** allele for a particular character.

- **Test cross :** is used to determine the real genotype of the dominant parent whether pure or hybrid.

Application on test cross:

- **In humans, black eyes allele dominates blue eyes allele.**

1. **Indicate the symbol of alleles.**
   Symbol of alleles : "B" for black eyes
   "b" for blue eyes
2. **Indicate the theoretical genotype of each individual:**
   For individual having phenotype :black eyes [B] : the theoretical genotype is BB or Bb

   For individual having phenotype blue eyes [b] : the genotype is bb

❖ **A cross is done between a black-eyes man and blue-eyes woman .**
Make a factorial analysis for the different cases to find the phenotypic % of their children.

Factorial analysis:

1st case : ♂ ♀

- Phenotype of P : [B] x [b]

- Genotype of P: BB x bb

-Gametes of P 100% B b 100%

- Punnet square :

♀ \ ♂	**B** 100%
b 100%	**Bb** 100 %

-

Analysis of table : Phenotype [B] 100%; therefore the dominant parent is pure

2nd case : ♂ ♀

- **Genotype of P** : Bb x bb
- **Gametes of P** : (50%) B b (50%) b (100%)
- **Punnet square of cross:**

♀ \ ♂	B 50%	b 50%
b 100%	Bb 50%	bb 50%

2 phenotypes : [B] 50%

[b] 50%

Therefore the dominant parent is hybrid

Hint: 1) Dominant allele has 2 possible probable genotypes: DD; or Dr
2) recessive allele has the property of purity: homozygous genotype rr
For [r] to appear,the parents should be carrier of allele "r" in their genotype.

- Monohybrid : [D - r]: autosomal genes (no differentiation between males and females)
  1) Pure [D] x pure [r] → F1 hybrid Dr
  2) F1 x F1 → F2 : ¾ [D] ; ¼ [r]
  3) F1 x [r] (test cross) : ½ [D] ; ½ [r]

❖ **Lethal allele** : is an allele that leads to the death of its homozygous carrier before reaching sexual maturity.

How do we know that there is lethal allele?

From the obtained results. When death occurs a modification in the proportion or percentages of the different phenotypes of F2 occurs.

Application in doc.f page 45

a. Specify the dominant allele.
   In the 2nd cross, the cross between 2 yellow parents gives a black phenotype in the offsprings.Thus the black allele is present and masked in the parents. Thus black allele is recessive and yellow allele is dominant.
b. Explain the results of the 2nd cross
   The appearance of the black phenotype in the parents shows that the parents are heterozygote. These results should be ¾ yellow and ¼ black. However this is not the case. The results are 1/3 black and 2/3 yellow, showing that a lethal allele is found. And since the lethal allele is an allele that leads to the death of its homozygous carrier, and since there is 1/3 black therefore yellow is the lethal allele.

Experiment: A > a (A dominates a)
The crossing between 2 hybrids give: 2/3 dominant; 1/3 recessive
Hybrid x hybrid

Aa x Aa → F2: 2/3 [A]; 1/3 [a]
F1 F1

♀ \ ♂	**A** ½	a ½
A ½	AA ¼	Aa ¼
a ½	Aa ¼	aa ¼

Normally: Aa x Aa →3/4 [A]; ¼ [a] (Theoretical results)

By comparing the phenotypic proportions of the results obtained : 2/3 [A]; 1/3 [a], we notice missing of one proportion of the dominant allele [A] and the recessive allele "a"has the property of purity: aa; and it appeared in the result of proportion 1/3 [a]. Hence allele "A" is lethal when in the homozygous state AA.

Verification: F1 x F1

♂ ♀

Genotypes of parents : Aa x Aa

Gametes of parents : ½A ½a ½A ½a

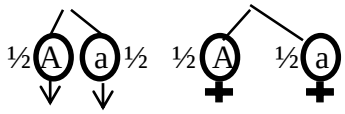


Table of cross:

♀ \ ♂	**½ A**	**½ a**
½ A	**¼ AA**	**¼ Aa**
½ a	**¼ Aa**	**¼ aa**

Analysis of table : 2/3 [A]; 1/3 aa ; AA lethal which verifies the result

- Transmission of alleles in case of **incomplete dominance**: genes are autosomal

Incomplete dominance cross: It is the crossing between 2 pure races that differ in one allelic character . The result is F_1 having a new intermediate phenotype that differs from both parents.

Application**: A cross is done between 2 pure races of plants: male having red flowers and female having white flowers. All the obtained plants in F1 were having pink flowers.**

♂ (pure plant) x ♀(pure plant)

Red flower x White flower → F1: pink flowers (Intermediate phenotype: combination between red allele and white allele) . Red allele and white allele are dominant alleles.There is no allele responsible for intermediate phenotype.Both dominant alleles are homozygous; the intermediate one is hybrid, which is a combination between the 2 dominant alleles.

Symbol of alleles: "R" for red "W" for white

Genotype of red flower: RR Genotype of white flower:WW

Genotype for pink flower (intermediate phenotype) : RW

F1xF1: RW xRW → ¼ RR →[R]
½ RW→[RW]
¼ WW→[W]
} 3 phenotypes

♀ \ ♂	R ½	W ½
R ½	RR ¼	RW ¼
W ½	RW ¼	WW ¼

- Codominance cross: It is the crossing between 2 pure races that differ in one allelic character . The result is F1 having a new phenotype that differs from both parents where each of the 2 dominant alleles is expressed independently from each other.

Example: Red flower x White flower or blood grp [AB]

RR x WW → F1: RW (all flowers in F1 are spotted with red and white)

F2= F1xF1→3 genotypes: RR ¼ ;WW ¼ ;RW ½ and 3 phenotypes : [R] ¼ ;[W] ¼ ;[RW] ½

Definitions:

Gene: fragment of DNA that carries a hereditary trait on chromosome. Ex.Blood group

Alleles: different versions of a gene Ex. A, B, and O for the blood group gene.

Genotype: Two letters that represent the two alleles of a given gene carried by an individual. Ex. AA or AO

Phenotype: expression of the genotype on the individual. It is represented by [A] or word ex. White.
Homozygote(pure race): an organism having 2 identical alleles of the same gene. Ex.BB , dd,,etc…

Heterozygote (hybrid): an organism having 2 different alleles of the same gene.Ex.Gw, Nd,…

Dominant allele: allele that is expressed in homozygotes and heterozygotes(symbolized by a capital letter).Ex. Allele A or Allele B

Recessive allele: allele that is only expressed in homozygote(symbolized by a small letter).

Ex. Allele r or Allele O

Codominant alleles: alleles that are both expressed in the phenotype ex. AB
True breeding line: a group of genetically identical homozygous individuals that, when intercrossed, produce only offspring that are identical to their parents.
Hybridization: It is the experimental crossing of 2 true-breeding organisms that differ in one or more traits to obtain a hybrid

Hybrid: It is a heterozygote produced by hybridization

Table summarizing the phenotypic results of F1, F2, test cross and lethality in a monohybrid cross.

Types of monohybrid cross		F1 result	F2 results (self cross: F1xF1)	Test cross or back cross: to know the real genotype of the dominant parent
Dominance case: Ex.: Genotype of parents: DD x rr		1 phenotype: [D] 100% 1 genotype :Dr hybrid 100%	Dr x Dr→**2 Phenotypes**:3/4 [D],1/4[r] 3 Genotypes:1/4 DD,1/2 Dr, ¼ rr	If D?x rr→1 [D]; then the dominant parent is pure DD If D? x rr→1/2 [D],1/2 [r]; then the dominant parent is hybrid or heterozygous Dr
Incomplete dominance or intermediate dominance case Ex: Red flower xWhite flower Genotype of parents: RRxWW		1 phenotype: Pink flowers 100% 1 genotype: RW 100%	RW x RW→**3 phenotypes**: ¼ [R],1/2 [RW] or pink flowers,1/4 [W] **3 Genotypes**:1/4 RR,1/2 RW,1/4 WW	----------
Codominance case (each dominant allele is expressed independently from the other) Ex.Red flowersxWhite flowers Genotype of parents :RRxWW		1 phenotype: Flowers spotted with red and white 100% 1 Genotype:RW 100%	RW x RW→**3 phenotypes**:1/4 [R],1/2[RW] or flowers spotted with red and white,1/4 [W] **3 Genotypes**: ¼ RR,1/2 RW ,1/4 WW	----------
Lethal cases	AA lethal	----------	Aa xAa→2/3 [A],1/3[a]	Aa x aa→1/2Aa, ½ aa ½ [A], ½ [a]
	aa lethal	----------	Aa x Aa →1 [A]	------ since [a] is lethal

By referring to document d p. 43, answer the following questions

1- How can you explain the presence of only gray mice in doc.d 1?

All the obtained descendants have the same phenotype as the parents because the crosses are performed between pure breeding line

2- How can you explain the presence of white mice in F2 doc. d.2?

Mice of F1 have the white allele which is inherited from one of the parents. This white allele is not expressed in F1 since it is a recessive allele.

Phenotype reveals the genotype

The phenotype reveals the genotype in the following cases:

- Recessive phenotype: as the recessive allele is expressed only in the homozygous state
- Codominant and incomplete dominant cases.

However,the phenotype doesn't reveal the genotype in the case of dominant phenotype where the dominant allele is expressed in homozygous and heterozygous state.

Document 2: Transmission of allelic genes

1- Objectives

- Explain and draw the segregation of the homologous chromosomes and chromatids.
- Analyze the genotypes of different descendents.

2- Definition of monohybridism: is the experimental crossing of two pure-breeding organisms that differ only in one trait.

3- Application:

A pure black mouse crossed with a pure white mouse gives in F1 100% black mice.

1) **Identify the dominant allele**

F1, which are all black, inherit one allele black from a parent and one allele white from the other parent. However, only the black allele is expressed. Therefore, the black allele is the dominant allele.

2**) Designate by symbols the corresponding alleles**

Let B be the symbol of the black allele

Let w be the symbol of the white allele

3) **Indicate the genotype of F1**

The genotype of F1 is Bw

4)**Make the necessary factorial analysis to find the phenotypic and the genotypic percentages in F2 (F1 xF1)**

Genotypes of the parents: male F1 Bw x female F1 Bw

Gametes and percentage B 50% w50% B 50% w 50%

Male gametes / Female gametes	B 50%	w 50%
B 50%	BB 25%	Bw 25%
w 50%	Bw 25%	ww 25%

3 Genotypes

25% BB

50% Bw

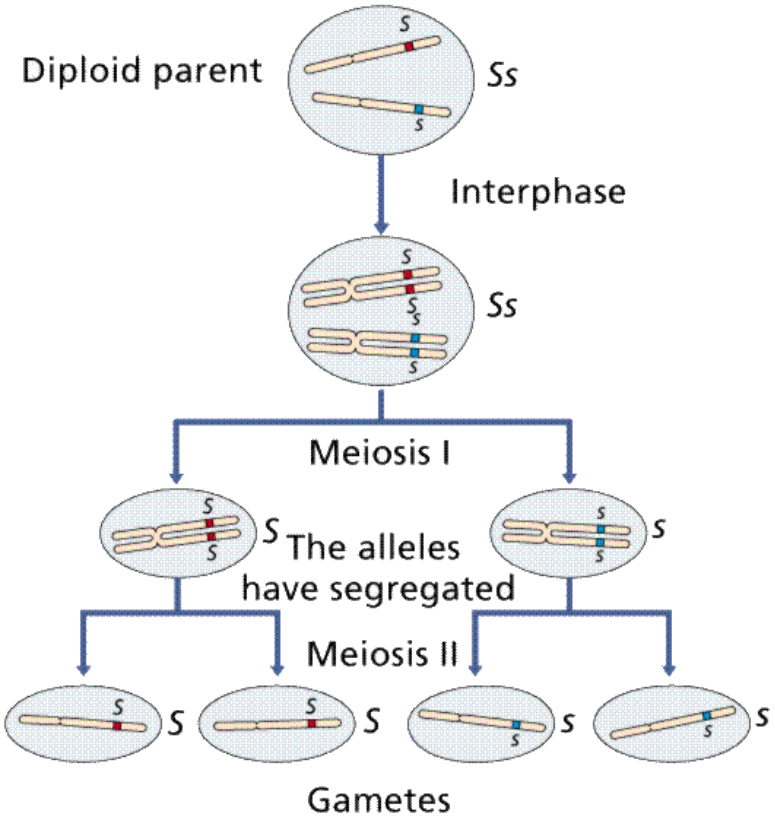
25% ww

2 Phenotypes

75% [B]

25% [w]

Schematize the segregation of chromosomes that leads to the formation of gametes of F1 (consider the following alleles S and s)



Test cross

Objective: Test cross is performed in order to find out whether an organism that shows a dominant trait is homozygote or heterozygote for that trait.

How is it performed?Crossing the organism that shows a dominant trait with an organism having a homozygous recessive trait that only produces 1 type of gametes carrying the recessive allele. Therefore the phenotype of the offspring reveals the type of alleles carried by the gametes of the parent to be tested.

Application:The fur color has 2 alleles: gray (G) which is dominant and white(w) which is recessive. In order to determine the genotype of a gray mouse, we cross it with a white mouse.

- Indicate all the possible genotypes of the gray mouse.
  GG or Gw
- Name the mentioned cross
  Test cross
- Make the necessary factorial analysis to find the genotype of the gray mouse in the different cases

- First case Genotype: male GG × female ww Gametes: G 100% w 100% Genotypes of offspring: Gw Phenotypes of offspring: 100% grey	- Second case Genotype: male Gw × female ww Gametes: G 50% w 50% w 100% Genotypes of offspring:50% Gw 50% ww Phenotypes of offspring: 50% grey 50% white