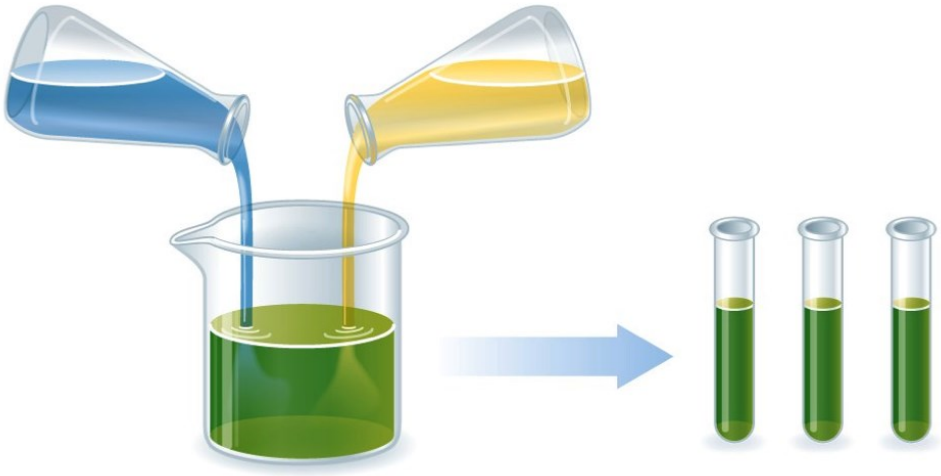
Inheritance

Inheritance

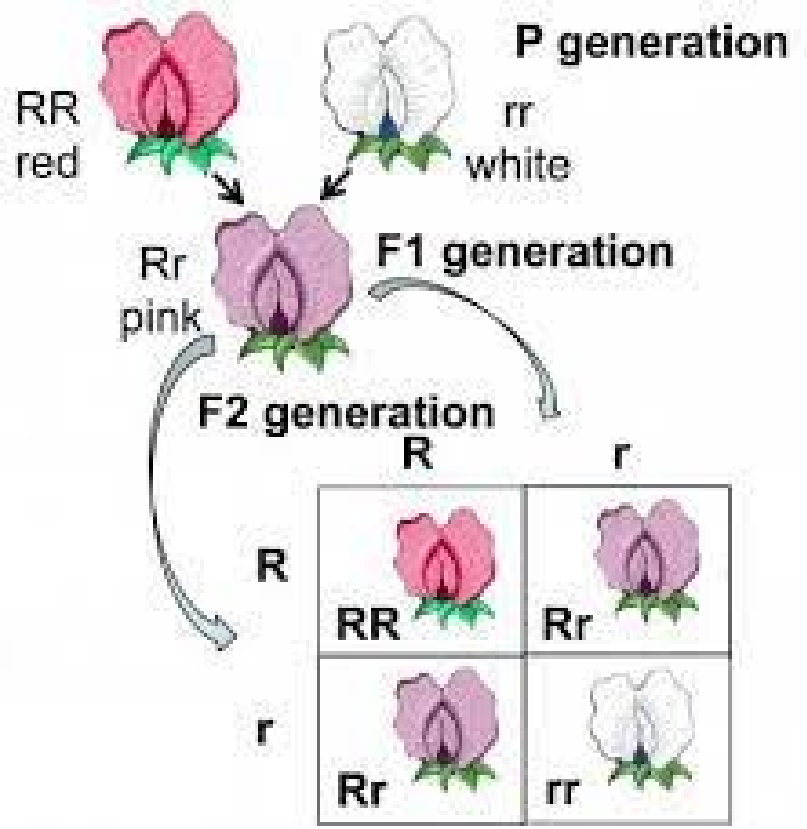
Blending inheritance

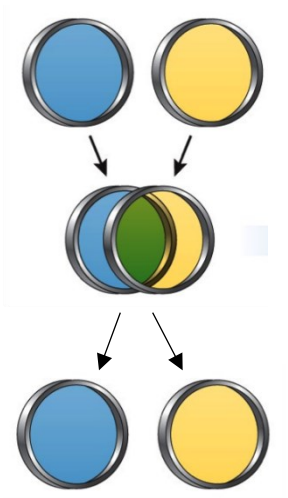


Fleeming Jenkin criticizes Darwin's theory of evolution.

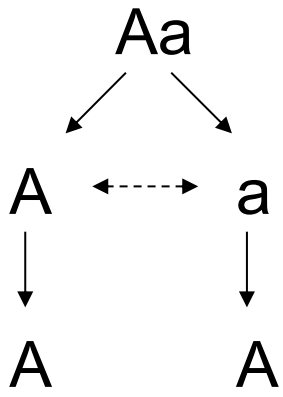
Mendel's theory of inheritance (1866)

Law of segregation

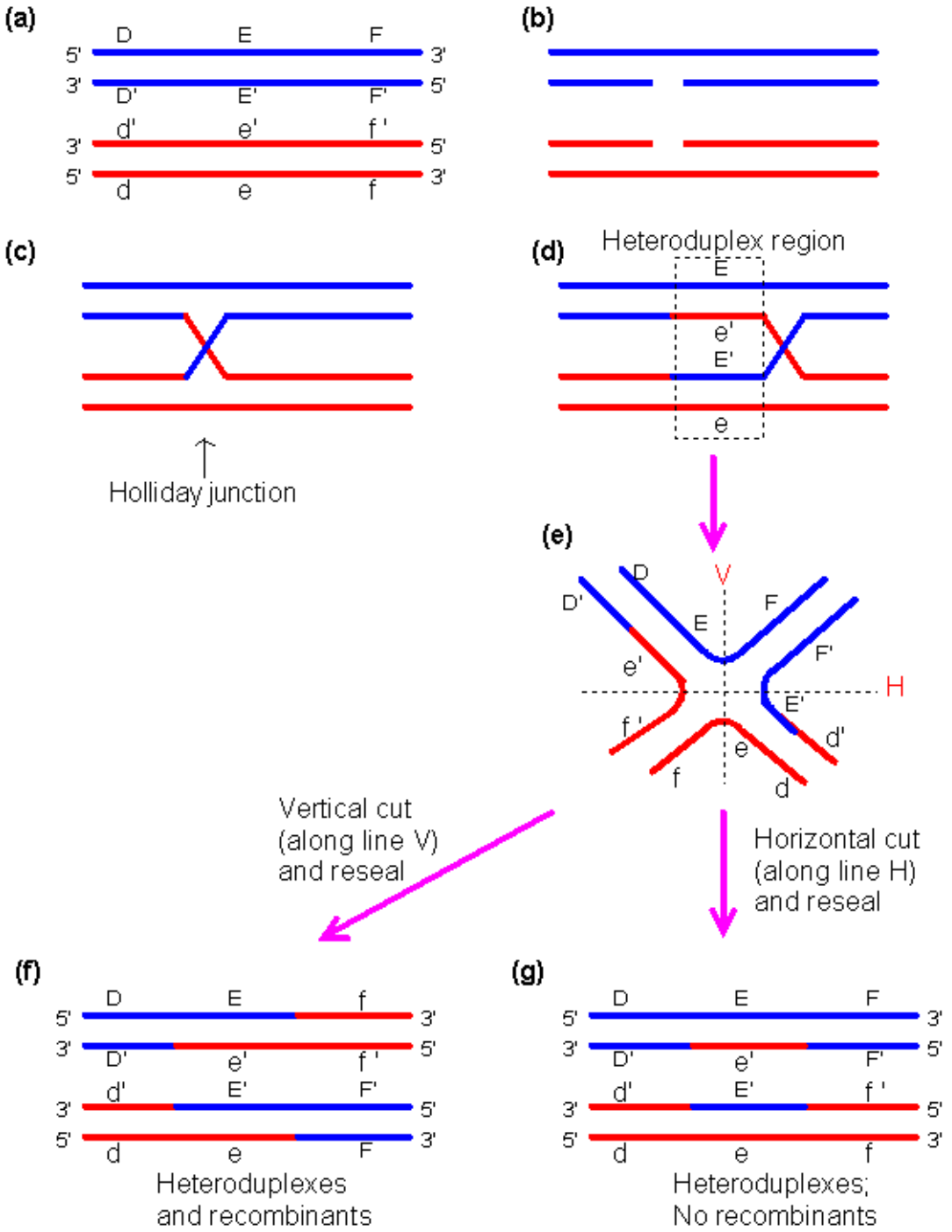




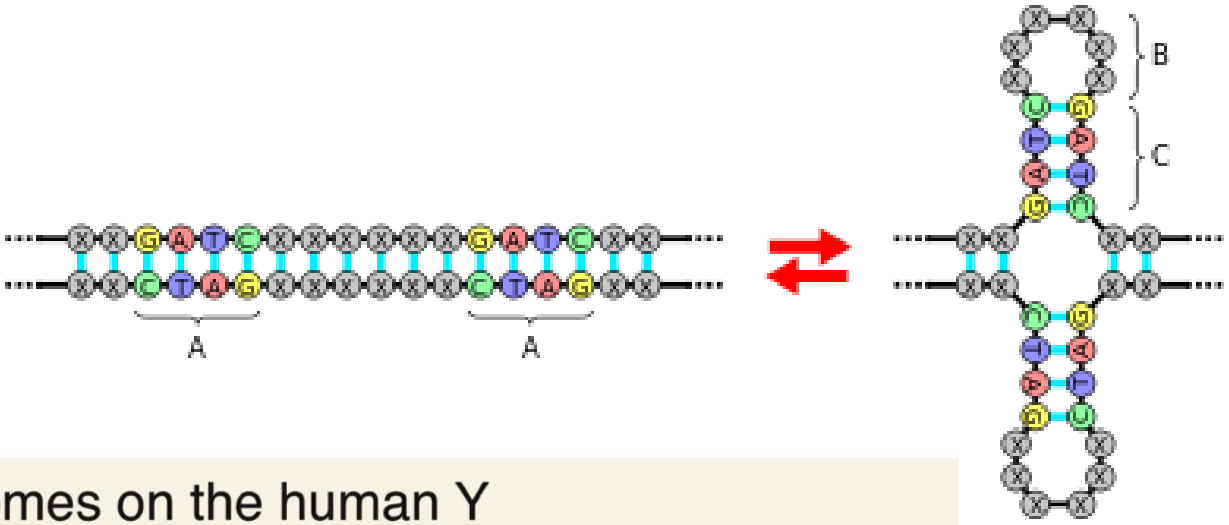
Gene conversion

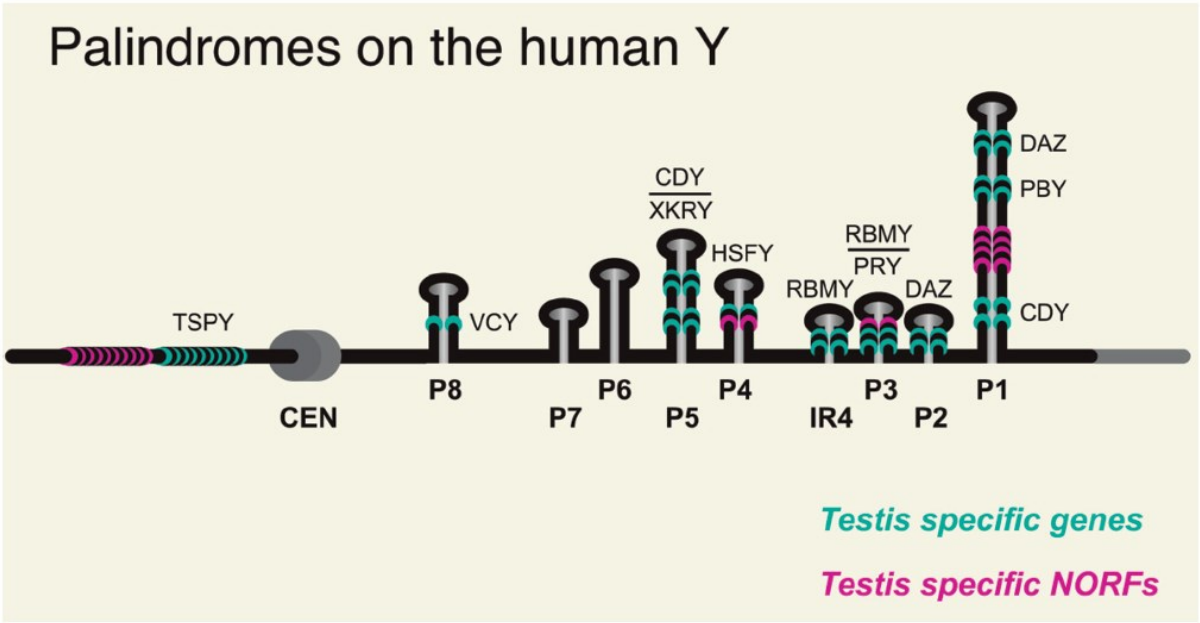


- Gene conversion during meiotic recombination.



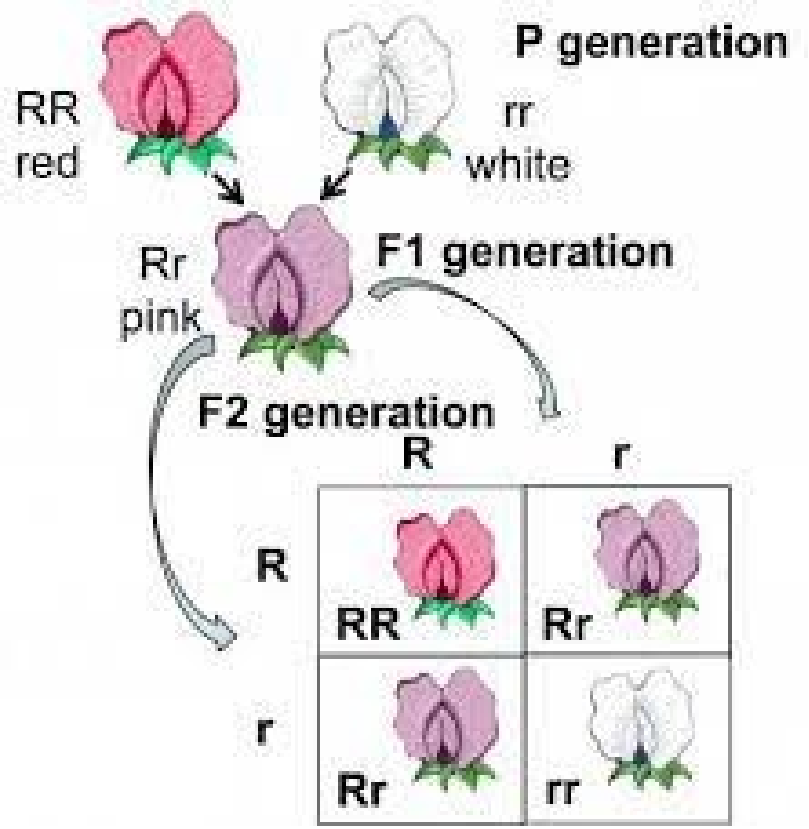
Gene conversion between paralogous sequences





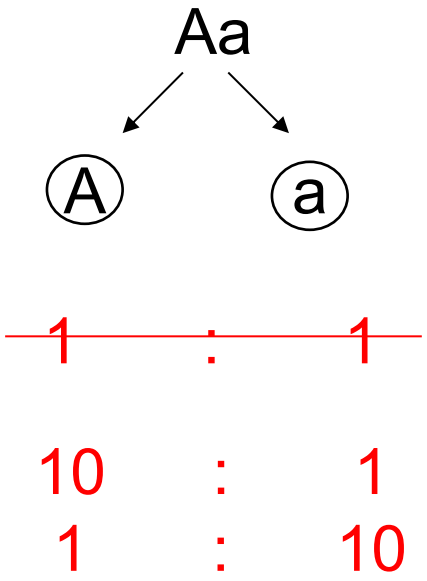
Mendel's theory of inheritance (1866)

Law of segregation

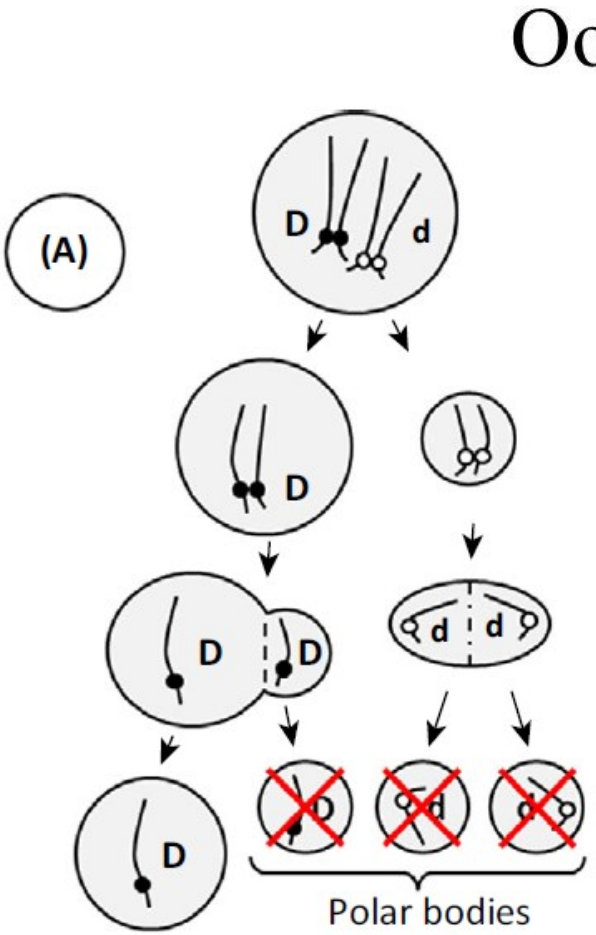


1:2:1

Meiotic drive

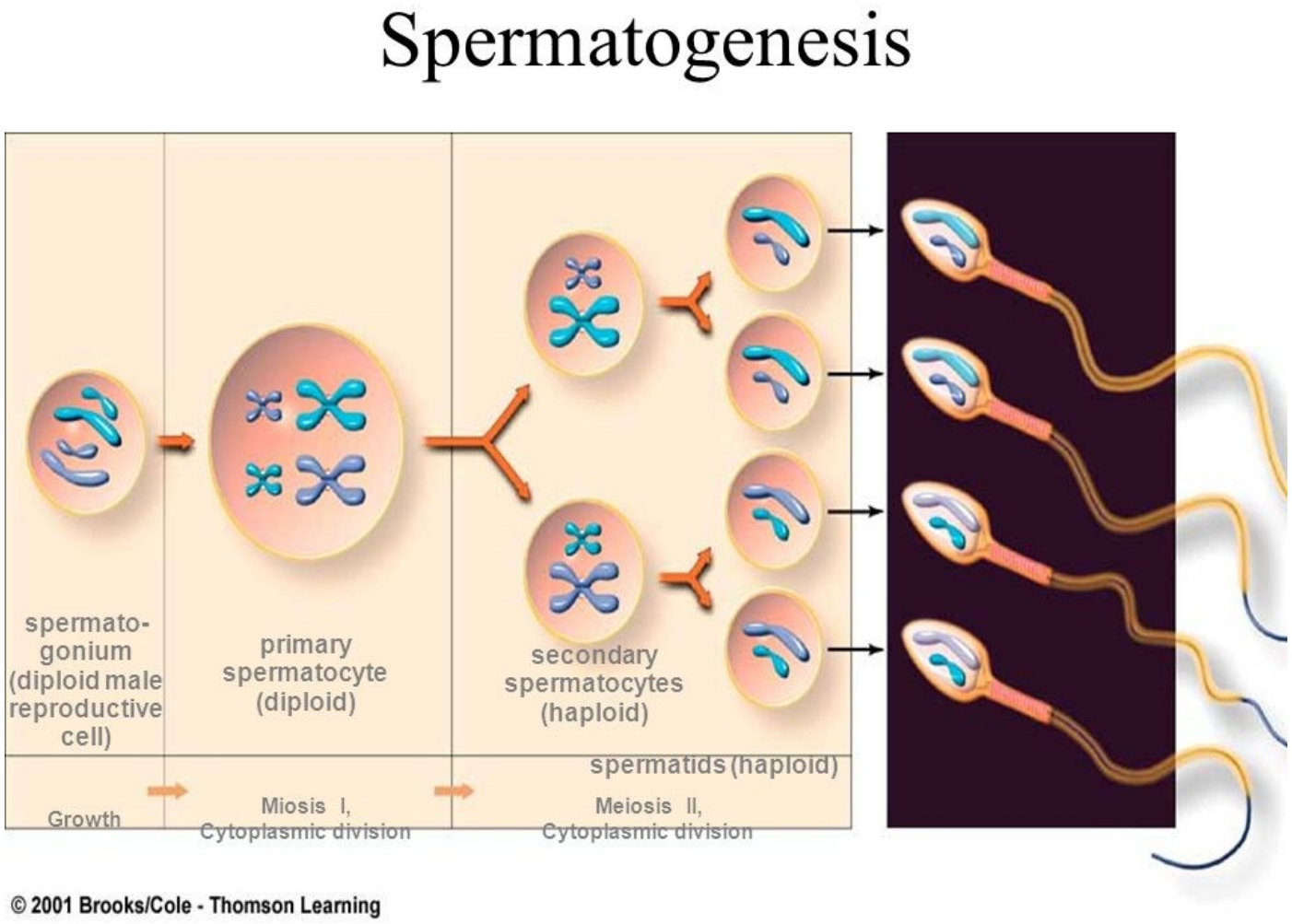


Female meiotic drive

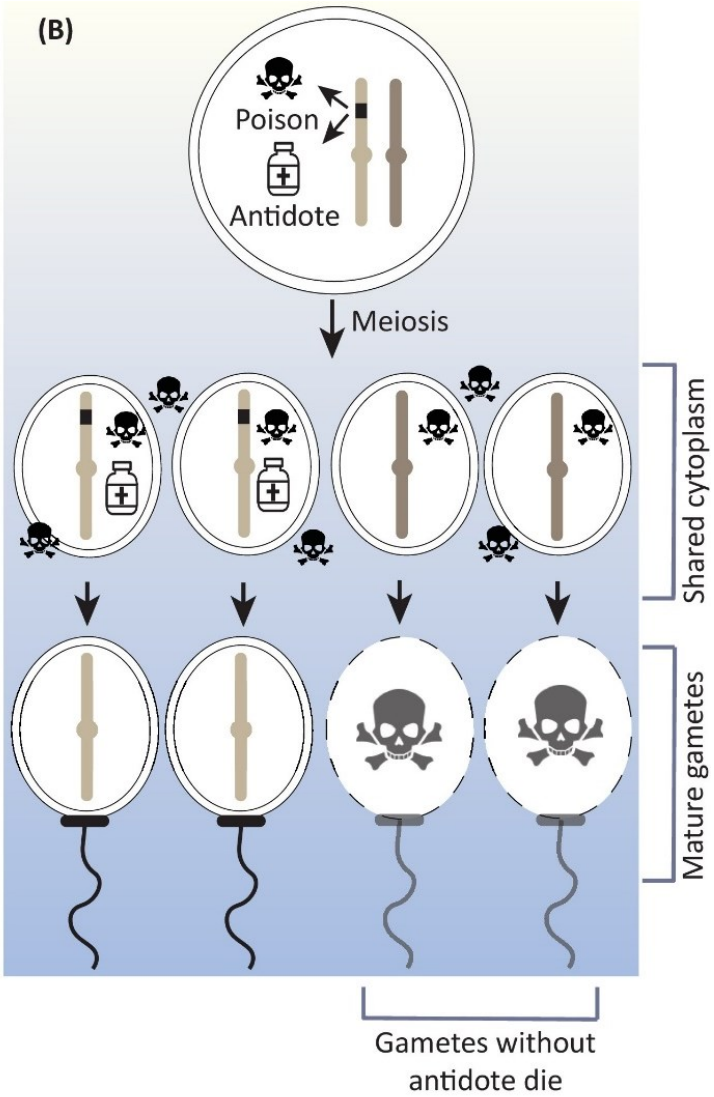


Monkey flower *(Mimulus guttatus)*

Male meiotic (gametic) drive



Mechanisms of male meiotic drive

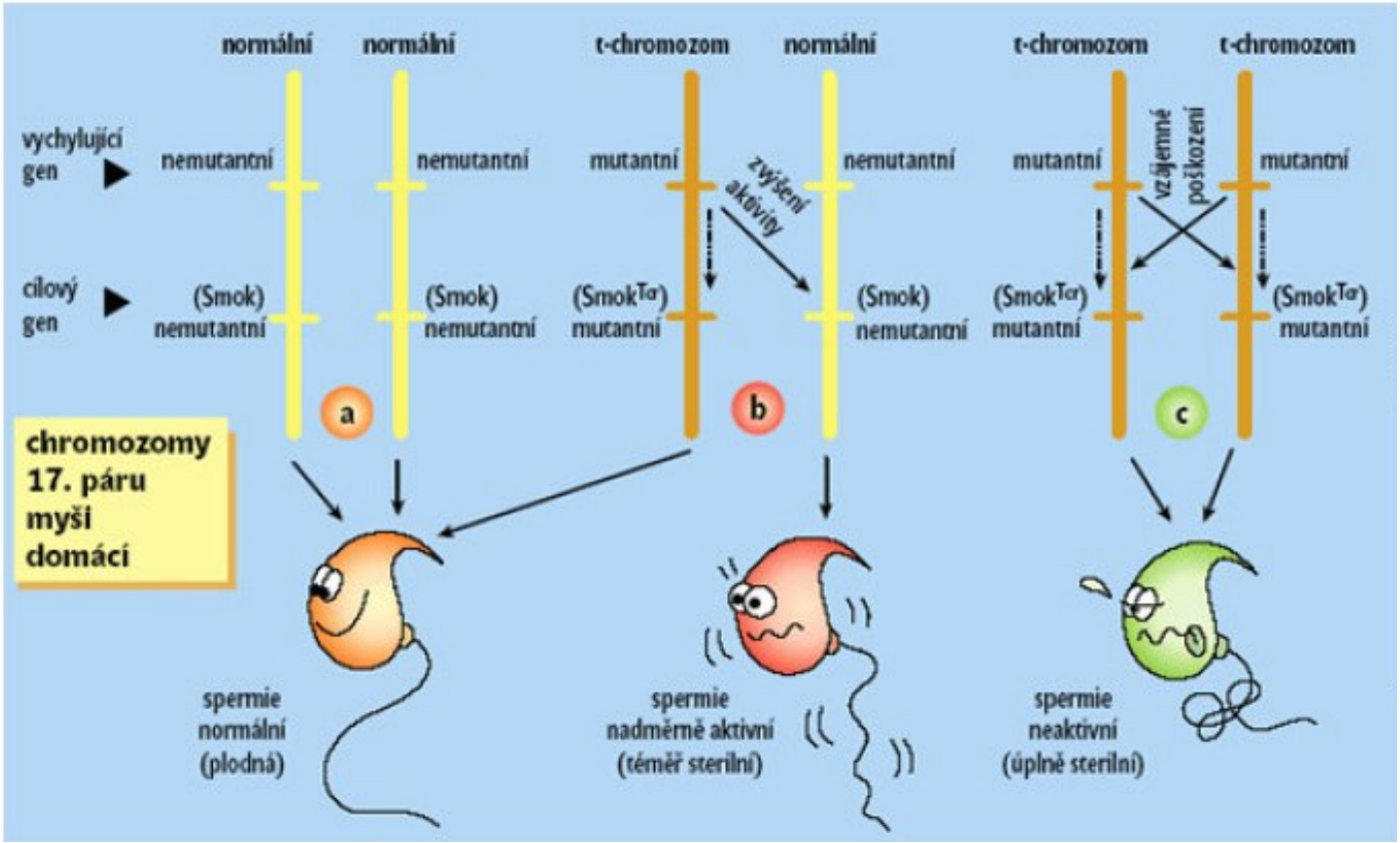


Drive mostly occur in non-recombining regions

- Inversions
- Sex chromosomes

t-haplotype

- Inversion on chromosome 17

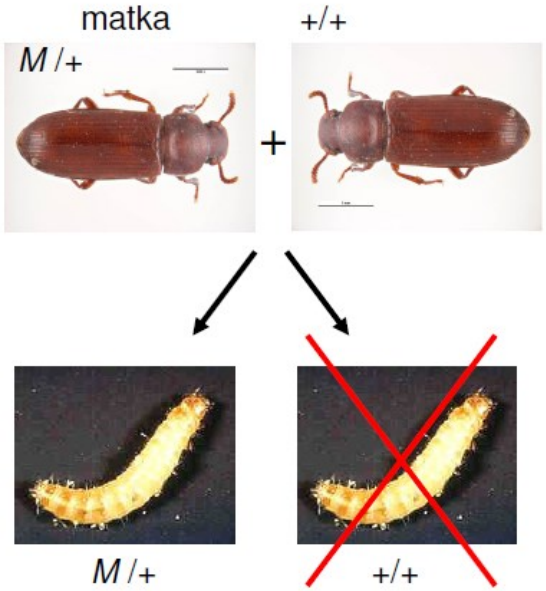


Zygotic drive

Medea (Maternal-Effect Dominant Embryonic Arrest)

- Allele causes death of progeny that do not inherite it
- Maternally expressed poison and zygotically epressed antidote.

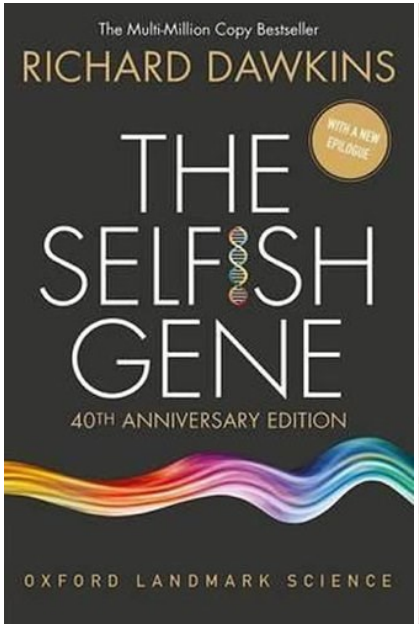
Tribolium castaneum

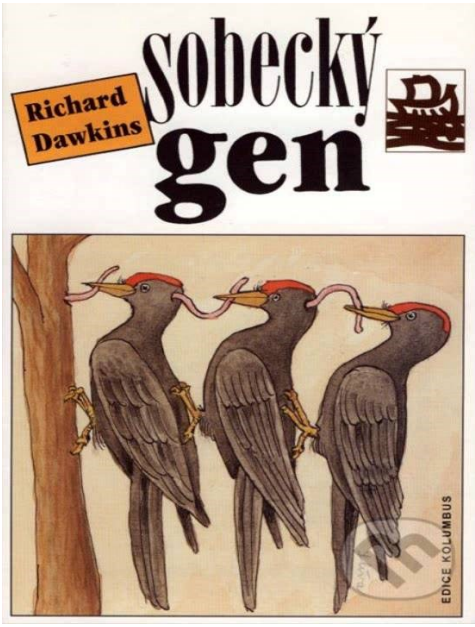


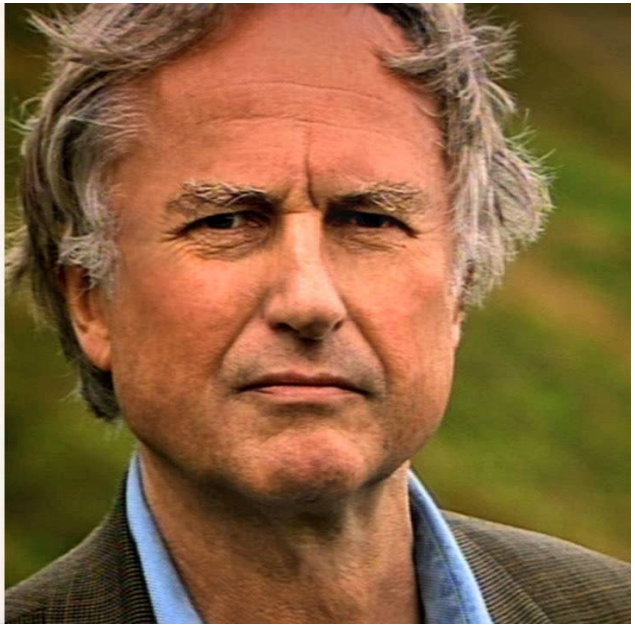
Syntetic drive

- Could be used to inroduce quickly some allele to the population.
- Possible practical applications: regulation of disseases etc.

Selfish genes



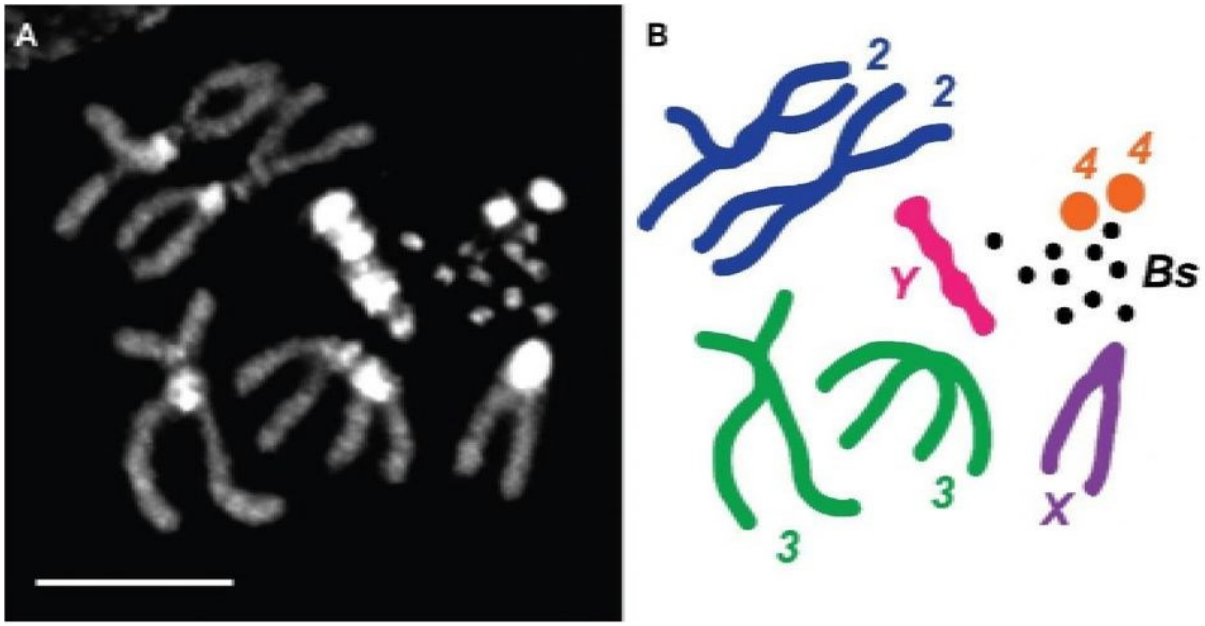




- Drive genes can spread in the population even if they do not provide any advantage to the individuals carrying them.

Selfish B chromosomes

- Additional parazitic chromosomes
- Only in some individuals in population, in one ore more copies
- Often spread via meiotic or mitotic drive mechanisms

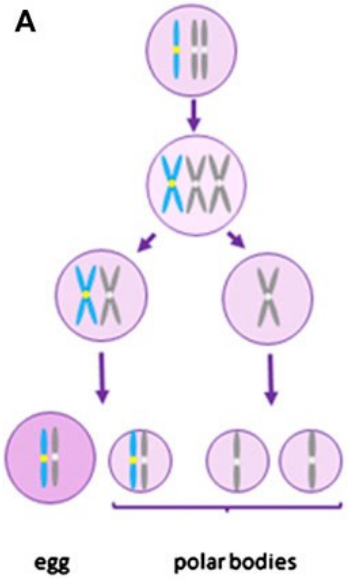


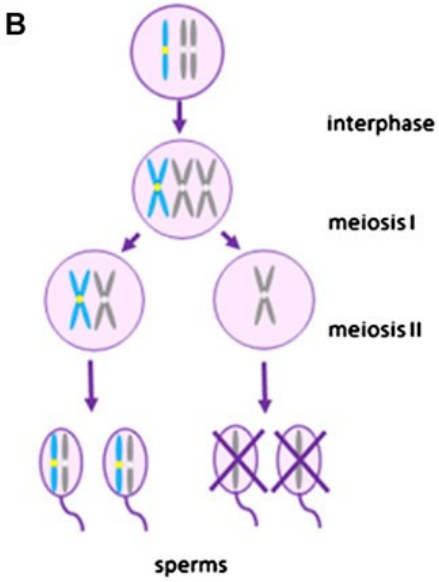
D. melanogaster B chromosomes

Hanlon et al. 2018

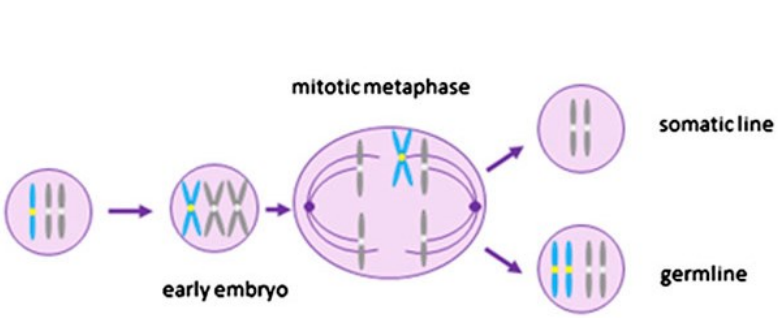
Selfish B chromosomes

Meiotic drive





Mitotic drive associated with gonotaxis



Lilium callosum

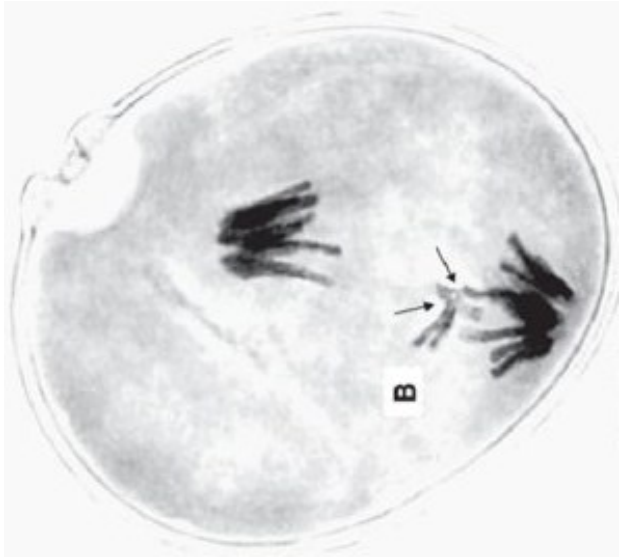
Pseudococcus affinis

Camnula pellucida

Selfish B chromosomes

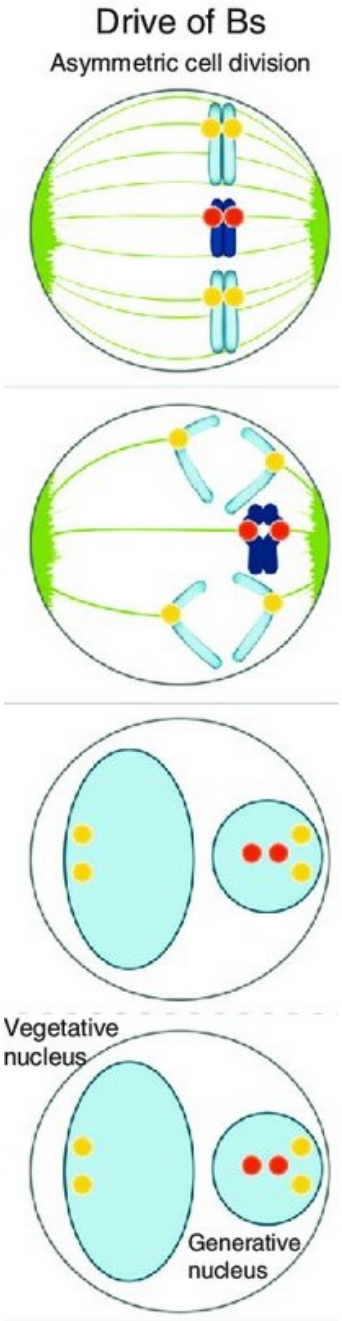
Postmeiotic mitotic drive in angiosperms

Rye (*Secale cereale*)



Vegetative cell

Generative cell

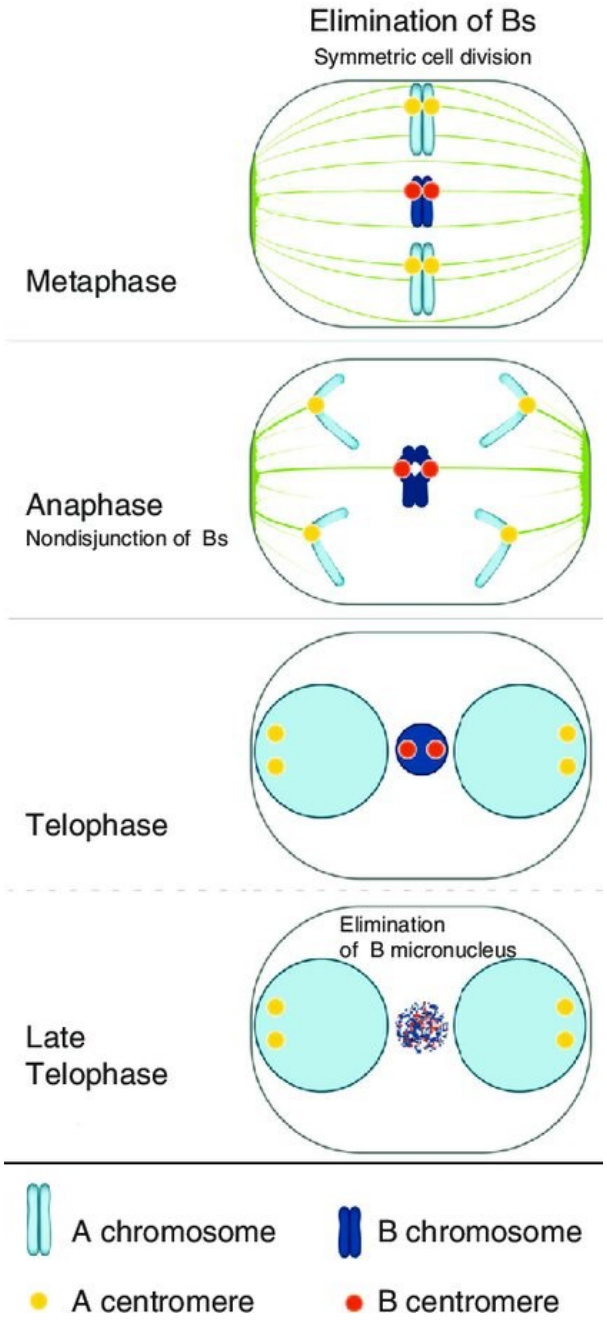


Tissue specific elimination of B chromozomes in plants

goatgrass

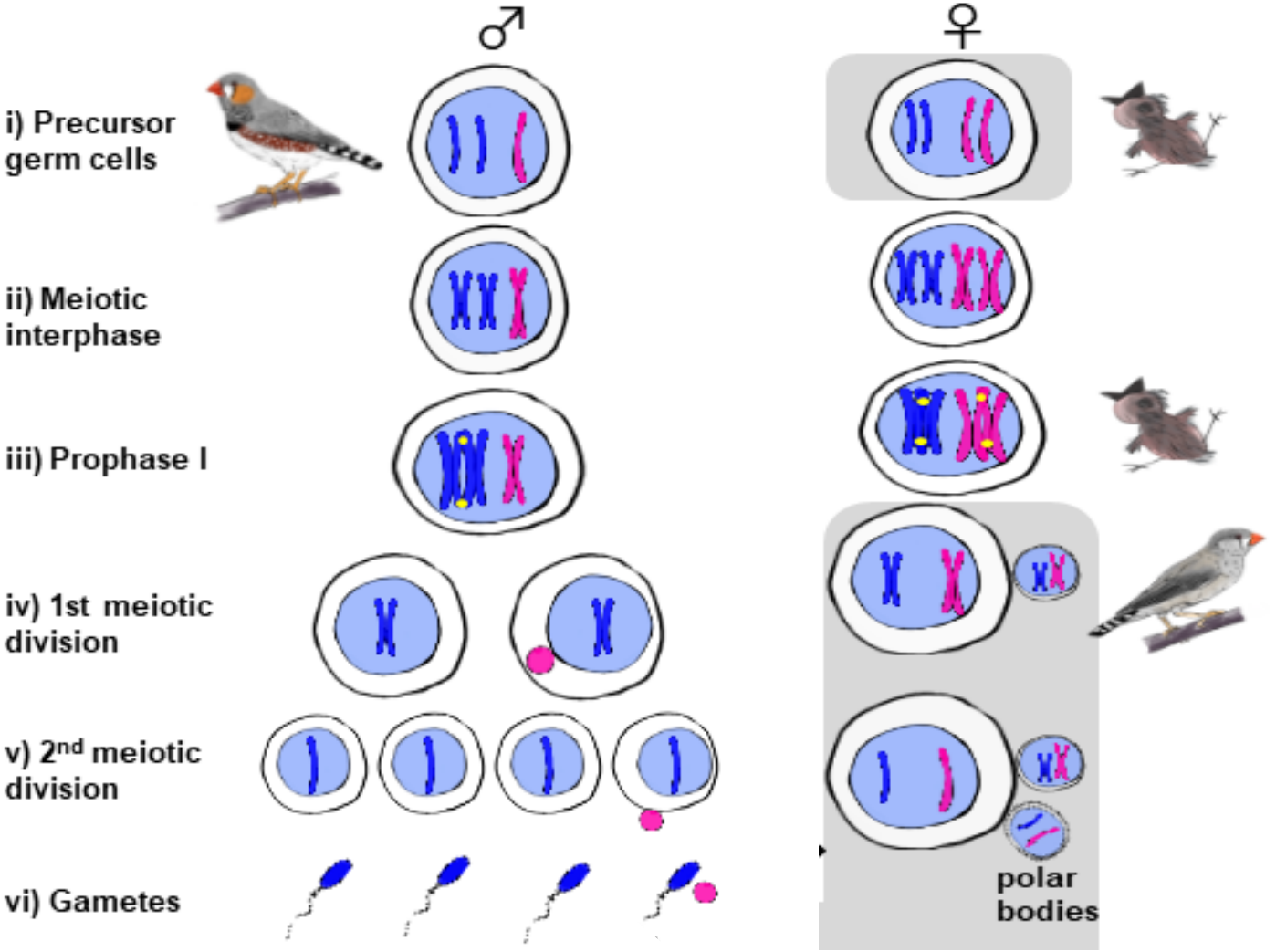
sorghum

Ruban et al. 2020



Germline-restricted chromosome

Possibly „domesticated“ B chromosome?



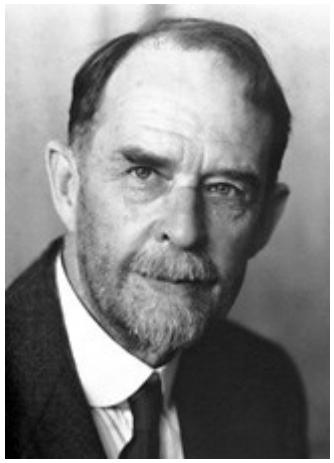
Mendel's theory of inheritance

Law of independent assortment

♀ \ ♂	pollen: AB	Ab	aB	ab
ovules: AB	AABB	AABb	AaBB	AaBb
Ab	AABb	AAbb	AaBb	Aabb
aB	AaBB	AaBb	aaBB	aaBb
ab	AaBb	Aabb	aaBb	aabb

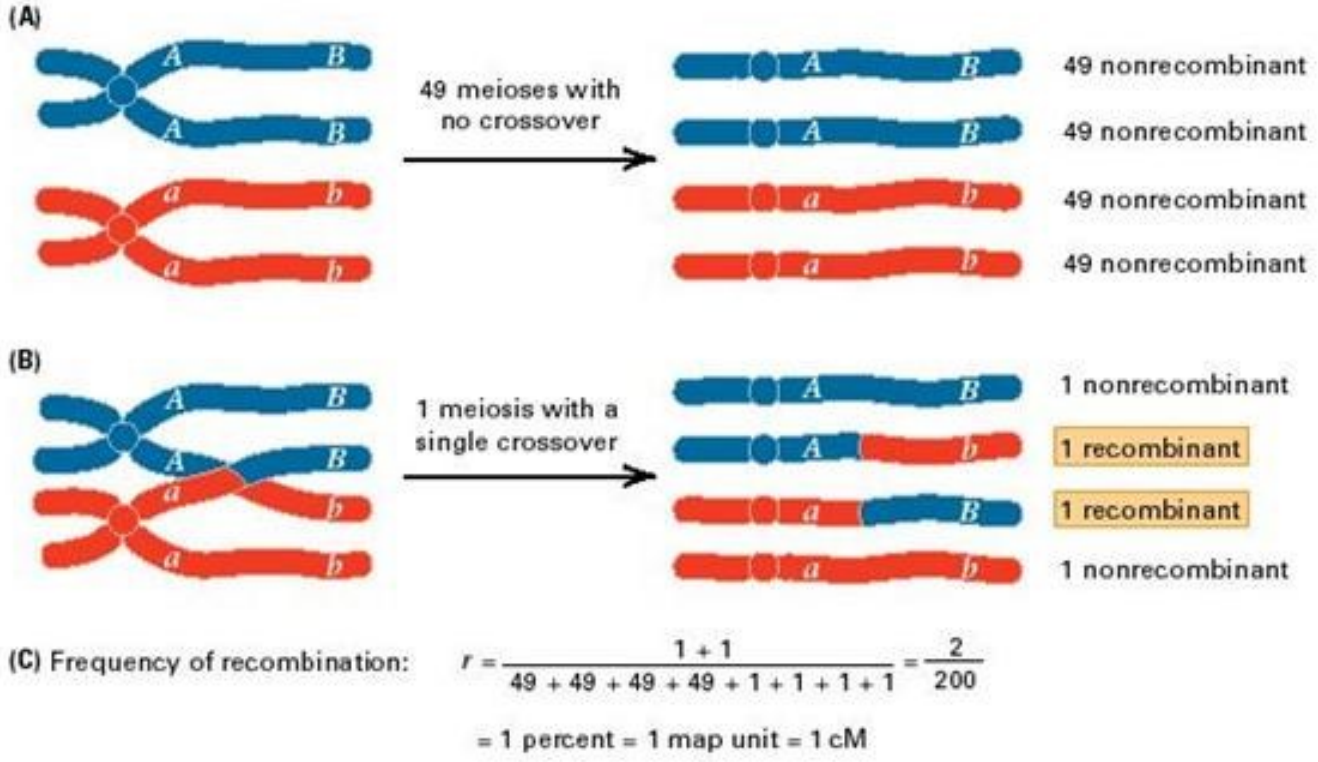
F_2 generation

Chromosomal theory of inheritance and gene linkage



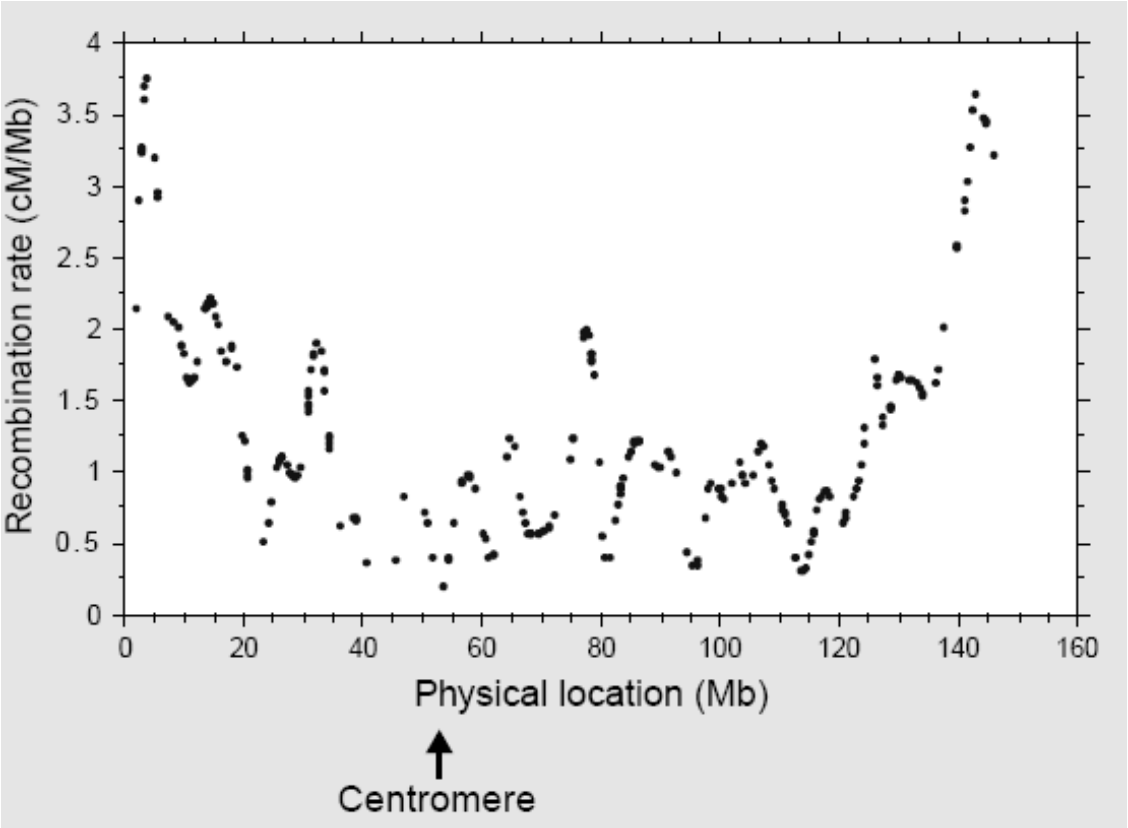
Thomas Morgan

- Aleles of different genes that are localized on the same chromosome tend to be inherited together.
- 1 cM ~ 1% recombinant genotypes



Recombination rate (r)

- Higher at the ends of chromosomes (near telomeres), lower around centromers.
- Recombination hotspots in some organisms (e.g. mammals).
- Crossing-over interference. Usually 1 crossing-over per chromosome (max. 3). Leads to higher recombination rate in smaller chromosomes.



Recombination rate (r)

- Males usually have higher recombination rates than females.
  humans: 1,7 x ; mouse 1,3 x
- **Haldane-Huxley rule**. If one sex do not recombine, it is the heterogametic sex (např. *Drosophila*, *Bombyx*).
- Absence of recombination on non-pairing sex chromosomes (Y,W).

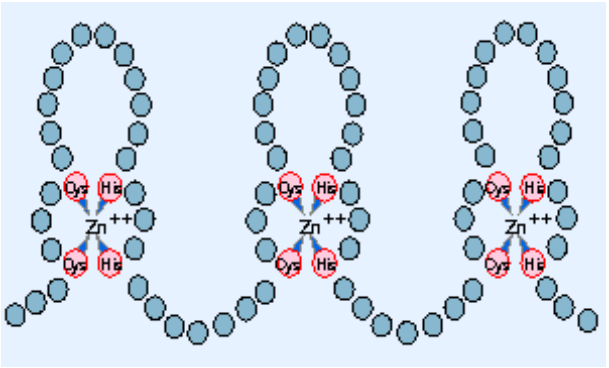
XY males

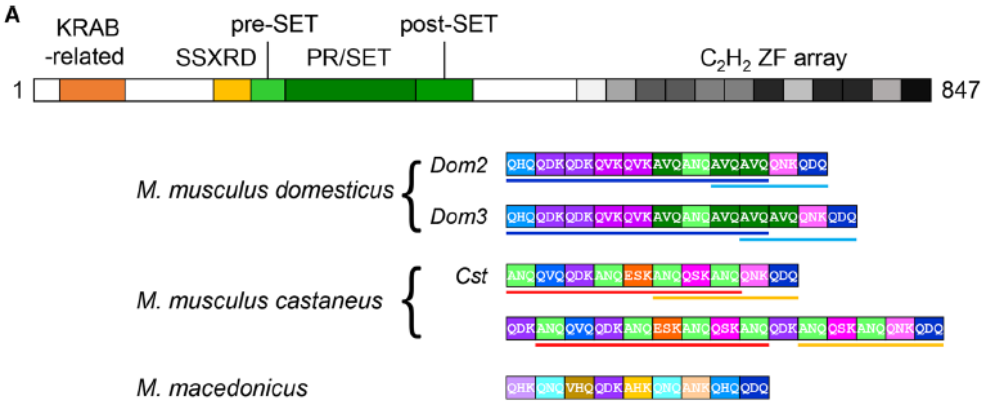
ZW females

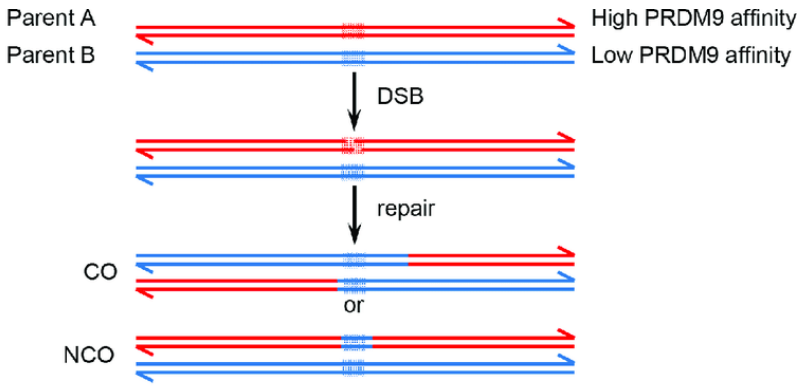
Hotspots of recombination

Prdm9

- DNA binding protein (zinc-finger domain). Determines the position of double strand breaks in meiosis (hotspots of recombination).
- Fast molecular evolution due to gene conversions.



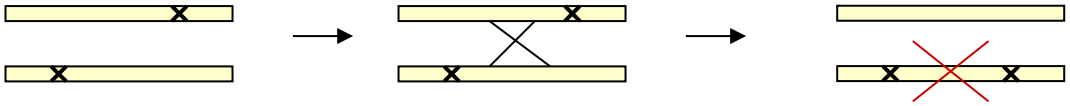




Asymetrical gene conversion.

Evolutionary importance of recombination

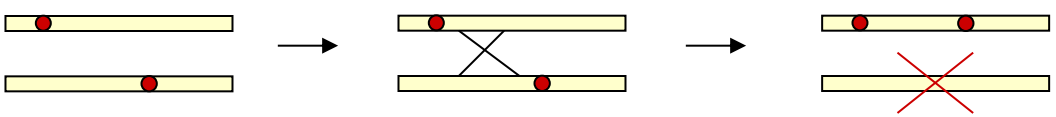
- Slows down accumulation of deleterious mutations (Muller's ratchet).

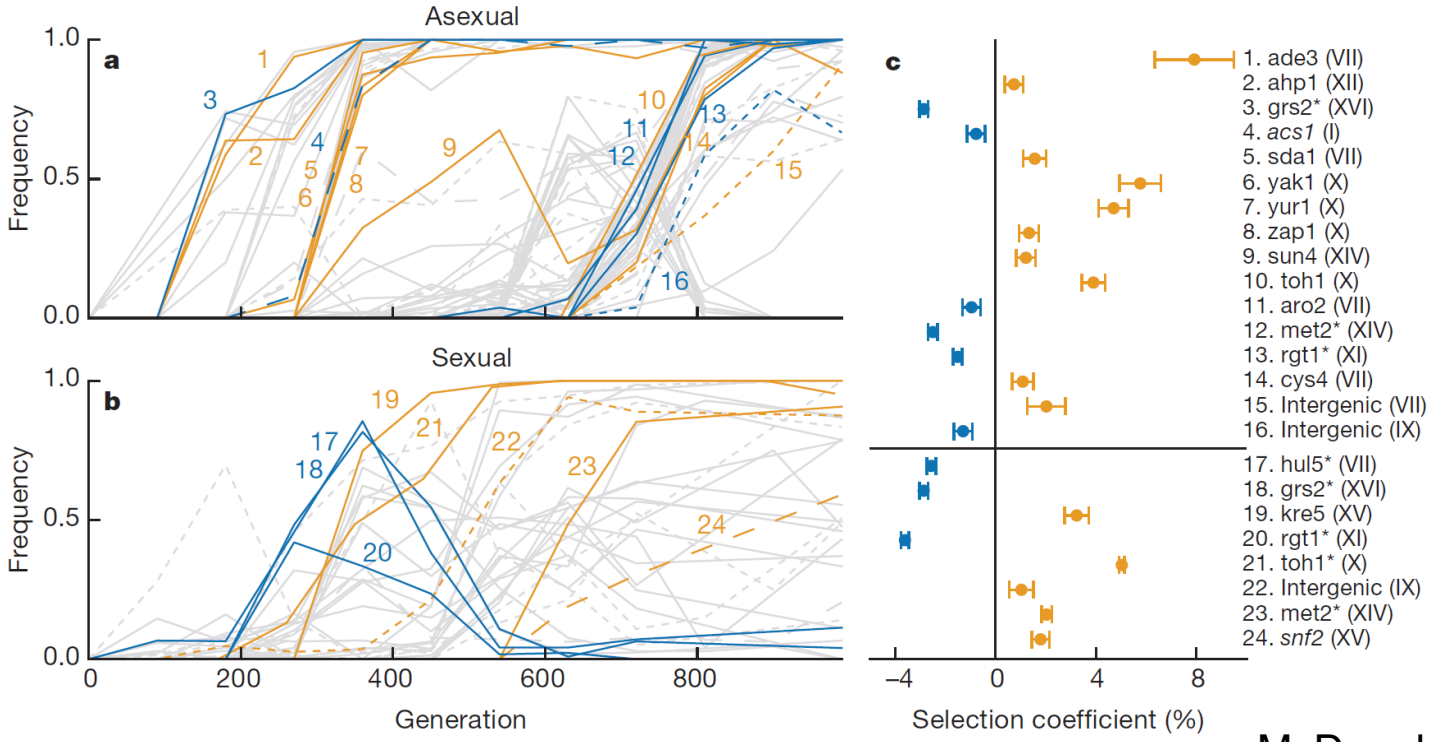


J. H. Muller

Evolutionary importance of recombination

- Allows to combine multiple advantageous mutations.
  Speed up adaptive evolution.

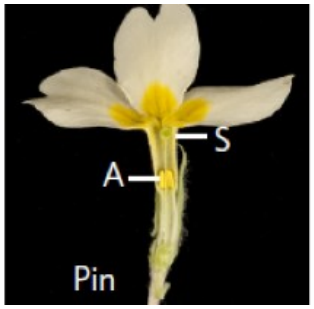


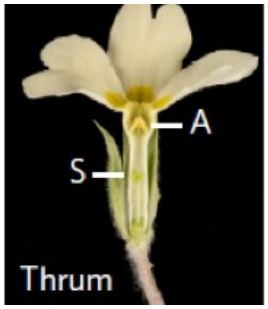


McDonald et al. 2016

Sometimes recombination between specific genes is disadvantageous

Supergenes





Heterostyly in *Primula vulgaris*

Received: 31 January 2024 | Revised: 24 May 2024 | Accepted: 17 June 2024

DOI: 10.1111/1755-0998.13988

RESOURCE ARTICLE

MOLECULAR ECOLOGY RESOURCES WILEY

The *Primula edelbergii S*-locus is an example of a jumping supergene

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Schweizerischer Nationalfonds zur Förderung der Wissenschaftlichen Forschung, Grant/Award Number: 175556

Abstract

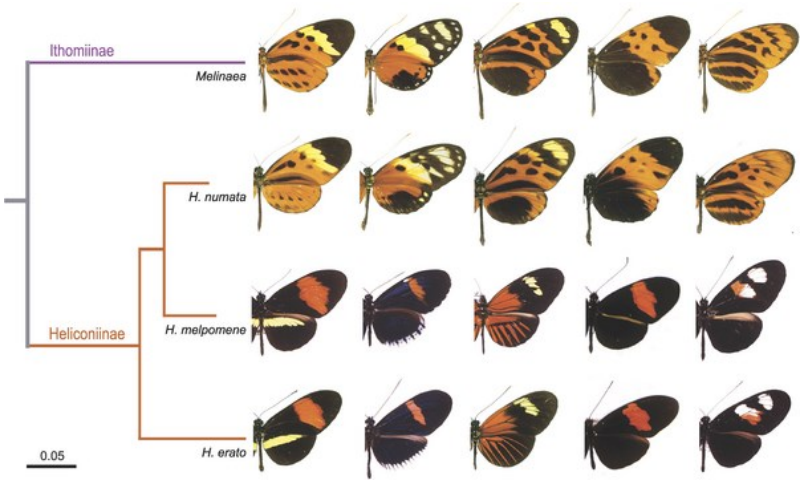
Research on supergenes, non-recombining genomic regions housing tightly linked genes that control complex phenotypes, has recently gained prominence in genomics. Heterostyly, a floral heteromorphism promoting outcrossing in several angiosperm families, is controlled by the *S*-locus supergene. The *S*-locus has been studied primarily in clo[illegible] other groups that independently evolved heterostyly. However, it remains unknown whether genetic architecture and composition of the *S*-locus are maintained among species that share a common origin of heterostyly and subsequently diverged across larger time scales. To address this research gap, we present a chromosome-scale genome assembly of *Primula edelbergii*, a species that shares the same origin of heterostyly with

PRESENTATION

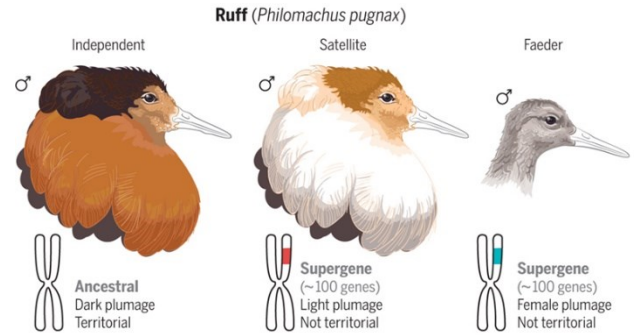
- Co-adapted gene complexes underlying complex traits. Inherited as a single gene.

Supergenes

Mimetic polymorfism in *Heliconius numata*

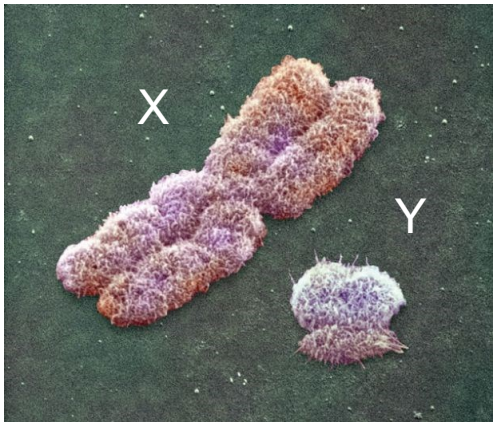


Male morphs in ruffs

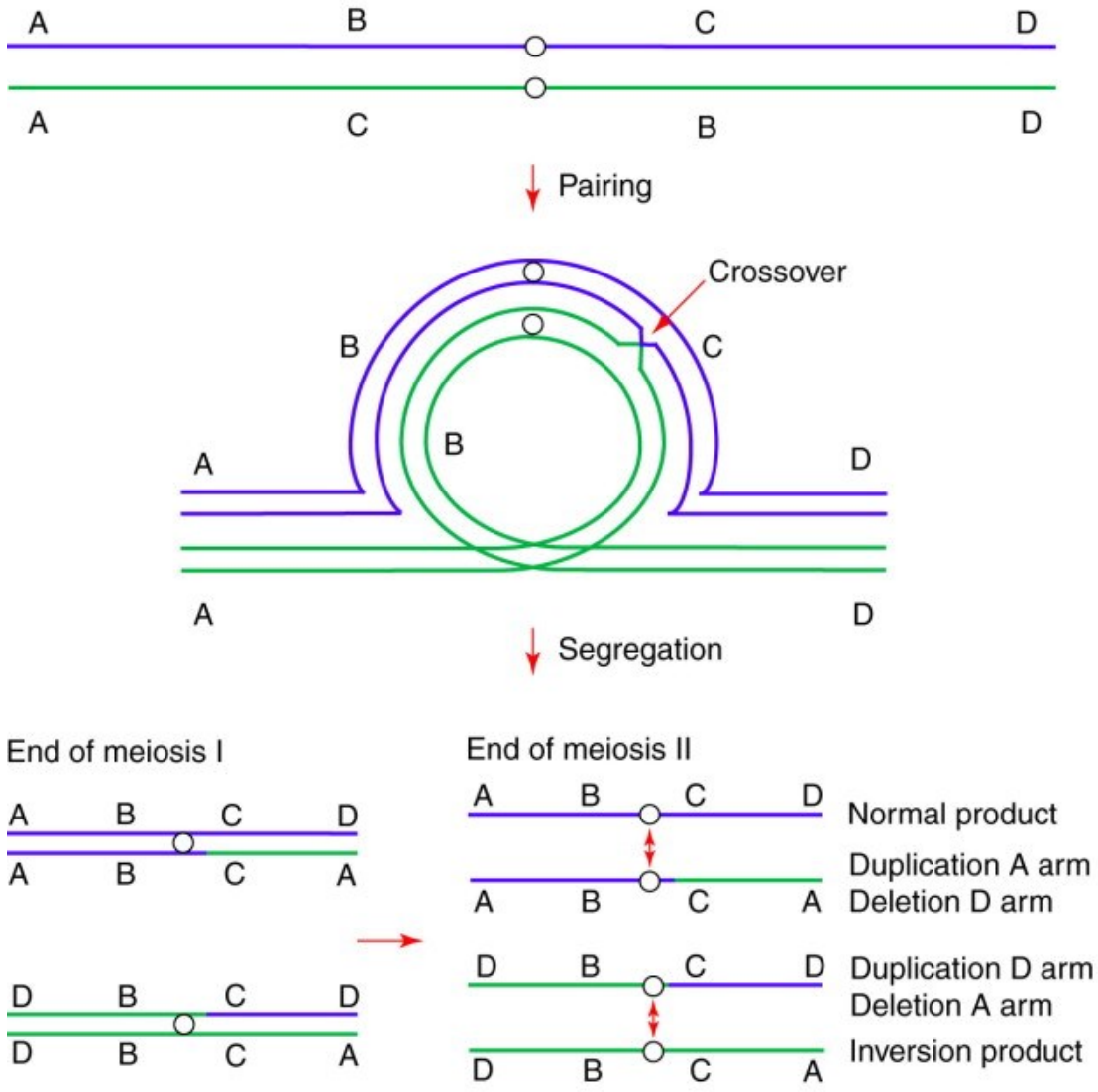


Kupper et al. 2016 Nat. Genet.

Sex chromosomes



Inverze účinně potlačuje rekombinaci



Mendel's theory of inheritance

Law of uniformity and identity of reciprocal F1 hybrids

♀ AA × ♂ aa

↓

Aa

♂ AA × ♀ aa

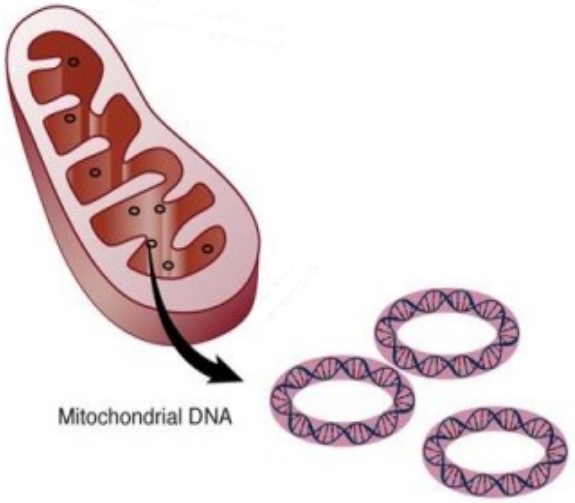
↓

Aa

Uniparental inheritance

Mitochondrial and plastid DNA

- Mostly maternal inheritance
- „Mothers curse“
- In rare cases paternal inheritance (molluscs).
- Most genes from mitochondrial and plastid DNA moved to nukleus.



Intracelullar parazite of Arthropods

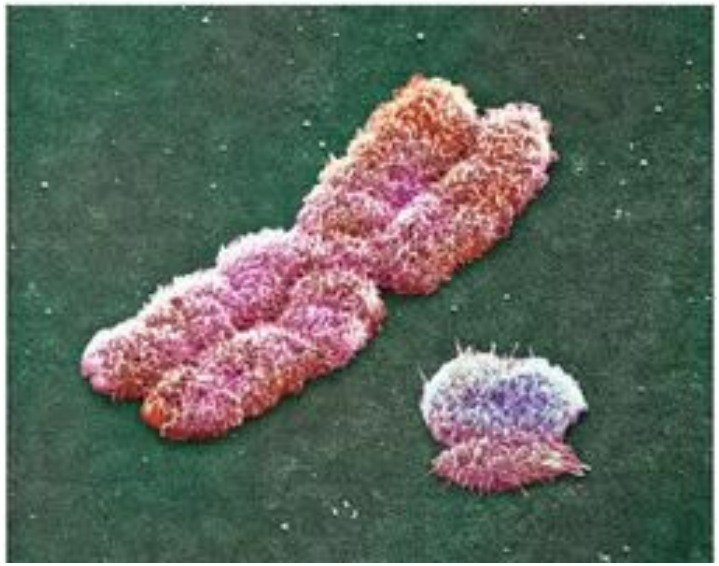
Wolbachia

- cytoplasmic incompatibility (infected males cannot reproduce with uninfected females)
- partenogenesis (infected females can reproduce without males)
- feminization of males
- killing males

Sex chromosomes

- Chromosom Y paternal inheritance.
- Chromosom W maternal inheritance.

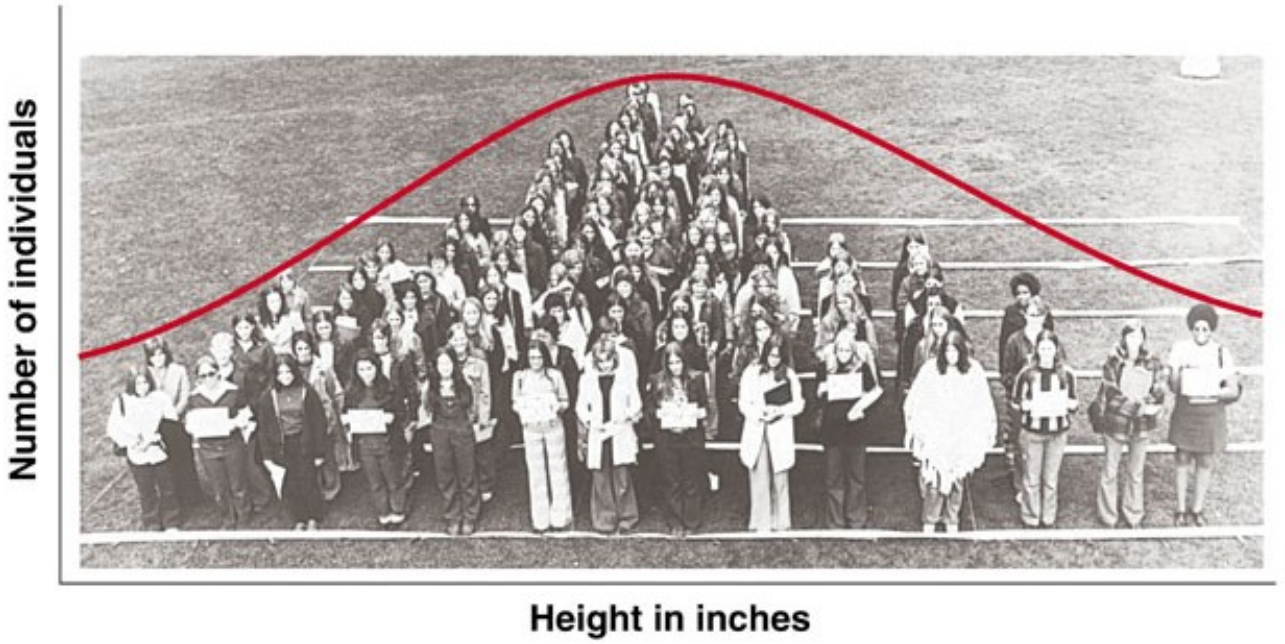
XY males
XX females



ZW females
ZZ males

Inheritance of quantitative traits

- continuous variation of traits
- traits underlined by many genes (interactions among genes)
- traits are often affected by environment
- inheritance can be less predictable



Heritability (H^2, h^2)

- Proportion of variance in a phenotype caused by genetic factors.

$$H^2 = V_G/V_P$$

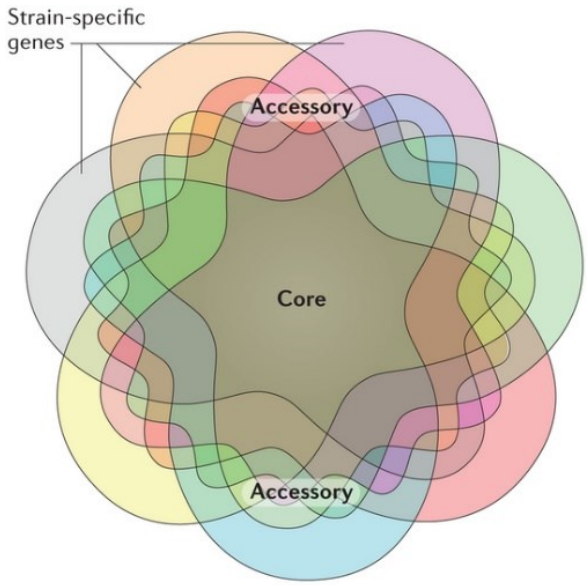
$$V_P = V_G + V_E$$

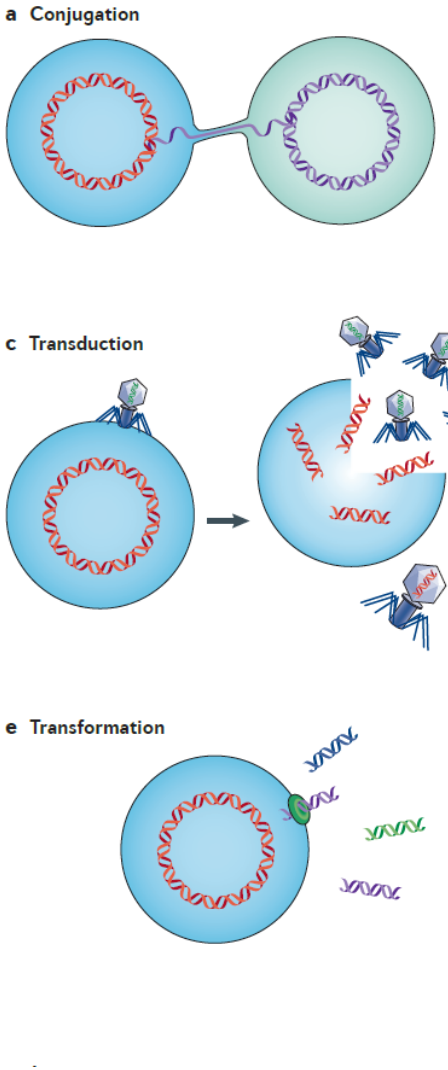
V_P - phenotype
V_G - genotype
V_E - environment

- Range between 0 and 1.
- Traits with higher heritability better respond to selection .

Horizontal gene transfer

- Widespread in prokaryotes
- pangenom = set of all genes of the given taxonomical group





PRESENTATION

PNAS RESEARCH ARTICLE | EVOLUTION OPEN ACCESS

Contingency, repeatability, and predictability in the evolution of a prokaryotic pangenome

Alan J. S. Beavan [a], Maria Rosa Domingo-Sananes [a,b], and James O. McInerney [a,1]

Edited by W. Doolittle, Dalhousie University, Halifax, NS, Canada; received March 27, 2023; accepted November 5, 2023

December 26, 2023 | 121 (1) e2304934120 | https://doi.org/10.1073/pnas.2304934120

Significance

Different strains of the same prokaryotic species often show significant variation in gene content. Whether this variation is due to genetic drift or selection is not well understood. If the latter, we expect sets of genes to be consistently and repeatedly gained or lost together, or sequentially. We used machine learning to predict the presence of variable genes in a large set of *Escherichia coli* strains, using other variable genes as predictors. We find a large proportion of genes are predictable, suggesting selection plays a role in their acquisition, loss, and maintenance. We show that some genes are consistently associated with the presence or absence of others. These results have implications for understanding evolutionary dynamics in prokaryotic genomes.

Horizontal gene transfer

- Less frequent in multicellular organisms.
- Movement of genes from mtDNA to nucleus.
- Transfer of genes from endosymbionts to the host.

Wolbachia → hmyz (např. *Drosophila*), hlístice

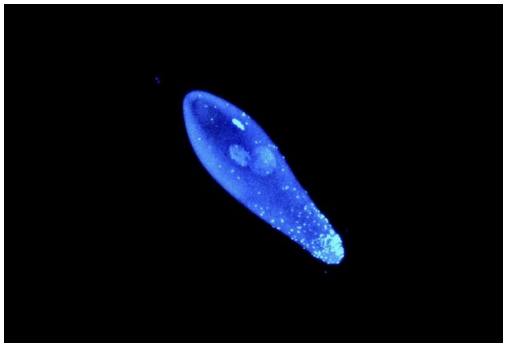
Elysia chlorotica

Acyrthosiphon pisum (aj.) – syntéza karotenoidů (původ: houby)

Sex determination in *Armadillidium*

- *Wolbachia,* can cause feminization of males.
- Horizontal gene transfer from Wolbachia to Armadillidium.
  The transferred Wolbachia genes determine female sex in Armadillidium..

Svinka obecná
Armadillidium vulgare



Wolbachia