3. Dihybridism

Dihybridism refers to a cross that involves two genes simultaneously. These genes may be **independent**, carried on two different chromosomes (independent assortment), or **linked**, carried on the same chromosome.

The Law of Independent Assortment of Characters

- The transmission of seed shape is not influenced by the transmission of seed color.
- The two traits are inherited ***independently***.
- The pairs of alleles that control these traits segregate independently of one another.
- Through dihybrid crosses, Mendel formulated the Law of Independent Assortment.
- This law states that each pair of alleles segregates independently of other pairs during gamete formation.
- The law applies only to genes located on different, non-homologous chromosomes.
- Genes located close together on the same chromosome tend to be inherited together (genetic linkage).

- Example: In the case of dihybridism with independent genes (genes carried on different, non-homologous chromosomes), the parents are heterozygous for both genes, each with one dominant allele and one recessive allele.)

We consider two pairs of alleles, **A/a** and **B/b**, which correspond to two 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:

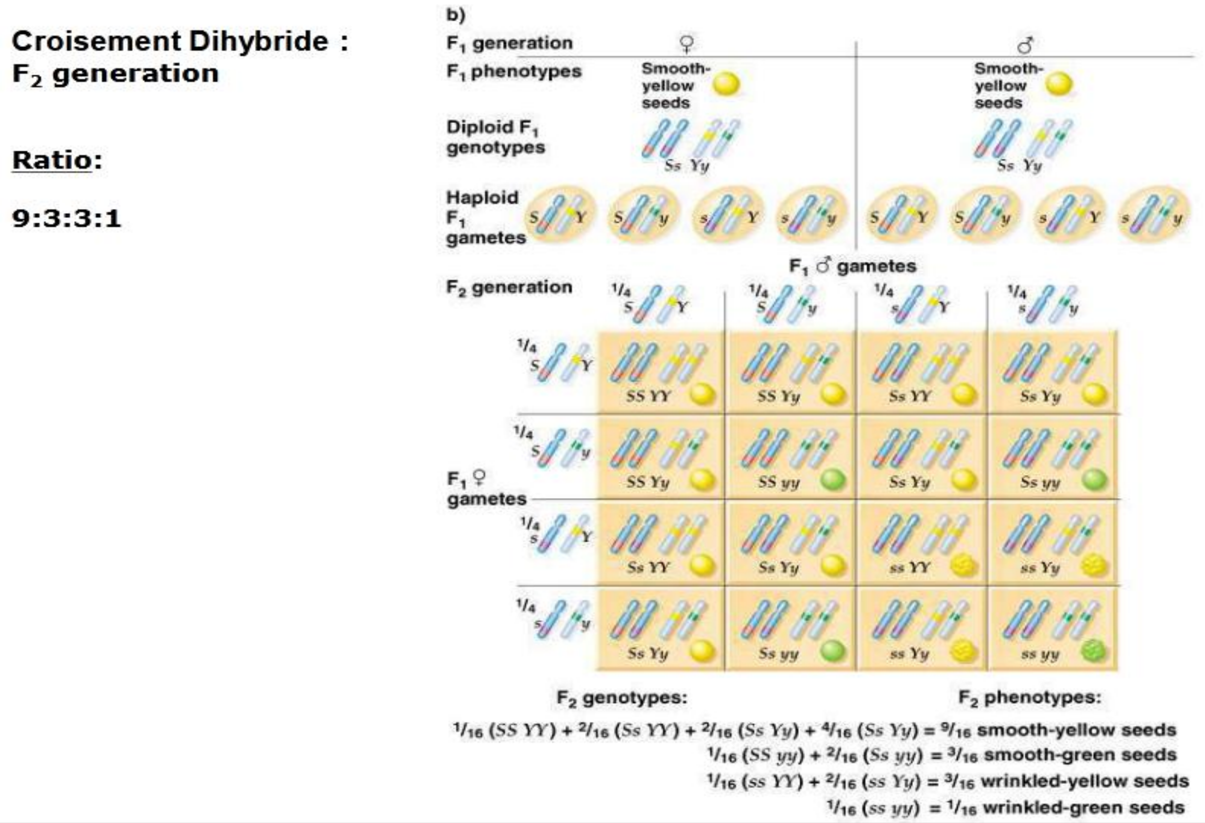
  F2 :

  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]**



- **Dihybrid test-cross**

• In monohybrid crosses, a test cross is used to determine whether an individual with a dominant trait is homozygous or heterozygous.

• This is done by crossing the individual with a ***homozygous recessive partner.***

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

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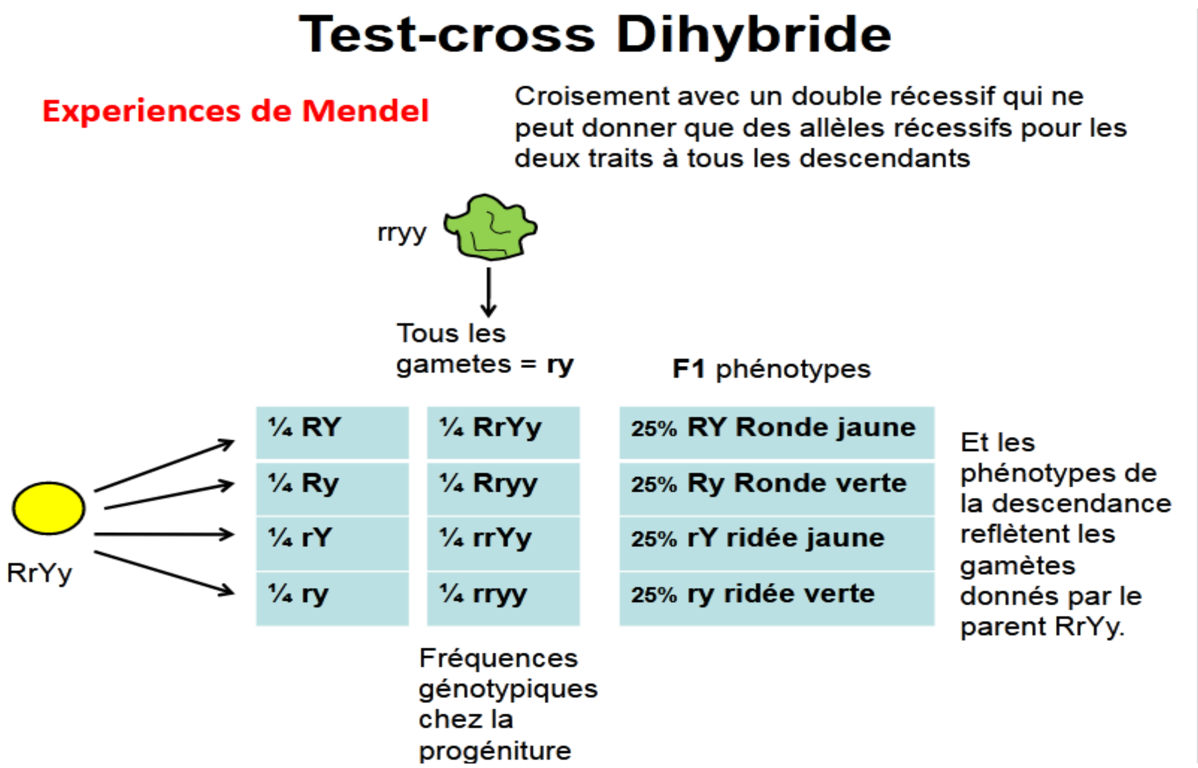


Cross interpretation:

- There are four types of offspring in equal proportions, with as many parental phenotypes as recombinant phenotypes.
- The double-recessive male produces only one type of gamete. From this, it can be inferred that the F1 female produces four types of gametes, indicating that each trait is controlled by a different gene (two genes in this case).
- The equal probability of parental and recombinant phenotypes shows that the F1 female produces parental gametes and recombinant gametes in equal numbers. This demonstrates that the genes assort independently during meiosis, with no preferential allelic association.
- Therefore, the genes under study are independent, meaning they are carried on different pairs of chromosomes.

4. Case of linked genes

Mendel's theory of inheritance postulated that genes assort independently. However, Thomas Hunt Morgan's work on fruit flies (*Drosophila melanogaster*) demonstrated that genes located on the same chromosome can be inherited together, a phenomenon known as genetic linkage.

Morgan's material: fruit flies

Why fruit flies?

- Feeds on fungi growing on fruits.
- Highly prolific, producing around 100 offspring every 15 days.
- Sex can be easily identified by examining the abdomen.
- Has only 8 chromosomes, providing a relatively small genome for study.
- Its giant polytene chromosomes are visible under a light microscope, allowing direct observation of chromosomal structure and gene movement.
- Sex determination is similar to that of humans.
- Females have three pairs of autosomes and one pair of sex chromosomes (XX).
- Males have three pairs of autosomes and one pair of sex chromosomes (XY).

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)

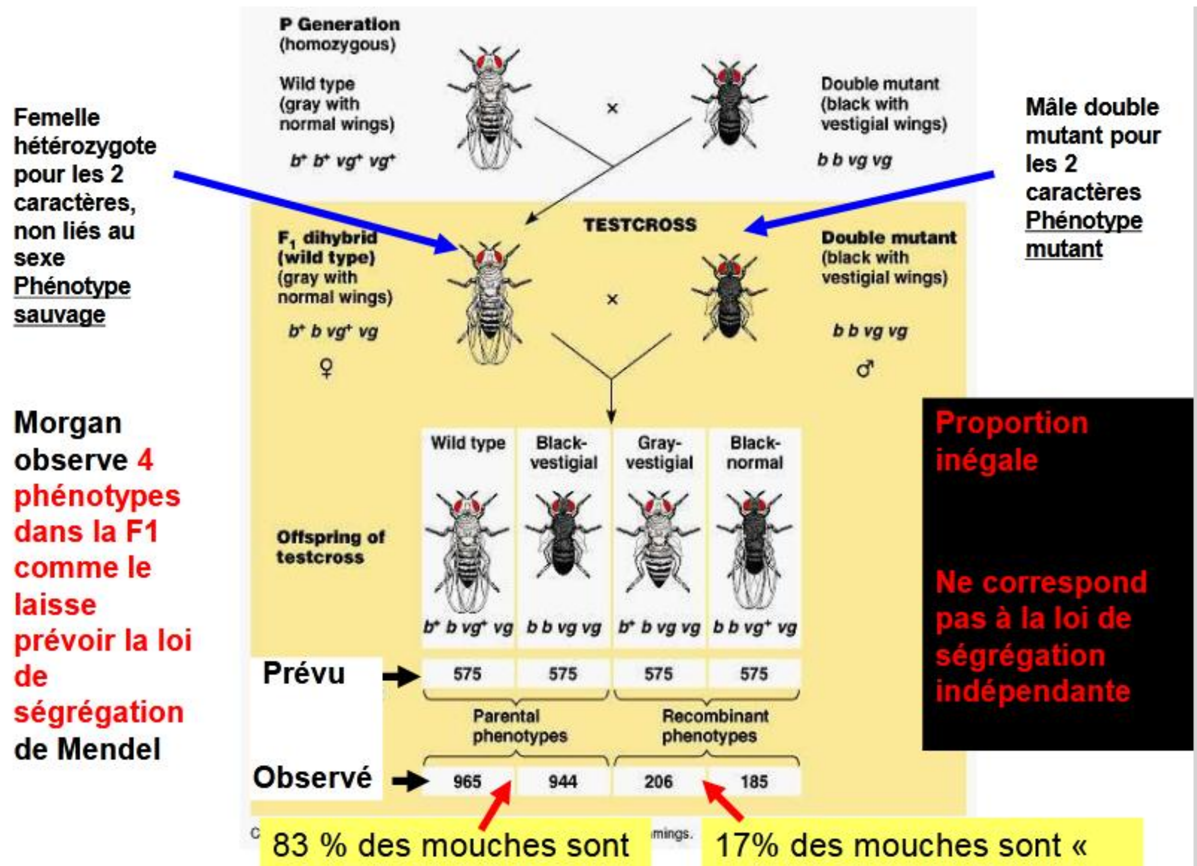
Crossing B:

♂ 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 homologous chromosomes that occasionally breaks the linkage between genes. This process is now known as **crossing-over**..

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)

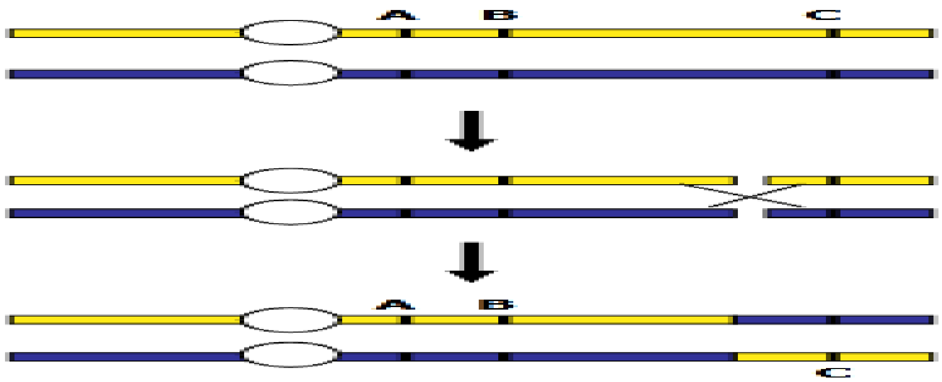
kilobases (kb) = 1000 bp

Megabases (Mb) = 1000 kb

A map is a representation of the genome. A ***physical map*** locates genes on chromosomes based on visible markers, while a ***genetic map*** positions genes relative to one another on a distance scale derived from the frequency of recombination between homologous chromosomes during gametogenesis.

Genetic distance reflects the recombination frequency (RF). During meiosis, ***crossing-over*** results in the exchange of genetic material between homologous chromosomes. If two genes are separated by recombination once in 100 meioses (recombination frequency of 1%), the genetic distance between them is defined as 1 centimorgan (1 cM).

The closer two genes are, the lower the probability that crossing-over will separate them, and therefore the smaller the genetic distance between them.



Genetic recombinants

Offspring that inherit parental traits in different allelic combinations than those present in the parents..

Recombination frequency

The ratio of the number of recombinant offspring to the total number of offspring, expressed as a percentage.

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

Genetic mapping unit

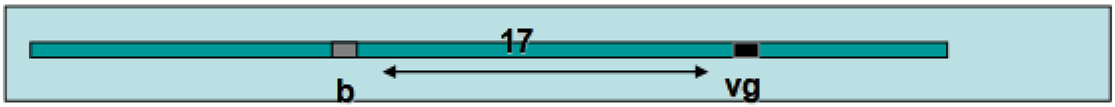
In the Morgan dihybrid cross there are 17% recombinant individuals, therefore there are 17 cM between the two genes b and vg .

Value of centimorgan

A centimorgan does not represent an absolute physical distance (in nanometers, for example), because the frequency of crossing-over is not uniform along the chromosome.

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

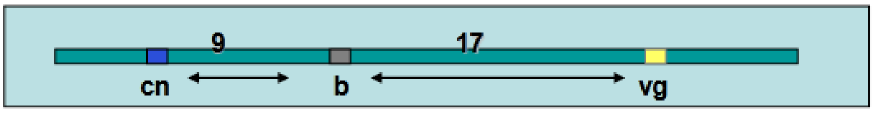
A cross between two *Drosophila* individuals for the *b* and *vg* characters produces 17% recombinant offspring. This corresponds to a genetic distance of 17 cM between the *b* and *vg* genes.



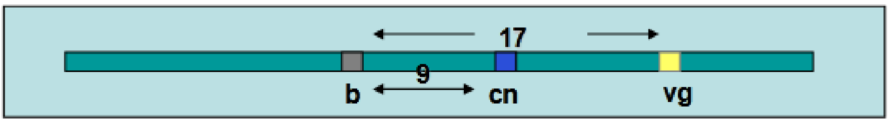
A cross between 2 drosophila for the characters b and cn (vermilion eyes) produces 9% of recombinants → 9 cM between the b and cn genes

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.