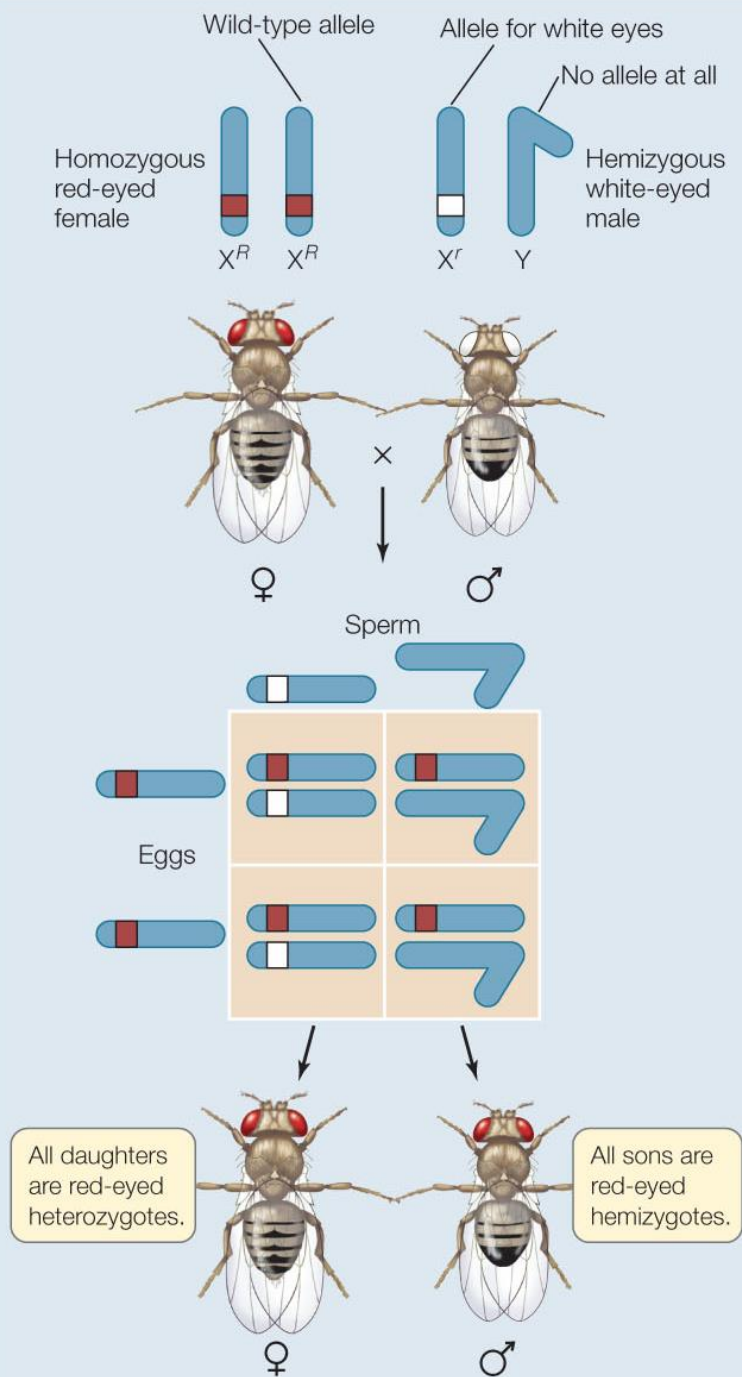


3ª Regra da Genética

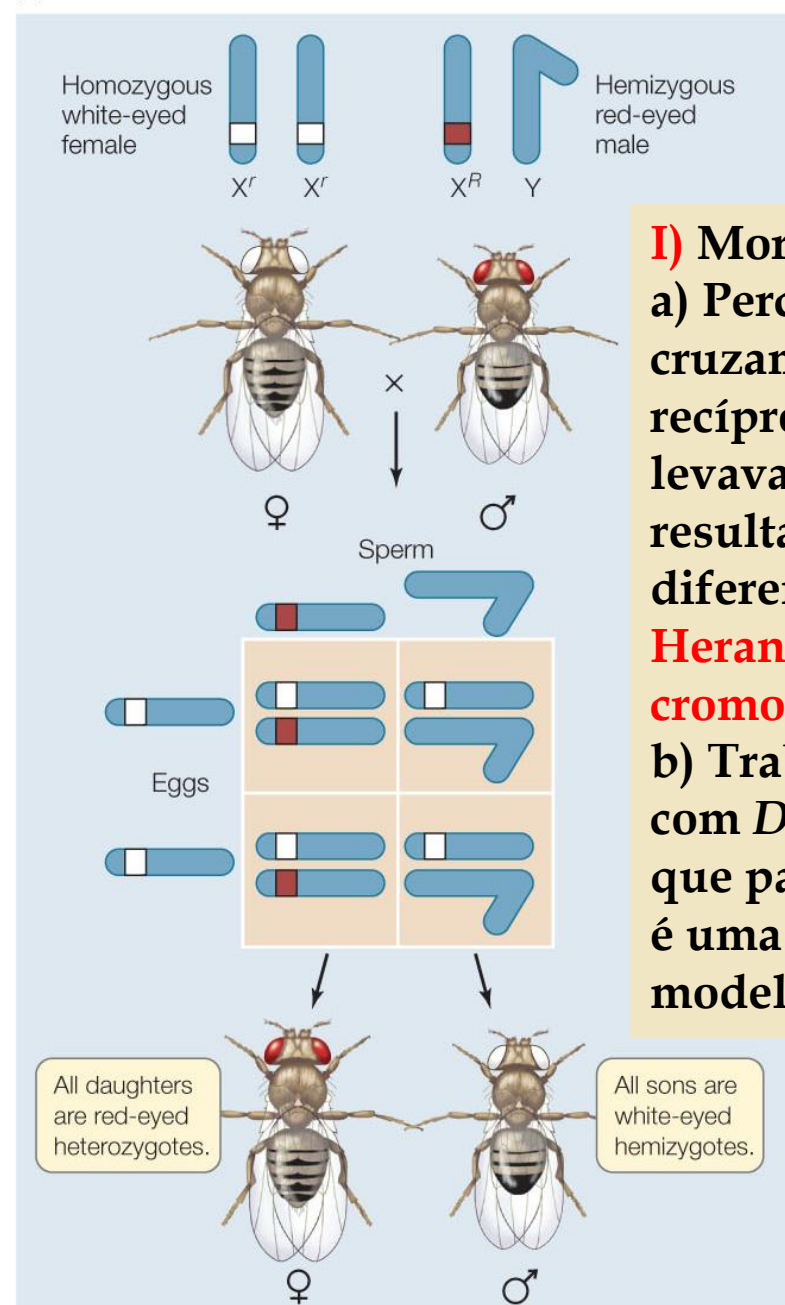
Estudo de genes ligados: Ligação (Linkage)

(Lei de Morgan
Thomas Hunt Morgan
was awarded the Nobel
Prize in 1933)





(B)



I) Morgan:
 a) Percebeu que cruzamentos recíprocos levavam a resultados diferentes:
Herança do cromossomo X
 b) Trabalhou com *Drosophila* que passou a ser uma espécie modelo

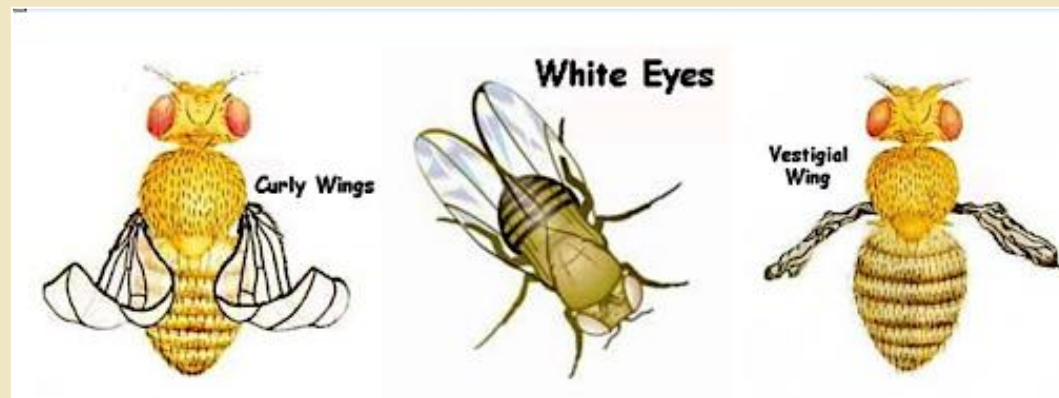
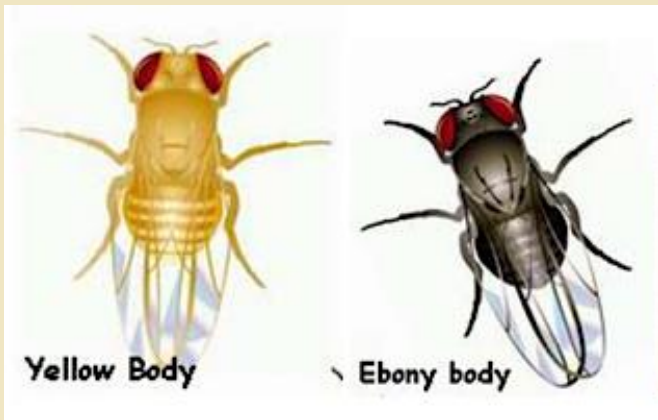


II) Características de uma espécie modelo

- 1. Fácil cultivo em laboratório, casa de vegetação, biotério
- 2. Fácil manuseio
- 3. É possível efetuar cruzamentos artificiais
- 4. Fenótipos de fácil reconhecimento
- 5. Diploide
- 6. Geração curta (poucos dias)



Espécie modelo: *Drosophila*



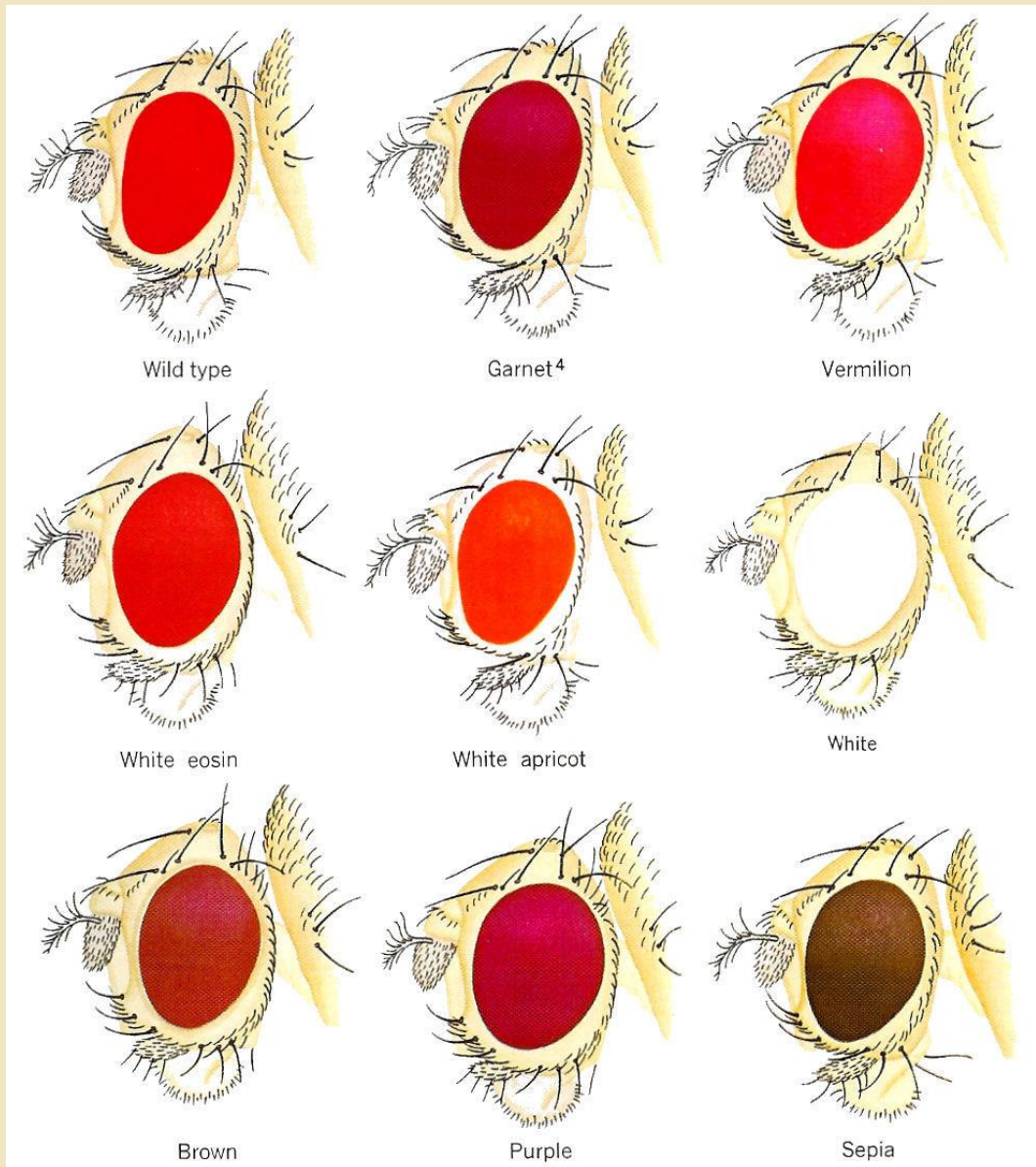


Plate I. Some eye colors in *Drosophila melanogaster*. (After E. M. Wallace, in *An Introduction to Genetics* by Sturtevant and Beadle, Saunders, 1938.)

Cor dos
olhos:
É um único
loco com
vários
alelos?
Ou há mais
de um loco?

Espécie modelo: *Escherichia coli*

- *E. coli* was one of the first organisms to have its genome sequenced, deepening our understanding of how DNA works and ultimately increasing our knowledge of how humans function.
- The French scientist Jacques Monod is reported to have said, "What is true for *E. coli* is true for the elephant."



Espécie modelo: *Arabidopsis thaliana*

- Ciclo de vida relativamente curto (6 semanas);
- Produção de um grande número de sementes;
- Facilmente cultivável em espaços restritos;
- Há um grande número de estudos científicos;
- Há muitos mutantes naturais e induzidos;
- Genoma sequenciado



Espécie modelo: *Zebra fish* (*Danio rerio*)



- Modelo vertebrado: 70% de seus 26 mil genes são semelhantes aos genes humanos;
- Um biotério com capacidade para criar 3 mil peixes do tipo *zebra fish* está disponível no Instituto Butantã. A espécie é usada como modelo em pesquisas científicas, principalmente na área de saúde;
- No biotério da PUC/RS, com 10 acasalamientos/dia (uma fêmea e dois machos) nascem 2 mil filhotes por mês. A espécie é usada para investigar a bioquímica da memória e de doenças neurodegenerativas como o mal de Alzheimer.

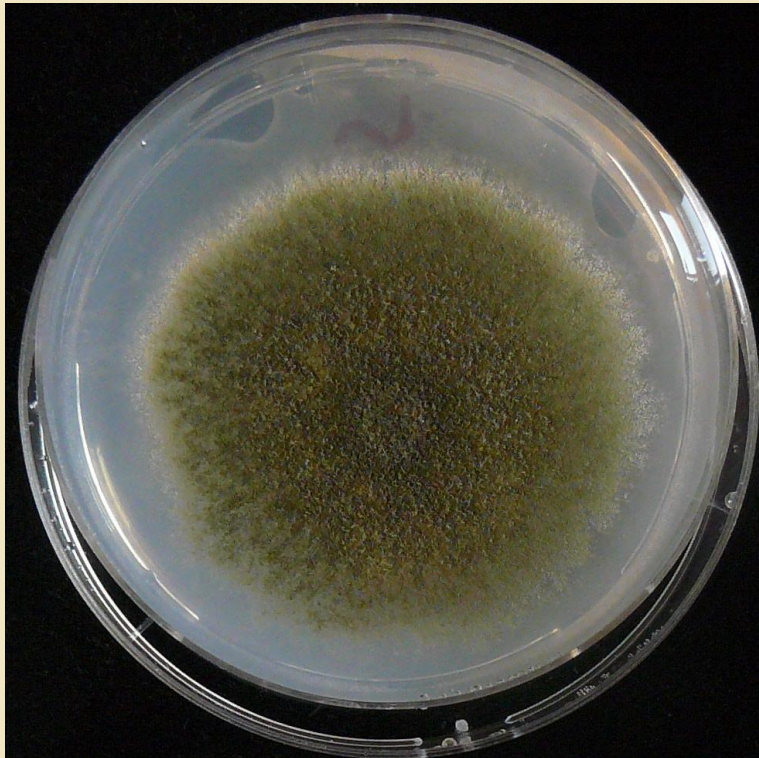
Espécie modelo: *Mus musculus*



No início do século XX, com o advento da Genética, os camundongos começaram a ser objetos de estudo. Diversas linhagens de animais, a exemplo do camundongo C57/BL6 (à esquerda), foram produzidas por cruzamentos entre irmãos. Assim pela uniformidade genética destas linhagens, os indivíduos reagem de forma semelhante, havendo pouca variância dos resultados experimentais. Embaixo, o mutante albino B6.



Espécie modelo: *Aspergillus nidulans*



Aspergillus nidulans is a particularly useful model organism for studies of cell biology and gene regulation. Its properties include: a haploid genome of modest size; sexual and asexual reproductive cycles; simple nutritional requirements; rapid growth and reproduction; small size; and readily observable, informative phenotypes.

Tamanho dos genomas e números cromossômicos

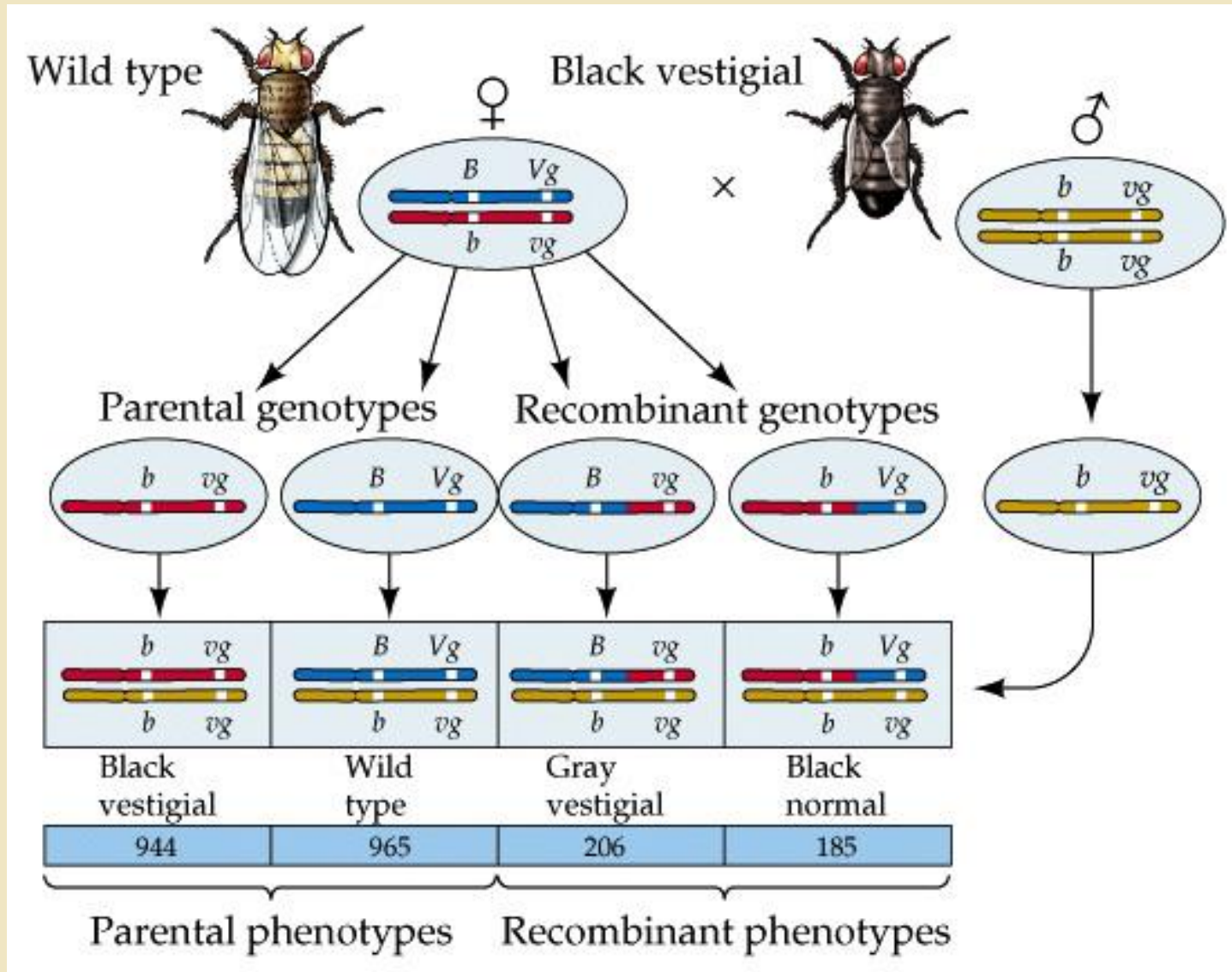
Organism	Genome size (Mb) ^a	Chromosome number ^a
Yeast (<i>Saccharomyces cerevisiae</i>)	12	16
Slime mold (<i>Dictyostelium</i>)	70	7
<i>Arabidopsis thaliana</i>	125	5
Corn	5000	10
Onion	15,000	8
Lily	50,000	12
Nematode (<i>Caenorhabditis elegans</i>)	97	6
Fruit fly (<i>Drosophila</i>)	180	4
Toad (<i>Xenopus laevis</i>)	3000	18
Lungfish	50,000	17
Chicken	1200	39
Mouse	3000	20
Cow	3000	30
Dog	3000	39
Human	3000	23

^a Both genome size and chromosome number are for haploid cells.

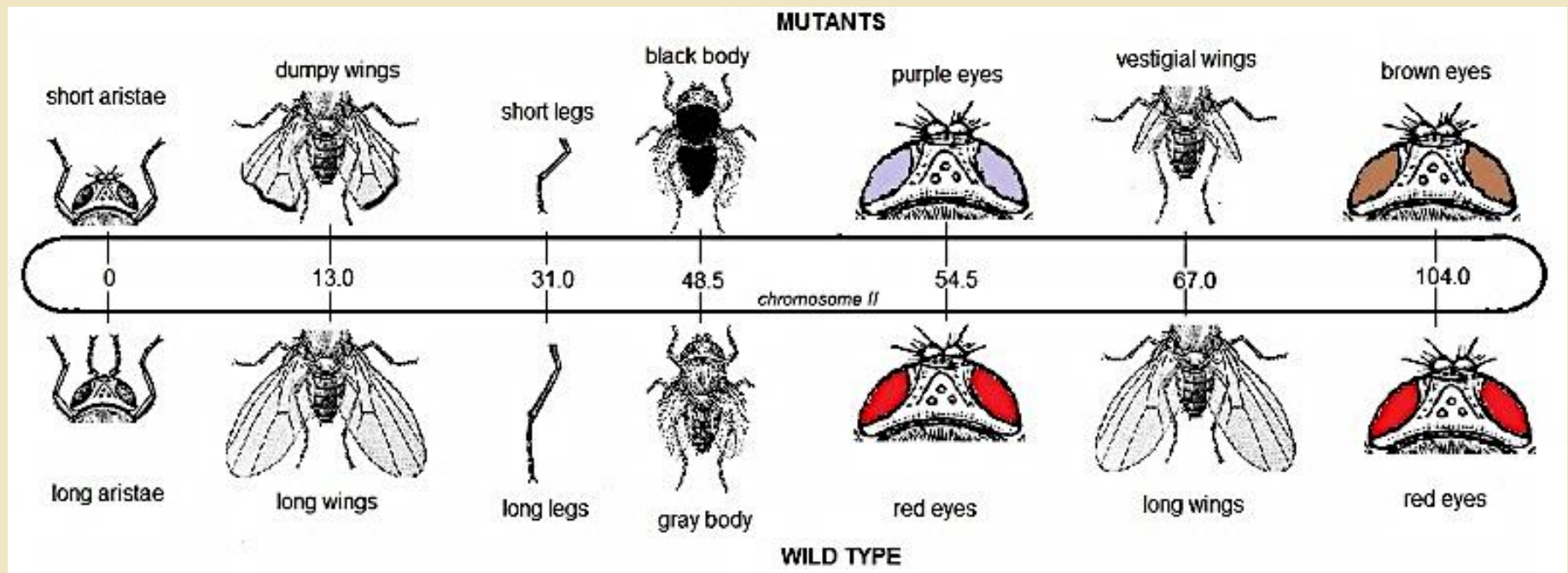
Mb = millions of base pairs.

THE CELL, Fourth Edition, Table 5.3 © 2000 ASM Press and Sinauer Associates, Inc.

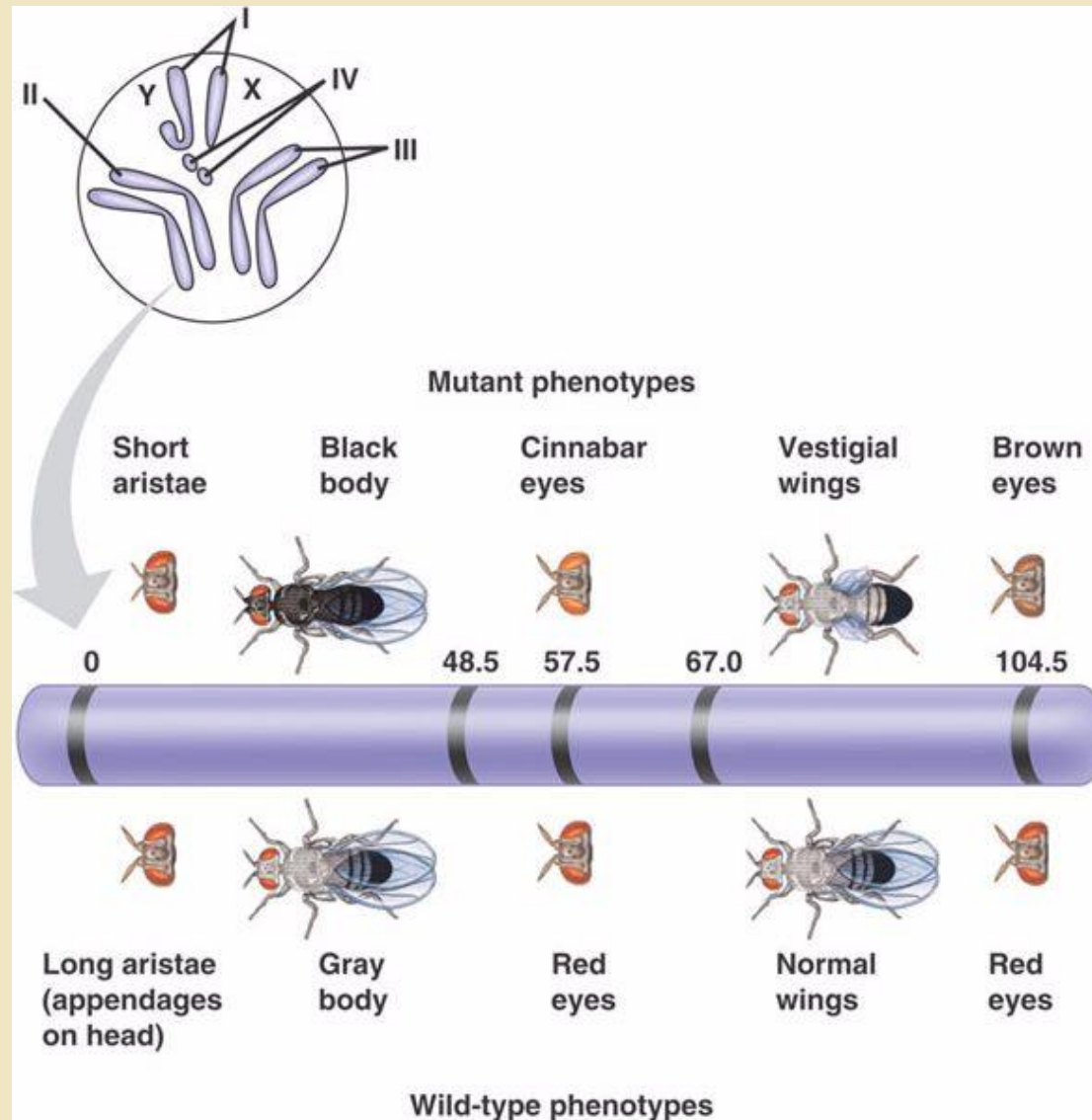
III) Morgan encontrou segregações que contrariavam a 2a lei de Mendel



IV) Vários fenótipos são controlados por genes ligados no mesmo cromossomo



V) Morgan associou as leis da Genética com a Teoria cromossômica da herança





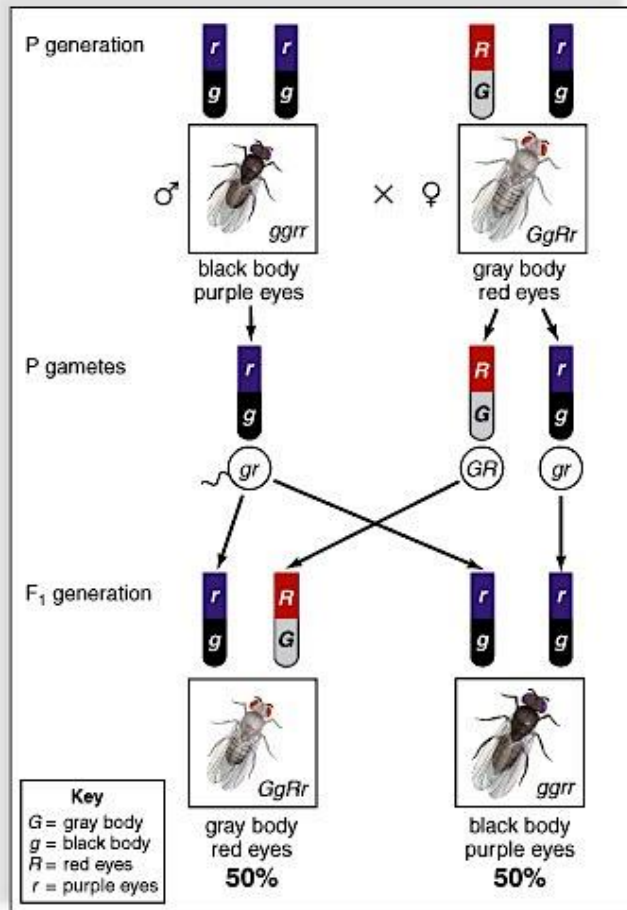
Morgan attracted extremely gifted students, in particular, A.H. Sturtevant, C.B. Bridges, and H.J. Muller (Nobel Laureate, 1946).

They were to discover a host of new laws of genetics, while working in the "Fly Room," in the Zoology Department at Columbia.

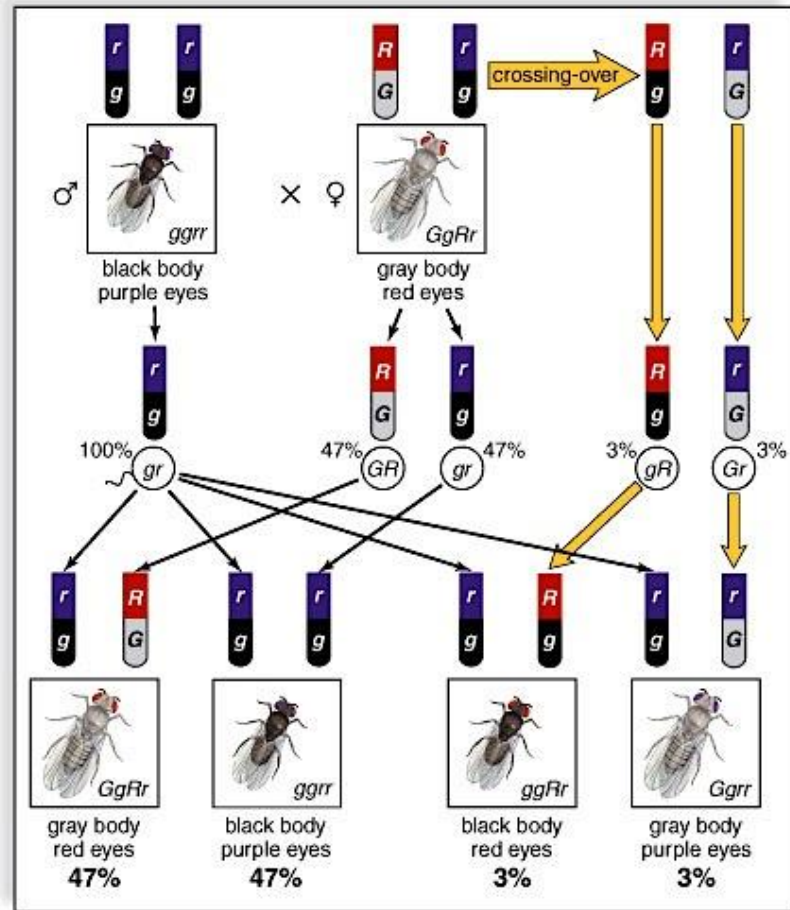
- Sturtevant described how chromosomes were the carriers of the hereditary material. Sturtevant, who was still an undergraduate, realized that the sex-linked genes might be arranged in a linear order. He spent a night constructing a genetic map based on 5 sex-linked mutations. Later, Bridges and Sturtevant identified and mapped 2 groups of autosomal (not sex-linked) genes and a 3rd such group was identified by Muller. The 4 linkage groups correlated nicely with the 4 pairs of chromosomes that *Drosophila* possess.

VI (a) Linkage: autosomal-linked genes

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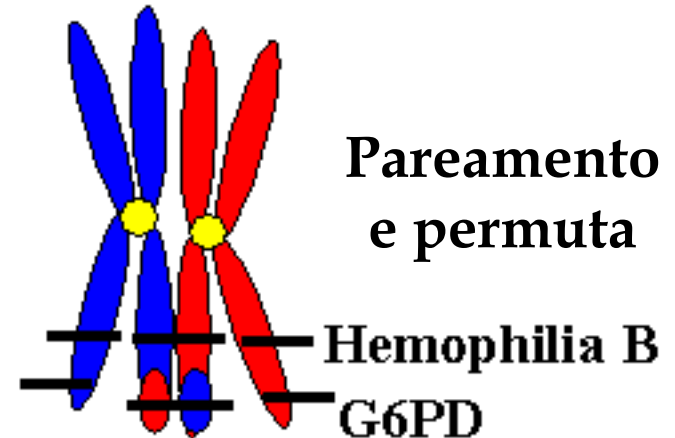
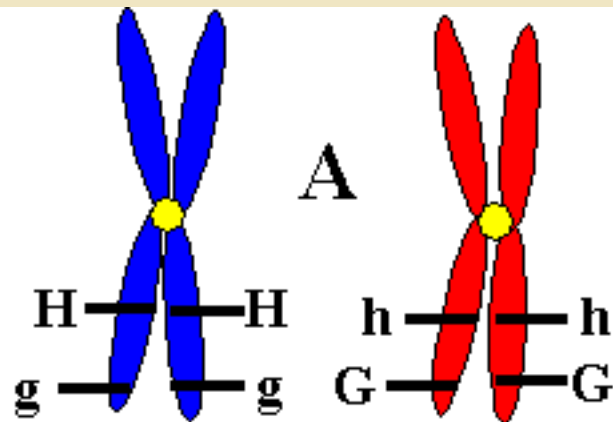


a.

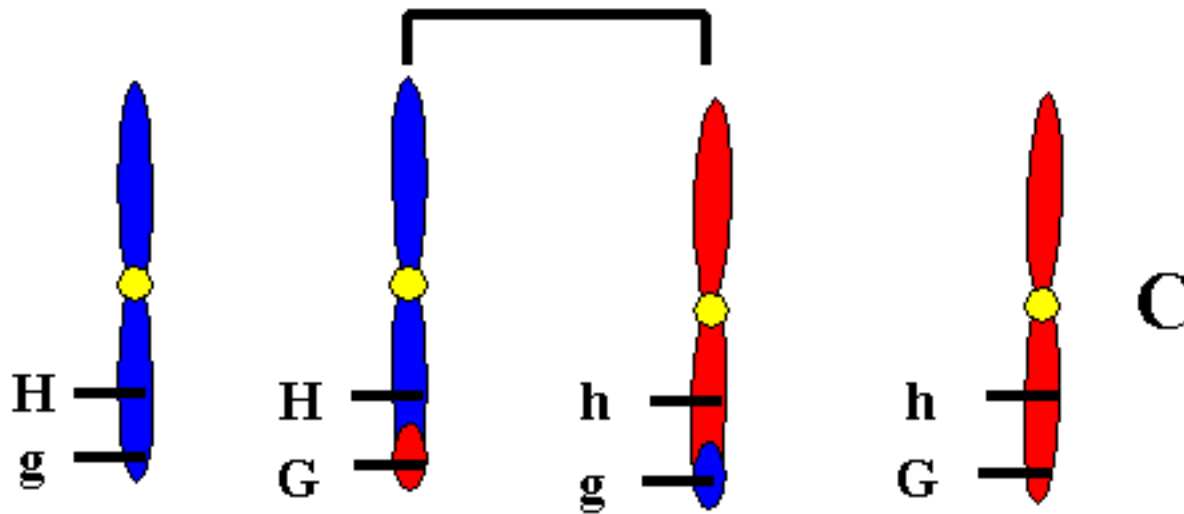


b.

VI (b) Sex-linked genes (X chromosome): pairing and crossover

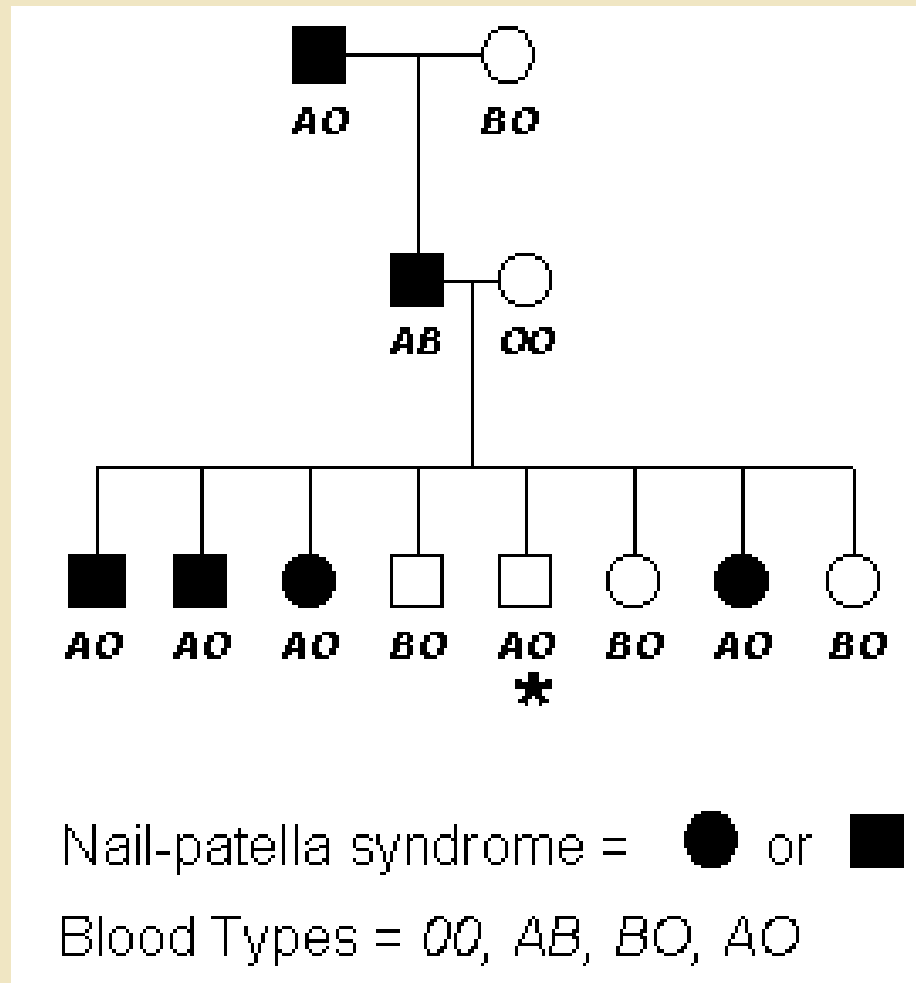


Recombinants



Autosomal-linked genes

Neste pedigree o alelo dominante que causa a doença está em associação com o alelo do tipo sanguíneo A (I^A)



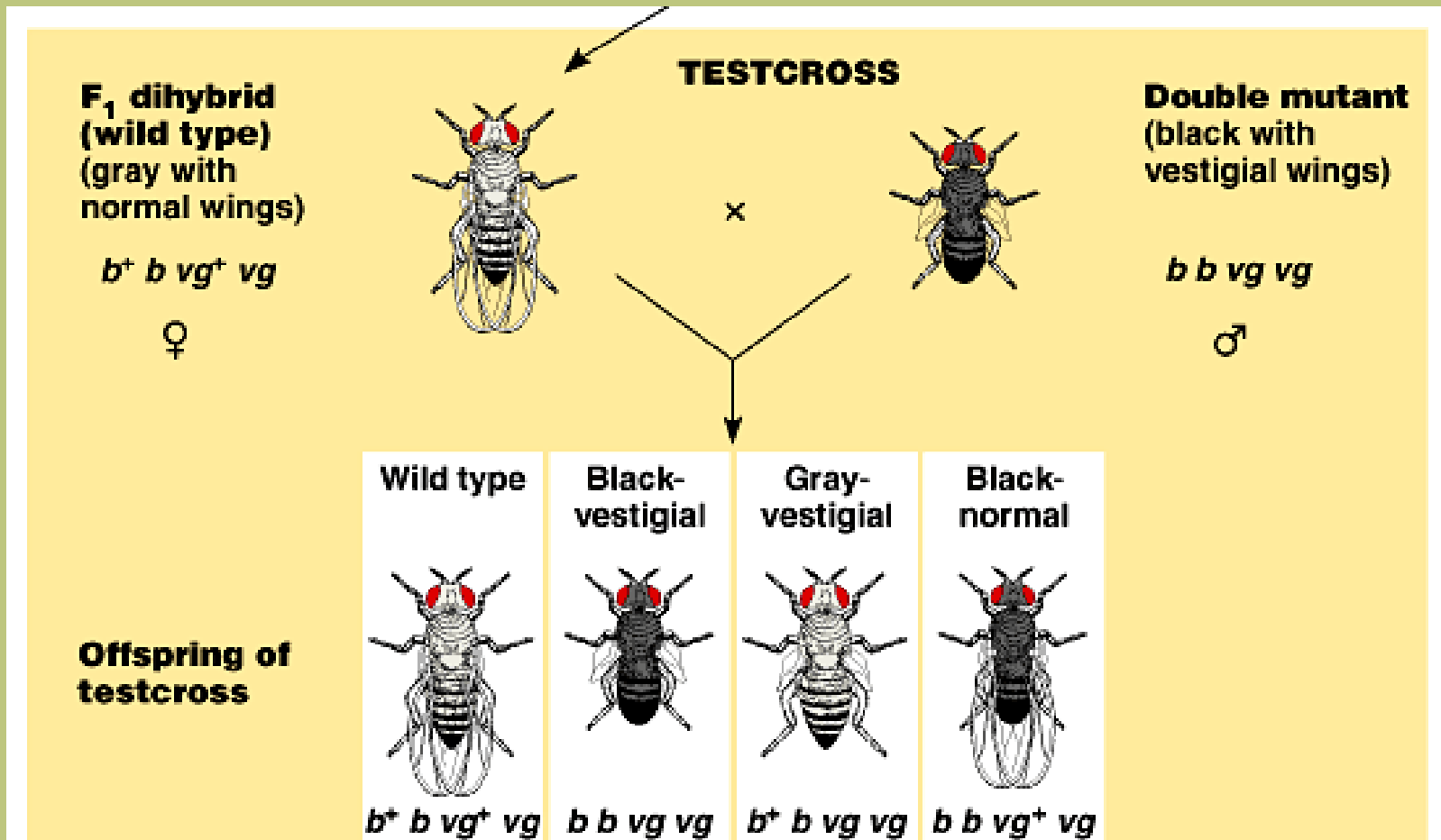
* Recombinante

Nail-Patella Syndrome and ABO Blood Groups are linked genes on chromosome 9

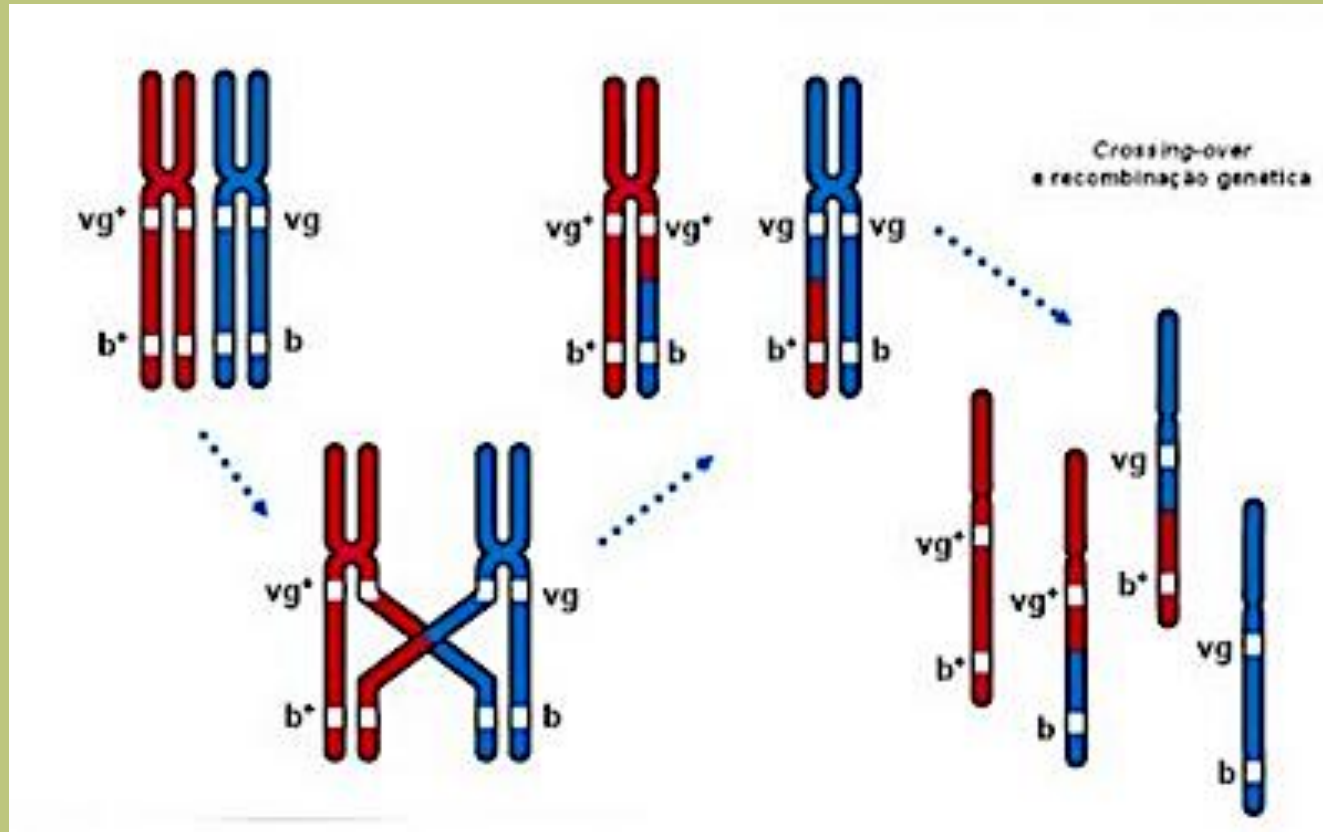
	Blood Groups				
Phenotype	O	A	B	AB	Total
Affected	62	53	20	4	139
Normal	62	79	13	6	160

An analysis of the pedigree of several family groups indicated that the locus for the nail-patella gene is situated on the same chromosome as the ABO locus, and their distance apart is about 10 units. It should be remembered that the nail-patella gene is not associated with any particular ABO allele.

VII) Estudos de ligação são feitos no “cruzamento-teste”



O valor da fração de recombinação (fr) é dado pela taxa de crossing-over



ESTUDAR:

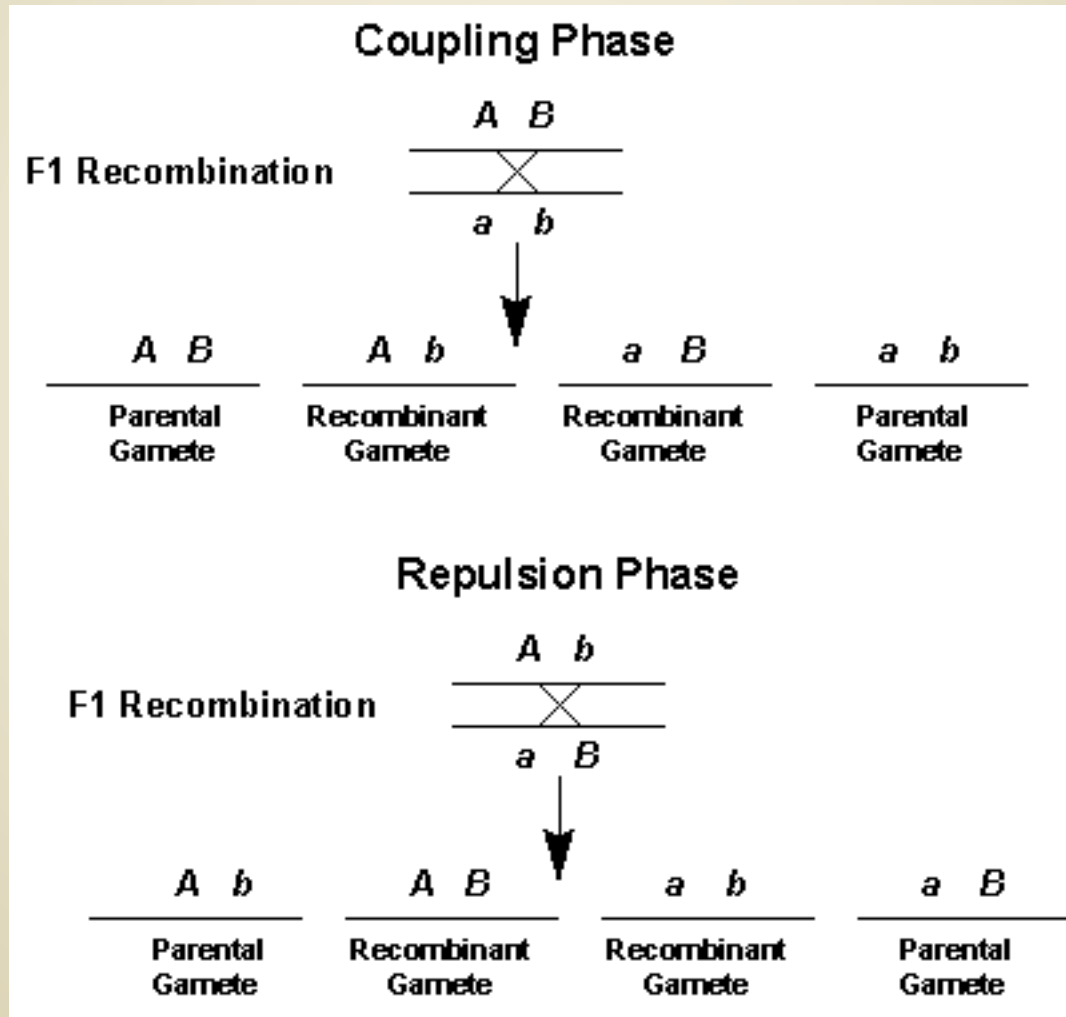
https://www.macmillanhighered.com/BrainHoney/Resource/6716/digital_first_content/trunk/test/hillis2e/hillis2e_ch08_4.html

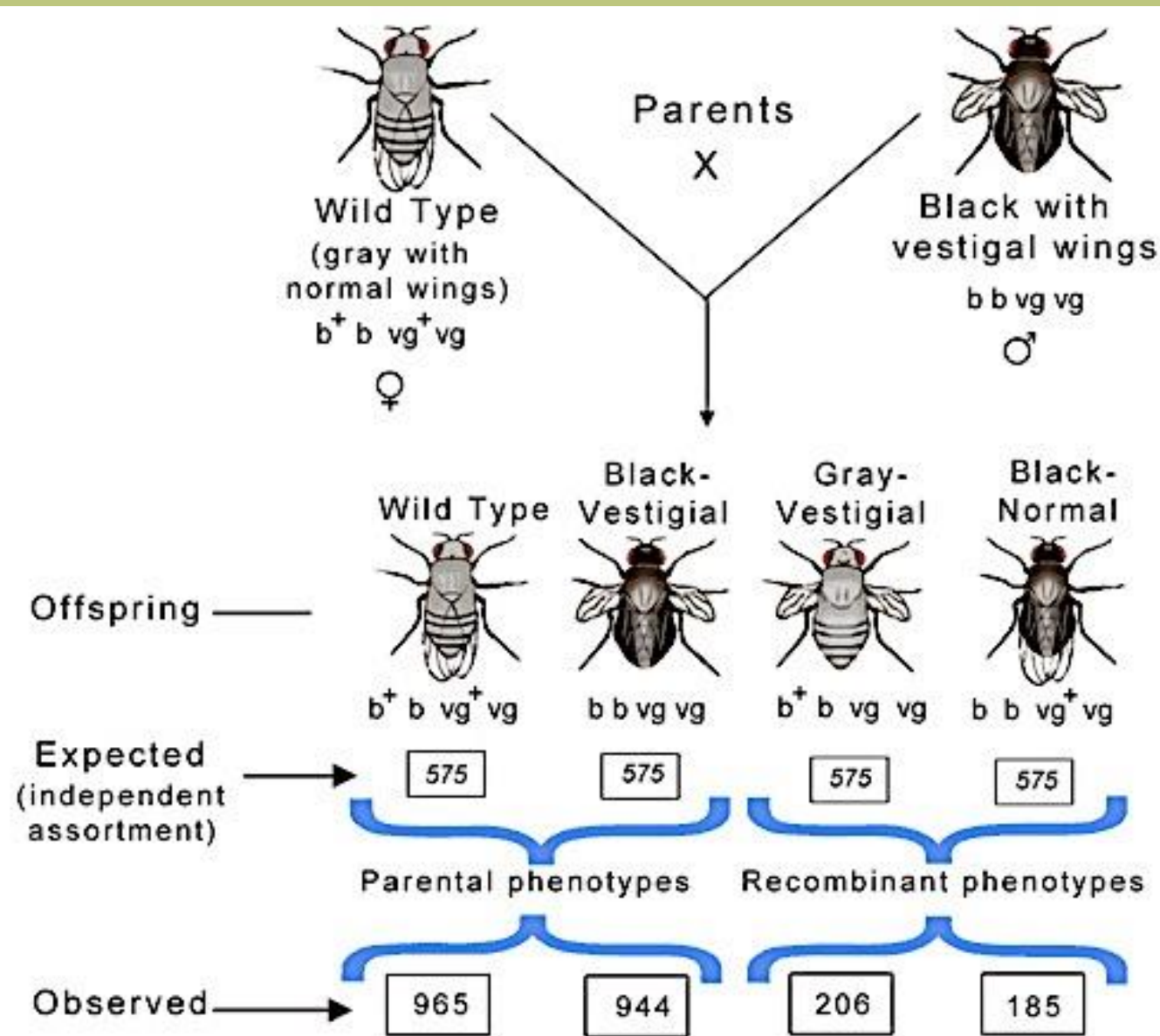
Cálculo da *fr*: no Cruzamento-Teste:

$$fr = r = \frac{\sum \text{tipos recombinantes}}{N}$$

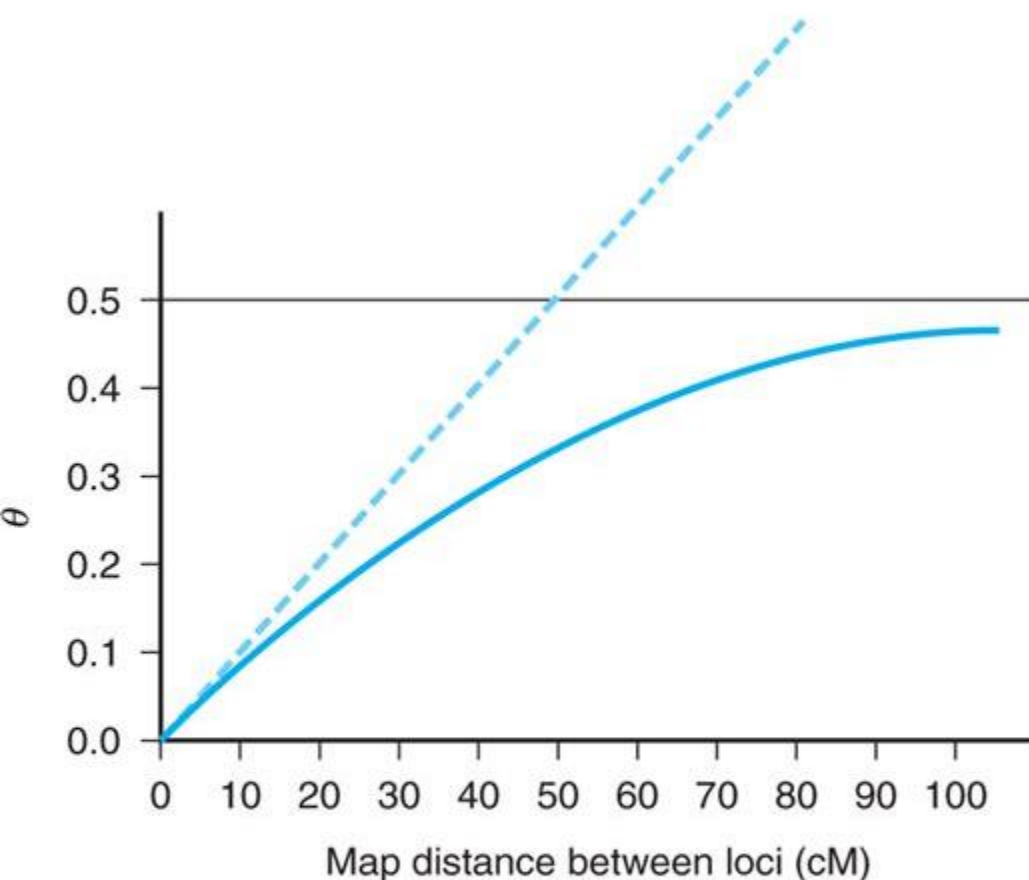
A distância entre os genes é função
da frequência de recombinação
A taxa de crossing é o dobro da *fr*

When two genes are close together on the same chromosome pair, they do not assort independently. **Coupling** refers to the linkage of two dominant or two recessive alleles, whereas **repulsion** indicates that dominant alleles are linked with recessive alleles.





$$fr = r = \frac{206 + 185}{965 + 944 + 206 + 185}$$



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The relationship between map distance in centimorgans and recombination fraction, θ . Recombination fraction (*solid line*) and map distance (*dotted line*) are nearly equal, with 1 cM = 0.01 recombination, for values of genetic distance below 10 cM, but they begin to diverge because of double crossovers as the distance between the markers increases. The recombination fraction approaches a maximum of 0.5 no matter how far apart loci are; the genetic distance increases proportionally to the distance between loci.

VIII) Mapa: cromossômico, genético e físico

