3. Dihybridism

Dihybridism is a cross that involves two genes simultaneously. These two genes are either independent carried by two different chromosomes (independent segregation of two genes), or linked carried by the same chromosome.

The Law of Independent Assortment of Characters

• It appears that the transmission of seed shape has no influence on the transmission of seed color

• The two characters are transmitted **INDEPENDENTLY**

• The pairs of alleles that control these two characters occur independently.

• Using a dihybrid cross , Mendel developed the law of independent assortment

• The law of independent assortment states that each pair of alleles segregates independently of the other pair of alleles during gamete formation.

• This law applies only to genes on different **non-homologous chromosomes**

• Genes located close to each other on the same chromosome tend to be transmitted together.

- **Example:** In the case of **dihybridism** , **independent genes** (genes carried by chromosomes different non-homologous chromosomes), **The parents are heterozygous** , in case of **dominance** (one dominant allele and one recessive allele)

We has 2 couples of A/a alleles And B/b, Who are located 2 different genes.

- ***The crossing of pure lines between they :*** **AA BB x aa bb** produces the F1 generation:

  F1 : 100% Aa Bb , **100%** phenotype **[AB]** dominant For both genes

- ***Self-fertilization of F1 :*** **Aa Bb x Aa Bb** produces the F2 generation:

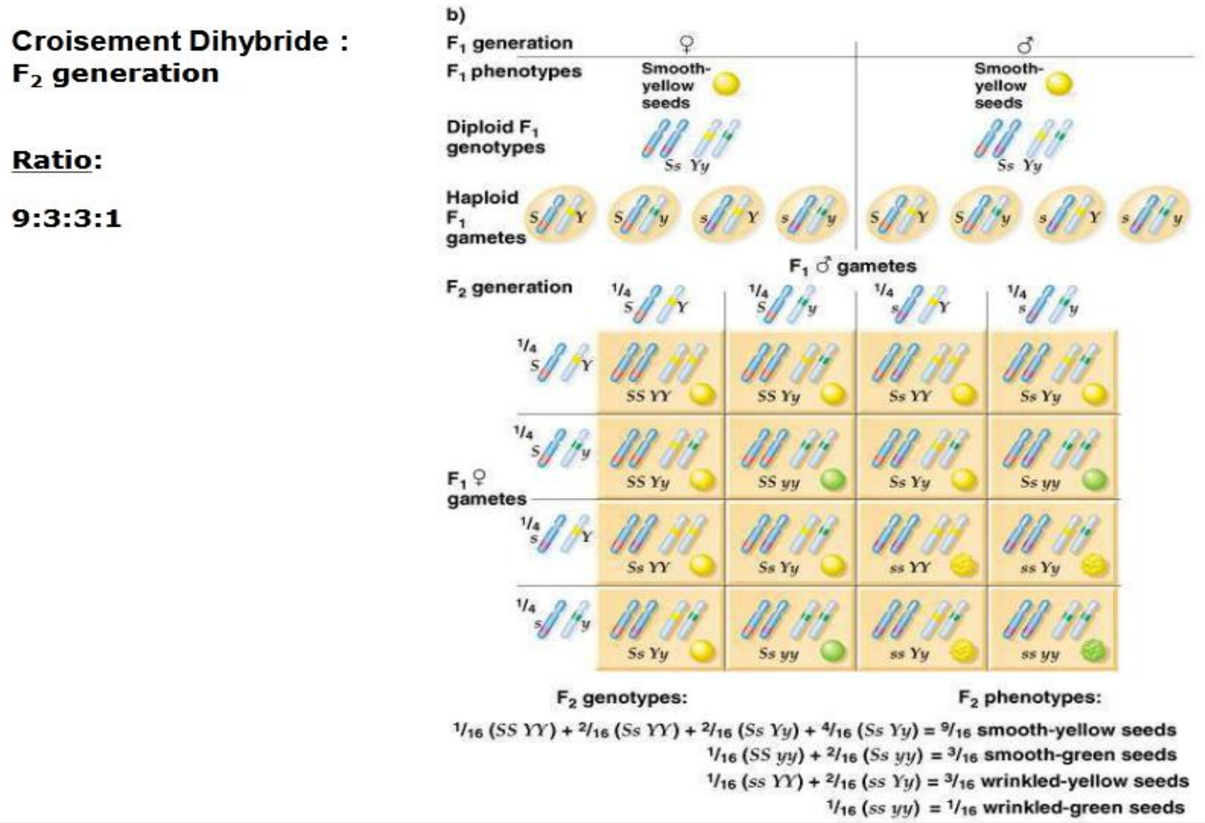
  F2 :

  Genotypes : Nine (9) different genotypes

  1/16 AABB, 2/16 AABb , 1/16 AAbb 1/16 aaBB , 2/16 aaBb , 1/16 aabb, 2/16 AaBB , 4/16 AaBb , 2/16 Aabb

Gametes	AB	Ab	aB	ab
AB	AABB	AABb	AaBB	AaBb
Ab	AABb	AAbb	AaBb	Aabb
aB	AaBB	AaBb	aaBB	aaBb
ab	AaBb	Aabb	aaBb	aabb

Phenotypes : four (4) phenotypes : **9/16 [AB], 3/16 [Ab], 3/16 [aB] and 1/16 [ab]**

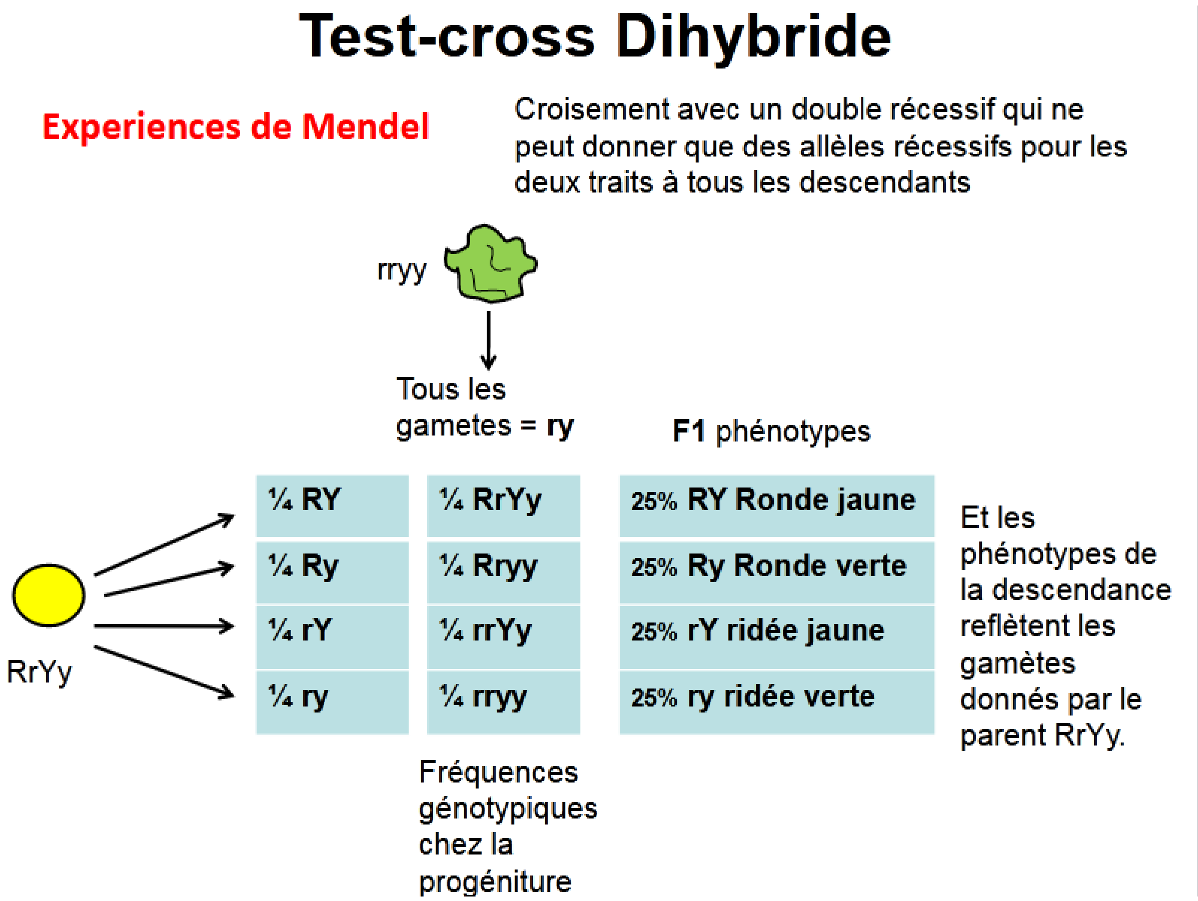


- **<u>Dihybrid test-cross</u>**

• In monohybrid crosses, to determine if a dominant trait is homozygous or heterozygous, a test-cross is necessary.

• This is done with a homozygous recessive

• The same principle applies to a dihybrid cross, where the test-cross is performed with an individual that is homozygous recessive for both traits (double homozygous recessive).



Cross interpretation:

There are four types of offspring in equal proportions, with as many parental phenotypes as recombined phenotypes.

The double recessive male only produces one type of gamete. It can be inferred that the F1 female produces four types of gametes, indicating that each trait is coded by a different gene (thus 2 genes here).

The equal probability of parental and recombined phenotypes shows that the F1 female produces as many parental gametes as recombined gametes, meaning the genes in question behave independently during meiosis (there are no preferential allelic associations). The genes in question are therefore independent, i.e., carried by different pairs of chromosomes.

4. Case of linked genes

Mendel's theory of inheritance postulated that genes are inherited independently, but Morgan and his work on fruit flies showed that genes on the same chromosome can be inherited together.

Morgan's material: fruit flies

Why fruit flies?

- feeds on fungi that grow on fruits
- Prolific (around 100 individuals every 15 days)
- The sex can be easily identified by the abdomen.
- Has only 8 chromosomes → less material to study
- Their giant chromosomes are visible under an optical microscope. It is therefore possible to track their movement and the movement of the genes they carry under the microscope.
- Sex determination resembles that of humans
- 3 pairs of autosomes and 1 pair of XX in the female
- 3 pairs of autosomes and 1 pair of XY in males

Morgan's dihybrid cross for two traits

Body character *gray* (b+, dominant) or black (b, recessive)

Character wings *normal* (vg +, dominant) or vestigial (vg , recessive)

Crossing A:

drosophila ♂ [normal wings ; gray body] (vg + b +// vg + b +) with

drosophila♀ [vestigial wings ; black body] (vg b// vg b)

100% F1 [normal wings ; gray body]

(vg +b +// vg b)

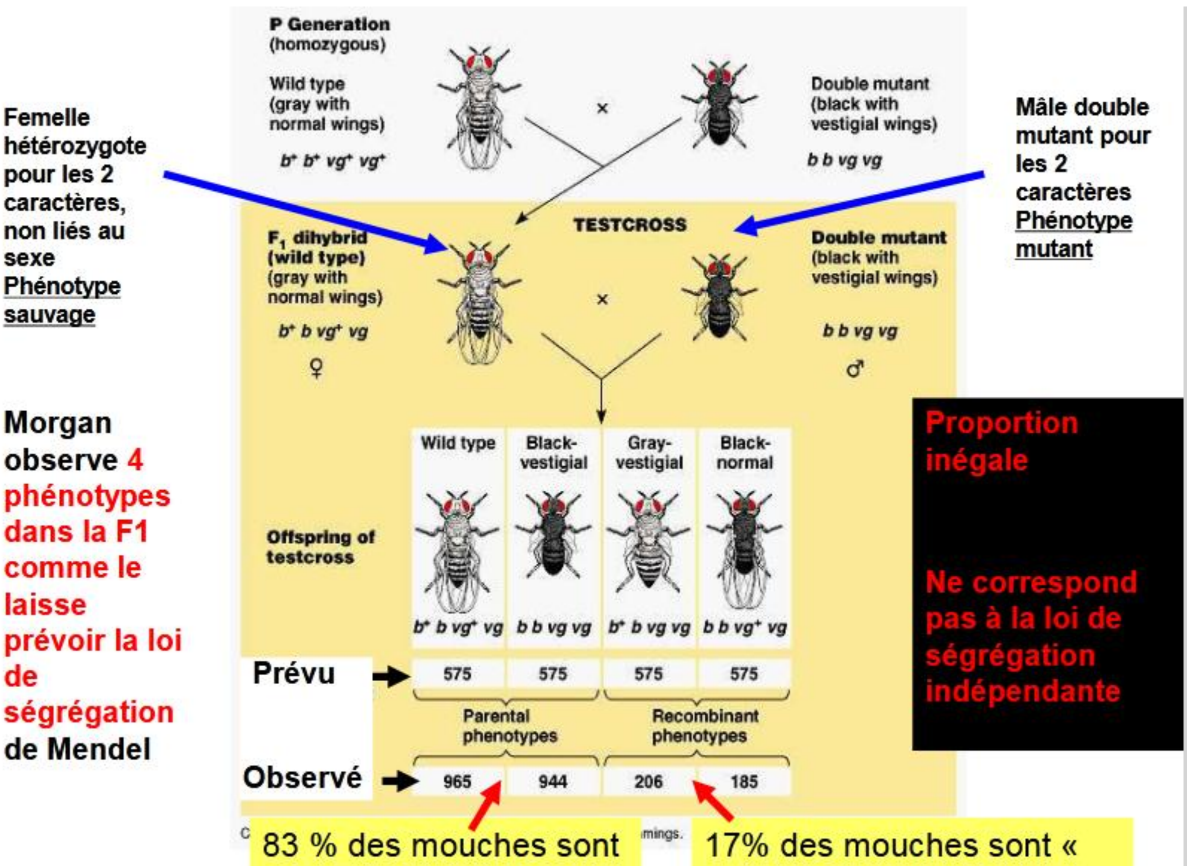
Crossing B:

♂ double recessive x ♀ F1 **(test cross)**

(vg b// vg b) (vg +b +// vg b)

Gamètes parentaux	(Vg + b+)	(Vg b)	(Vg + b)	(Vg b+)
(Vg b)	(vg+b+//vg b) [Vg+; b+] 965	(vg b//vg b) [Vg-; b-] 944 >	(vg+ b//vg b) [Vg+; b] 185	(vg b+//vg b) [Vg; b+] 206

Types Parentaux 83% > **Types Recombinants 17%**



Morgan's first hypothesis to explain his results

The genes studied (body/wings) are located by the same chromosome and are transmitted together (most often) in a gamete.

Morgan's second hypothesis to explain his results

There is a mechanism of segment exchange between homologues that sometimes breaks the linkage between genes.

5. <u>Establishment of there map genetic</u>

There are two main types of cards:

- **genetic maps:** distances are expressed in centimorgan (cM)
- **physical maps:** distances are expressed in base pairs (bp)

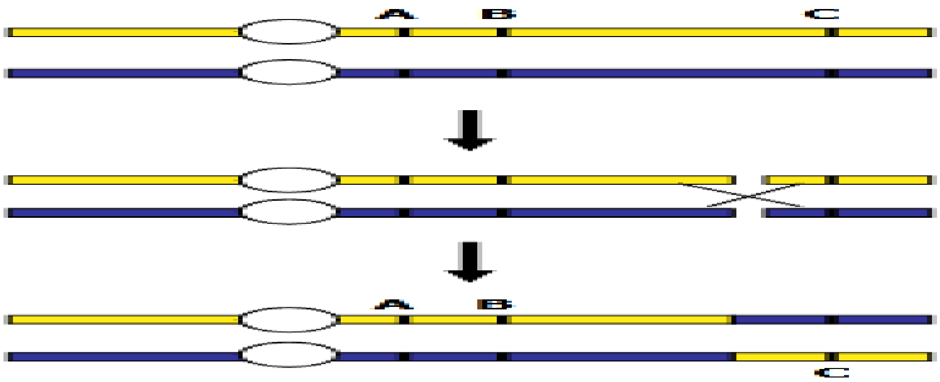
kilobases (kb) = 1000 bp

Megabases (Mb) = 1000 kb

A map is a representation of the genome. The physical map allows genes to be located on chromosomes based on visible markers. The genetic map situates genes relative to each other on a distance scale by exploiting the frequency of recombination between homologous chromosomes during gametogenesis.

Genetic distances reflect the frequency of recombination (FR). During meiosis, "crossing-over" causes genetic material to be exchanged between homologous chromosomes. When two genes are close enough to be separated only once in 100 instances (recombination frequency 1%), the genetic distance between them is set at 1 centimorgan (1 cM).

The closer two genes are, the less likely they are to be separated by a crossing-over, and the smaller the genetic distance between them.



Genetic recombinants

Offspring that inherited parental traits, in different allelic combinations than the parents had.

Recombination frequency

Ratio of the number of recombinants (recombinant types) to the total number of descendants. dihybrid cross there are 17% recombinant individuals.

$$FR = \left[\frac{206 + 185}{2300}\right] \times 100 = 17$$

Genetic mapping unit

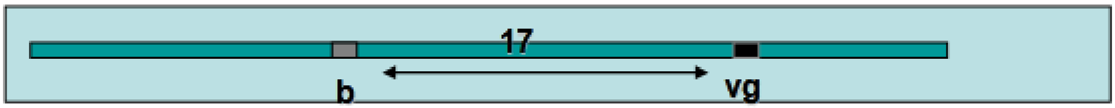
In the Morgan dihybrid cross there are 17% recombinant individuals, therefore there are 17 cM between the two genes b and vg .

Value of centimorgan

Centiorgans do not have an absolute dimension, in nm for example, because the frequency of crossing over is not the same everywhere along the chromosome.

Construction of a genetic map for the b, vg and cn alleles

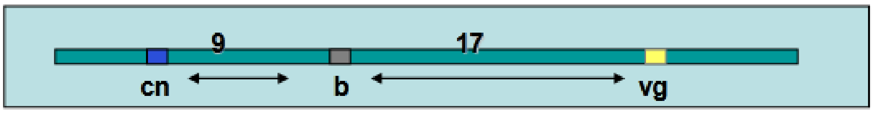
A cross between 2 drosophila for the b and vg characters produces 17% of recombinants →17 cM between the b and vg genes



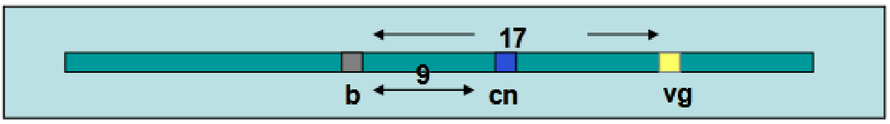
A cross between 2 drosophila for the characters b and cn (vermilion eyes) produces 9% of recombinants → 9 cM between the b and cn genes

What is the genetic map of the three genes? Map A or Map B?

A



B



We can't answer with these data, we need another cross. A student of Morgan, made this cross. He found 9.5% recombinants for the cn and vg characters .

→ 9 cM between cn and vg genes

So the correct card is: card B.