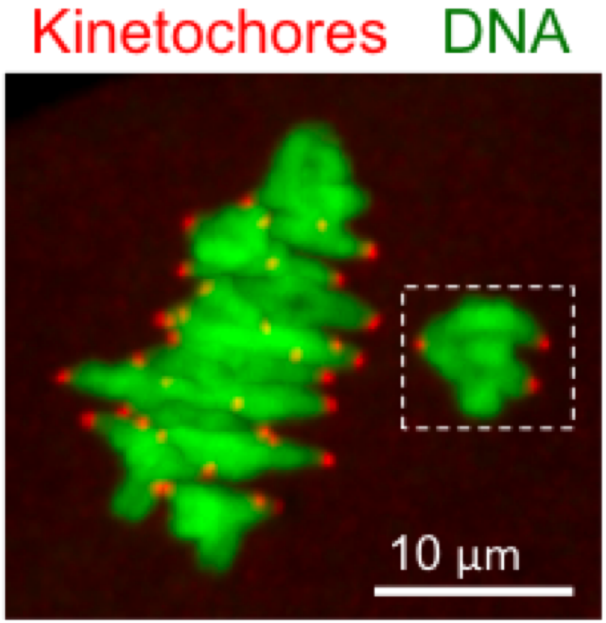
Selfish genetic elements



http://web.sas.upenn.edu/lampson-lab/

"Mendelian inheritance is a marvelous device for making evolution by natural selection an efficient process.... The Mendelian system works with maximum efficiency only if it is scrupulously fair to all genes. It is in constant danger, however, of being upset by genes that subvert the meiotic process to their own advantage." James F. Crow (1979)

The Evolution of Sex Ratio Distorter Suppression Affects a 25 cM Genomic Region in the Butterfly *Hypolimnas bolina*

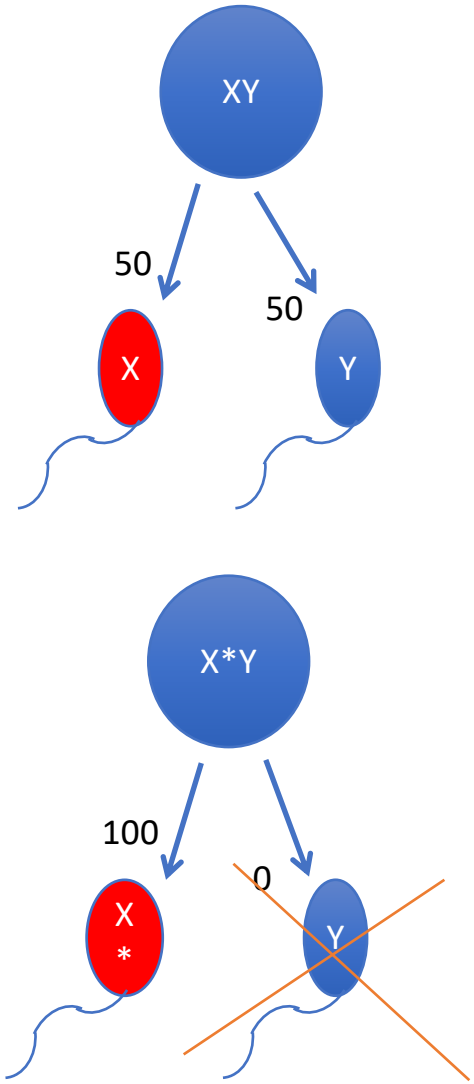
Emily A. Hornett, Bruce Moran, Louise A. Reynolds, Sylvain Charlat, Samuel Tazzyman, Nina Wedell, Chris D. Jiggins, Greg D. D. Hurst

100:1 female-biased sex ratio in 2001 & dating back to 19th C.
to a 1:1 sex ratio by 2006

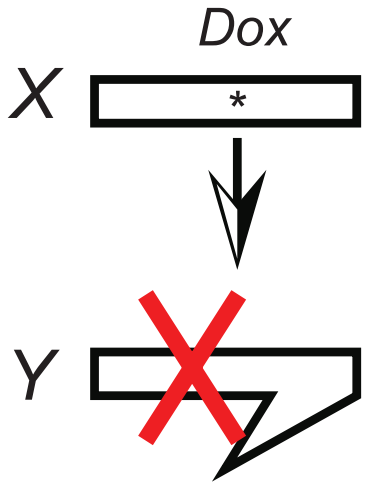
https://en.wikipedia.org/wiki/Hypolimnas_bolina

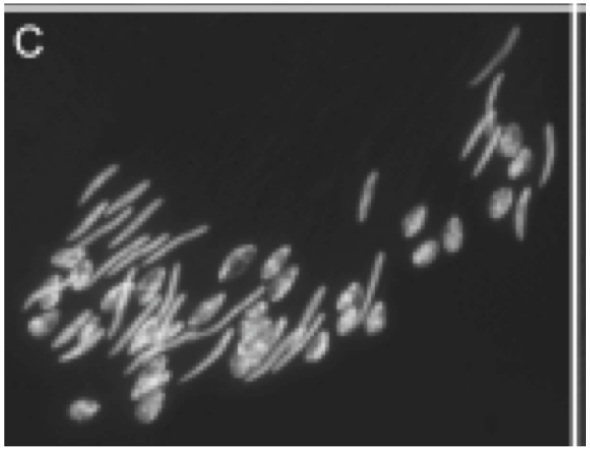
Sex ratio distorters

- The X chromosome of a father is not transmitted to his male offspring.
- Therefore the X chromosome in males can benefit by evolving to damage sperm carrying the Y.



An example of a sex ratio distorter





Winters sex ratio distorter

OPEN ACCESS Freely available online PLOS BIOLOGY

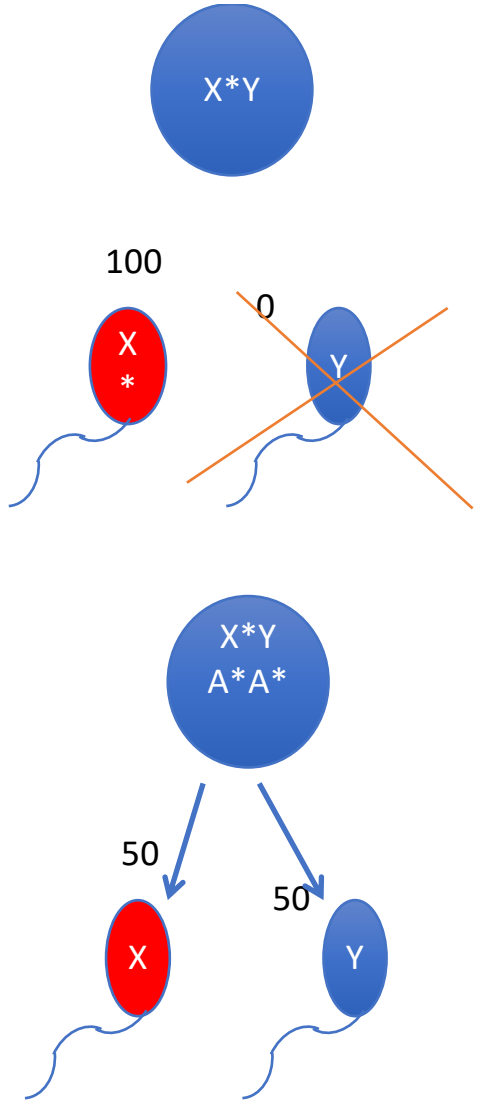
A *sex-ratio* Meiotic Drive System in *Drosophila simulans*. II: An X-linked Distorter

Yun Tao[1,2*], Luciana Araripe[1], Sarah B. Kingan[1], Yeyan Ke[1], Hailian Xiao[2], Daniel L. Hartl[1]

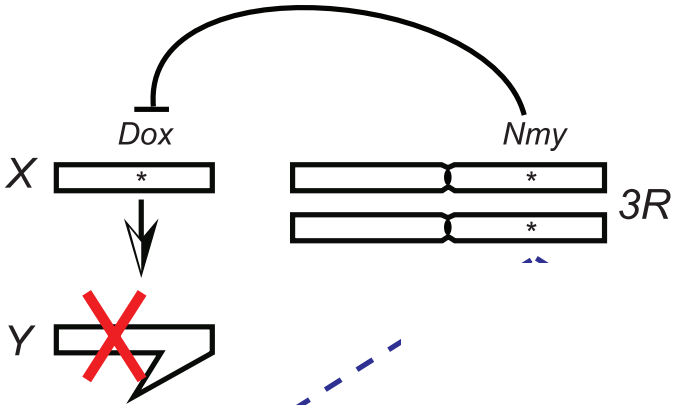
1 Department of Organismic and Evolutionary Biology, Harvard University, Cambridge, Massachusetts, United States of America, **2** Department of Biology, Emory University, Atlanta, Georgia, United States of America

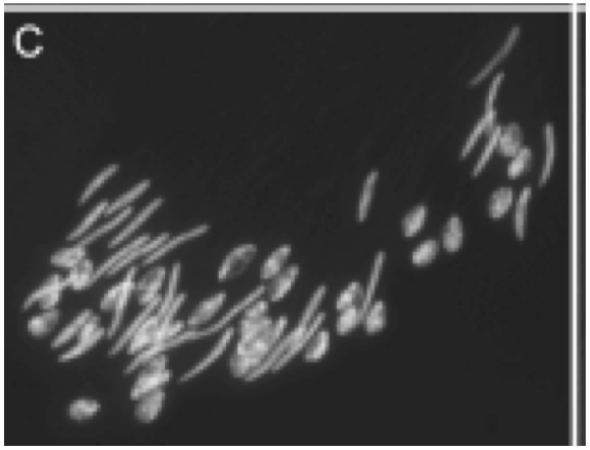
Sex ratio distorters

- Subsequently suppressors of distortion can arise and spread restoring sex ratio to 50/50.
- These occur on the:
- Other sex chromosome (e.g. Y)
- Autosomes
- Systems of drivers and suppressors are frequently uncovered in crosses between species



An example of a sex ratio distorter





Winters sex ratio distorter

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A *sex-ratio* Meiotic Drive System in *Drosophila simulans*. II: An X-linked Distorter

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1 Department of Organismic and Evolutionary Biology, Harvard University, Cambridge, Massachusetts, United States of America, 2 Department of Biology, Emory University, Atlanta, Georgia, United States of America

OPEN ACCESS Freely available online PLOS BIOLOGY

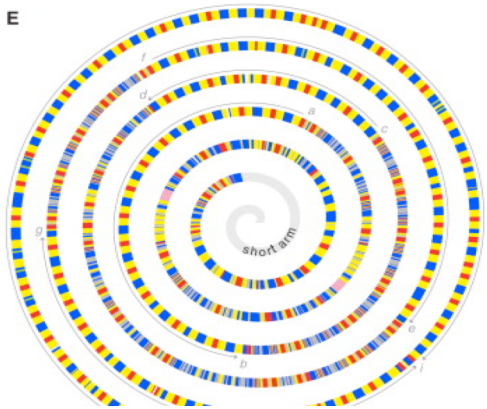
A *sex-ratio* Meiotic Drive System in *Drosophila simulans*. I: An Autosomal Suppressor

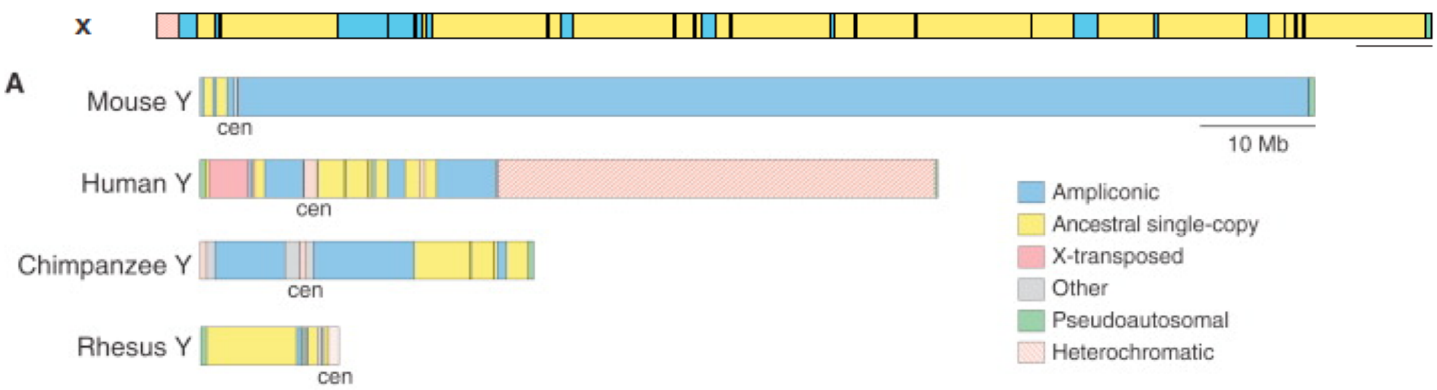
Yun Tao[1,2*], John P. Masly[3¤], Luciana Araripe[1], Yeyan Ke[1], Daniel L. Hartl[1]

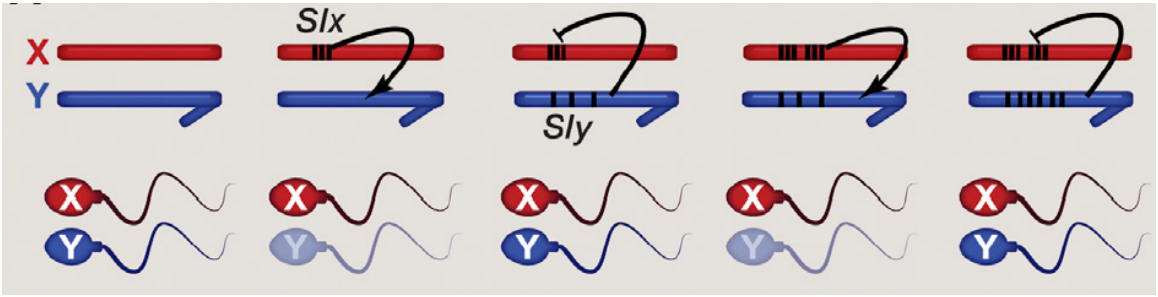
1 Department of Organismic and Evolutionary Biology, Harvard University, Cambridge, Massachusetts, United States of America, 2 Department of Biology, Emory University, Atlanta, Georgia, United States of America, 3 Department of Biology, University of Rochester, Rochester, New York, United States of America

Sequencing the Mouse Y Chromosome Reveals Convergent Gene Acquisition and Amplification on Both Sex Chromosomes

Y.Q. Shirleen Soh,[1,2,7] Jessica Alföldi,[1,2,7,8] Tatyana Pyntikova,[1] Laura G. Brown,[1,3] Tina Graves,[4] Patrick J. Minx,[4] Robert S. Fulton,[4] Colin Kremitzki,[4] Natalia Koutseva,[1] Jacob L. Mueller,[1,9] Steve Rozen,[1,10] Jennifer F. Hughes,[1] Elaine Owens,[5] James E. Womack,[5] William J. Murphy,[5] Qing Cao,[6] Pieter de Jong,[6] Wesley C. Warren,[4] Richard K. Wilson,[4] Helen Skaletsky,[1,3] and David C. Page[1,2,3,*]







Selfish Genetic Elements: selection below the individual

Other forms of selfish elements:

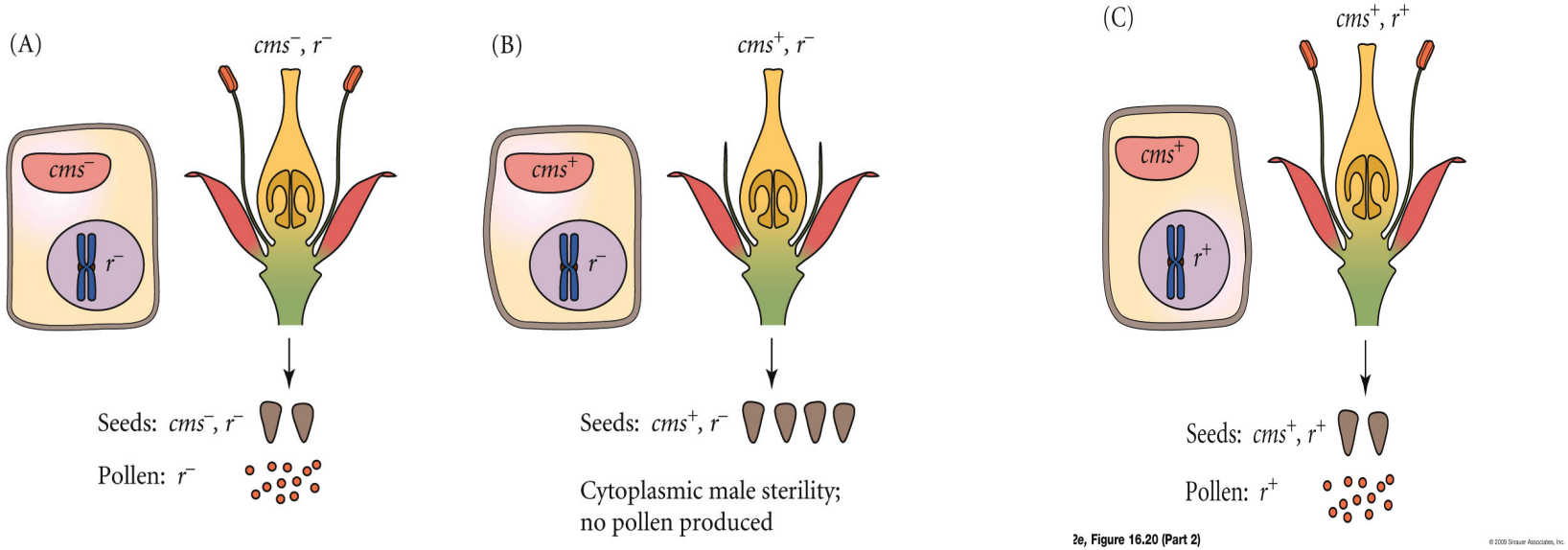
X-killing Y chromosomes
Autosomal killer systems:
T-allele in mouse
Segregation distortion system in Drosophila

Selfish centromeres in female meiosis.
Mitochondria cytoplasmic male sterility in hermaphrodite plants

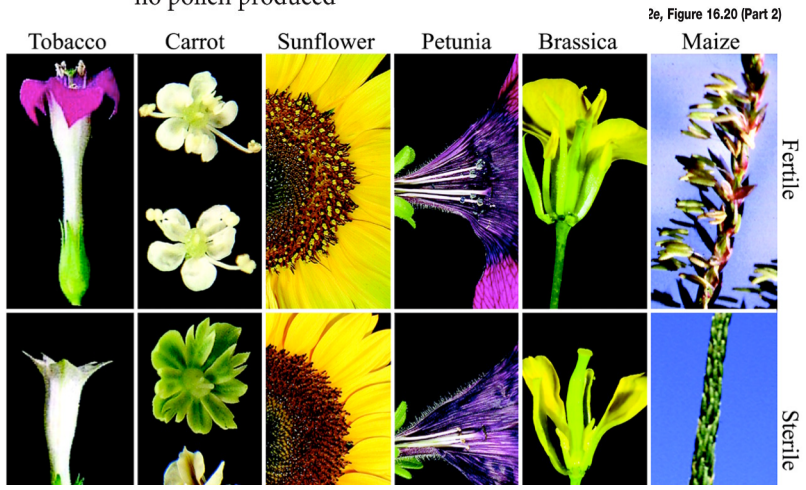
Transposable elements.

Cancer

cytoplasmic male sterility (CMS) in plants

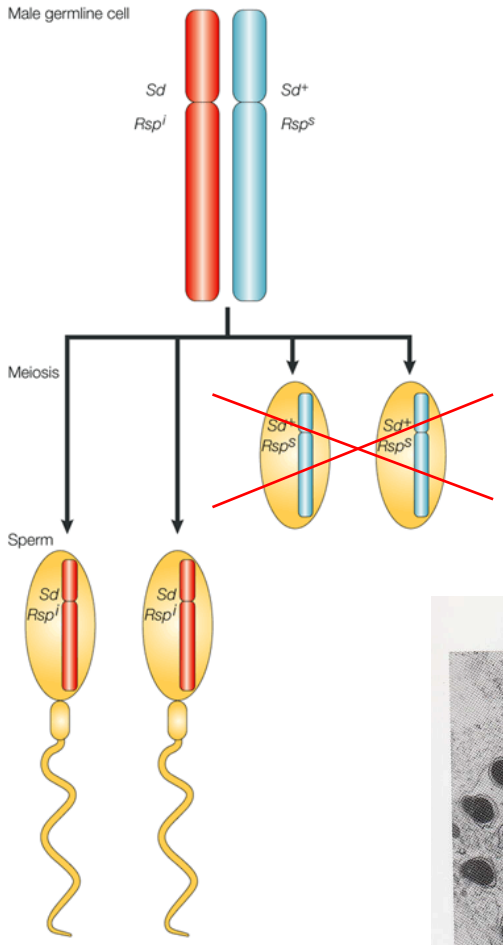


***EVOLUTION 2e*, Figure 16.20 (Part 1)**



http://www.plantcell.org/content/16/suppl_1/S154.full

Photographs: G. Brown (Brassica), P. Simon (carrot), R. Wise (maize), and K. Glimelius (tobacco).

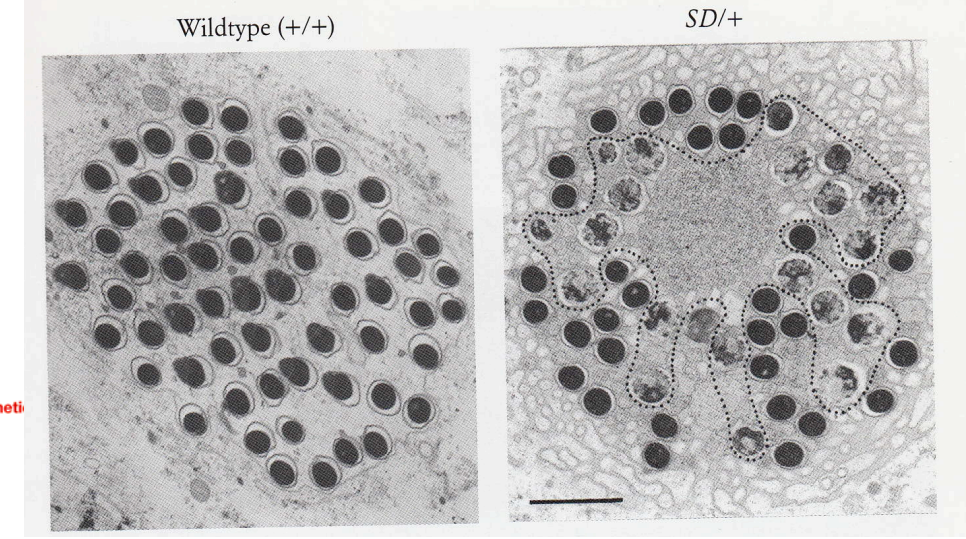


Autosomal killer system: Segregation distortion in *D. melanogaster*

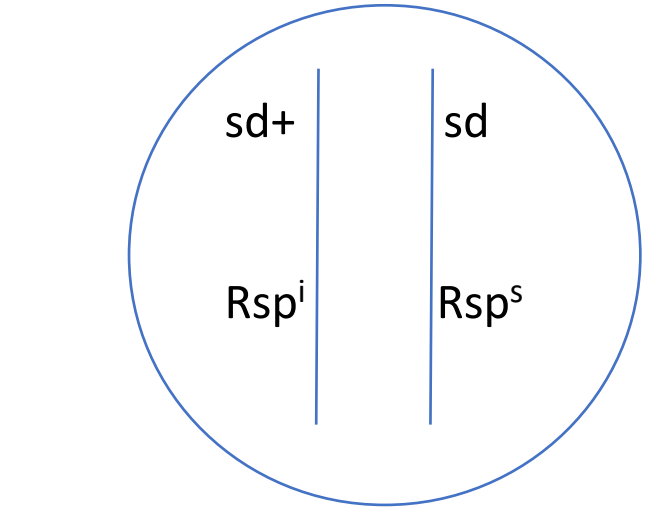
Sd sperm poison Sd^+ sperm in a heterozy.

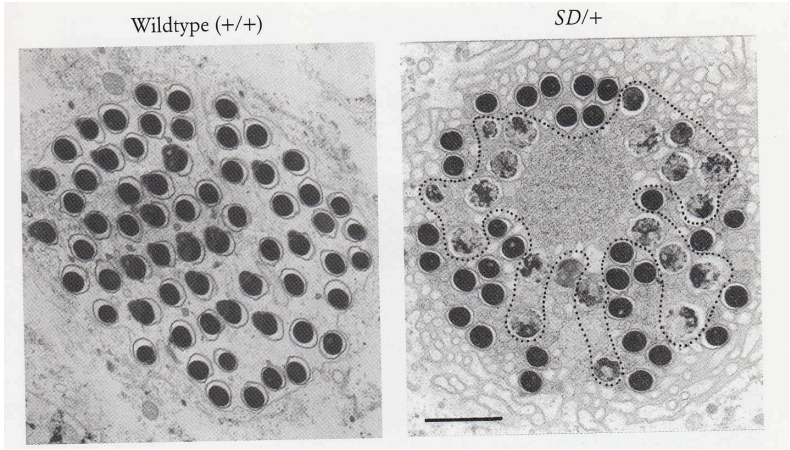
However, Sd/Sd homozygotes are mostly sterile.

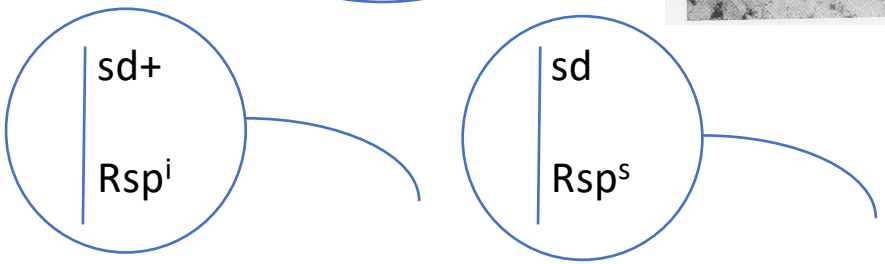
Segregation-distorter allele balanced
At 5% in D. melanogaster



Autosomal killer system: Segregation distortion in *D. melanogaster*

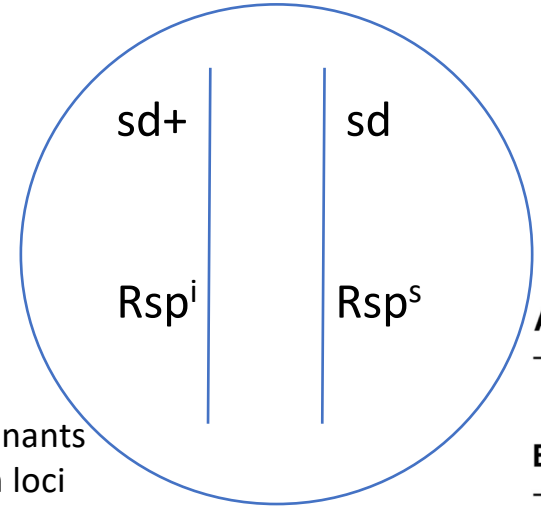




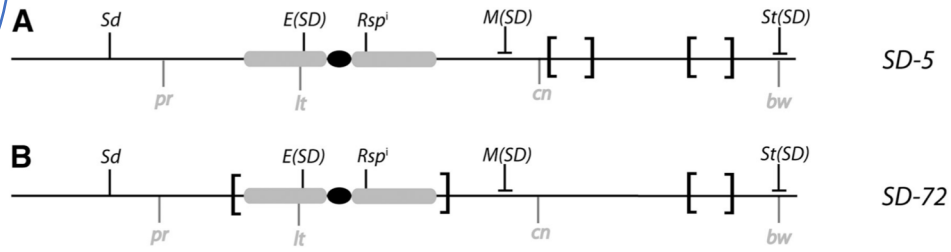


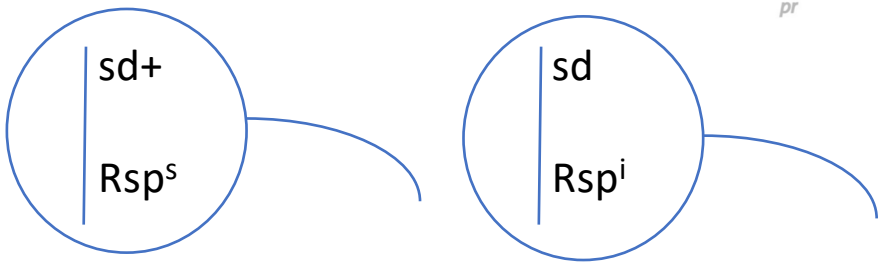
sd produces a protein that targets Rsp^i repeat

Autosomal killer system: Segregation distortion in *D. melanogaster*



Recombinants between loci





sd produces a protein that targets Rsp^i repeat

The Selfish *Segregation Distorter* Gene Complex of *Drosophila melanogaster*

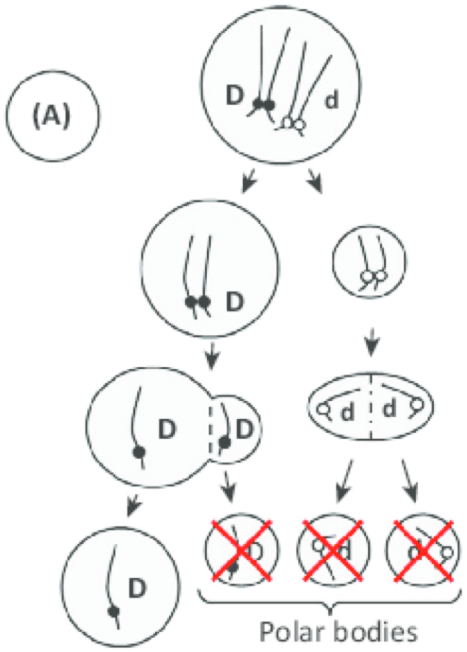
Amanda M. Larracuente, Daven C. Presgraves

GENETICS *September 1, 2012 vol. 192 no. 1 33-53; DOI: 10.1534/genetics.112.141390*

Centromere-Associated Female Meiotic Drive Entails Male Fitness Costs in Monkeyflowers

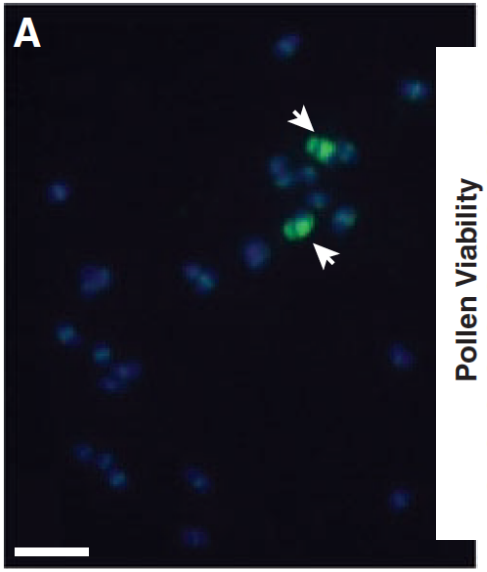
Lila Fishman* and Arpiar Saunders†

Female meiosis

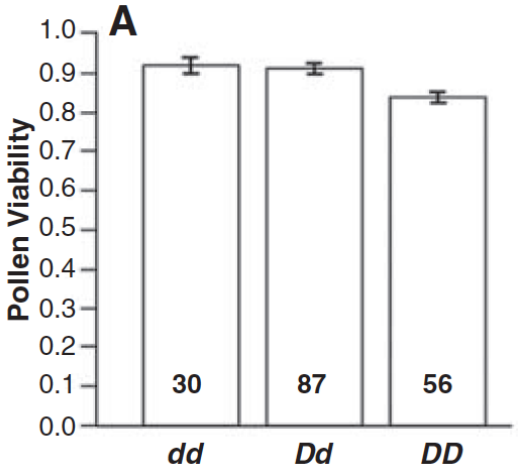


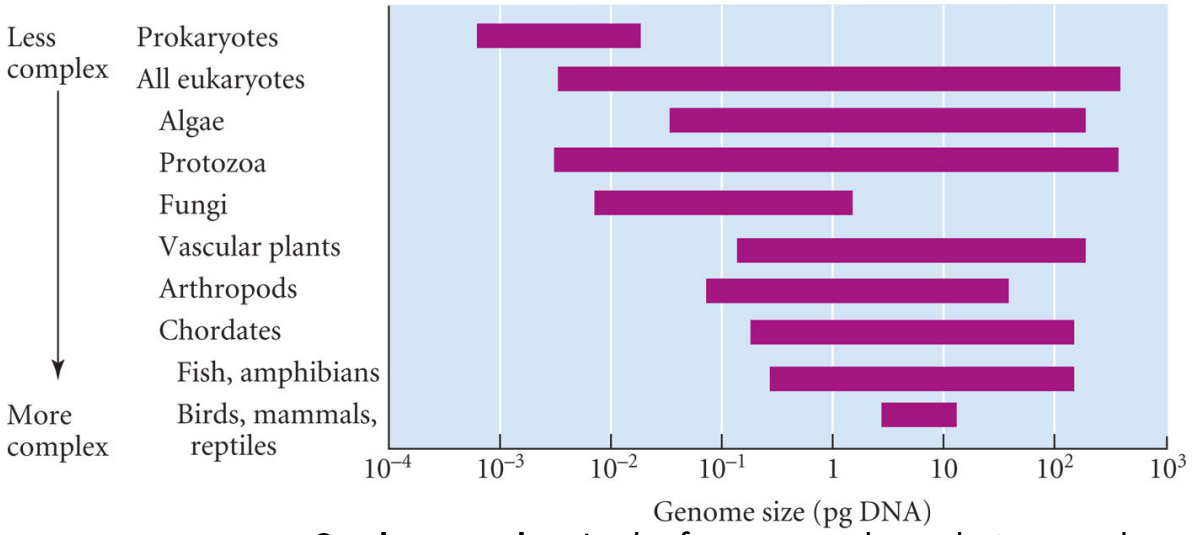
D/d
50/50
98/2

Lindholm et al



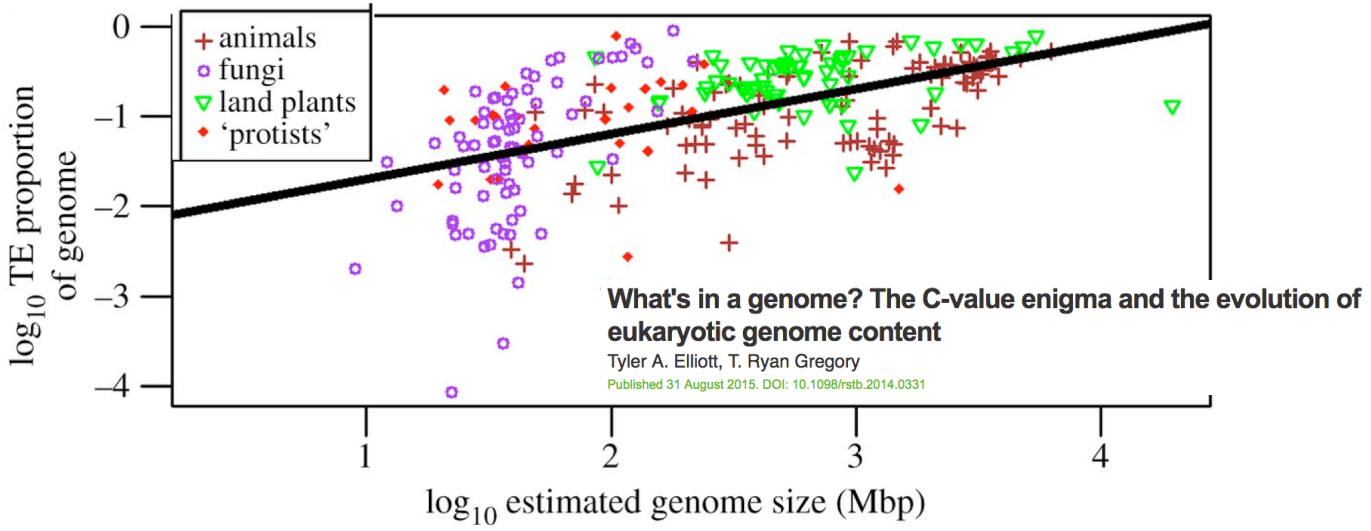
Cost in males





EVOLUTION 3e, Figure 3.26

C-value paradox: Lack of correspondence between phenotypic complexity of eukaryote organisms and the size of the genome.

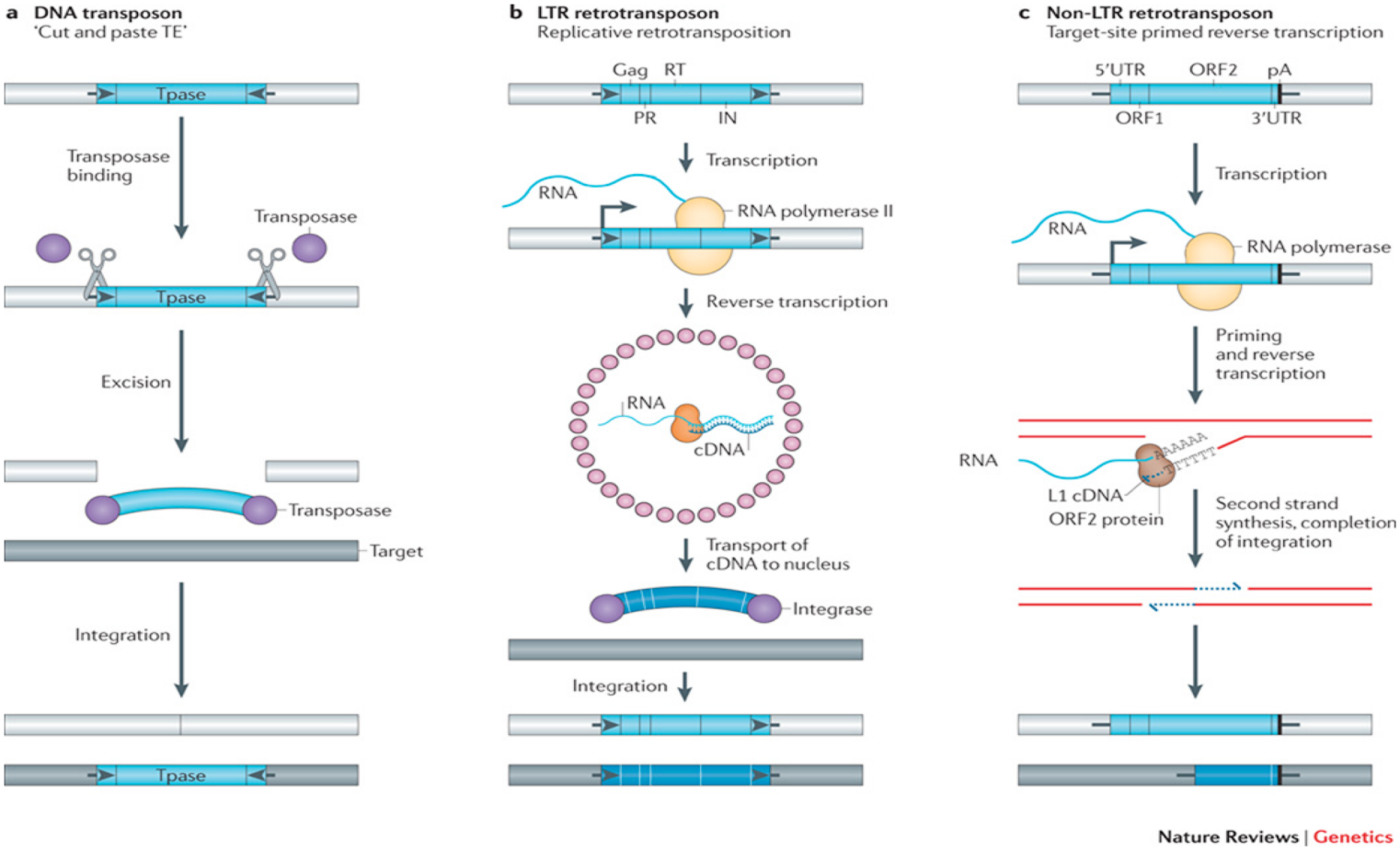


What's in a genome? The C-value enigma and the evolution of eukaryotic genome content

Tyler A. Elliott, T. Ryan Gregory

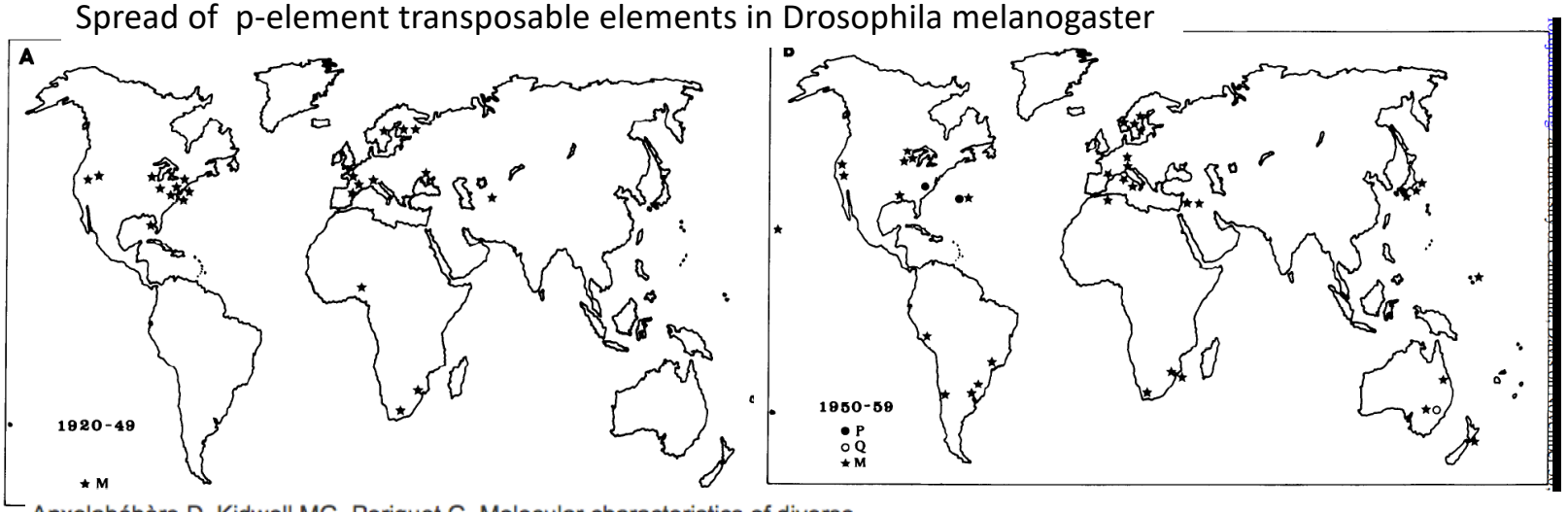
Published 31 August 2015. DOI: 10.1098/rstb.2014.0331

Various transposable elements have evolved that have elaborate ways to propagate themselves through genomes. Hosts have many ways to try and stop them



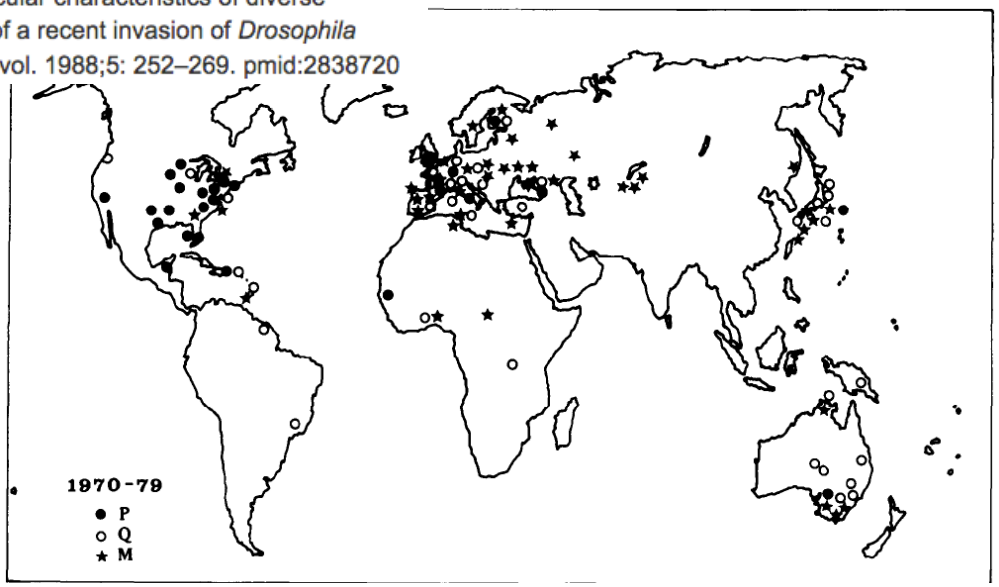
Nature Reviews | Genetics

Spread of p-element transposable elements in Drosophila melanogaster

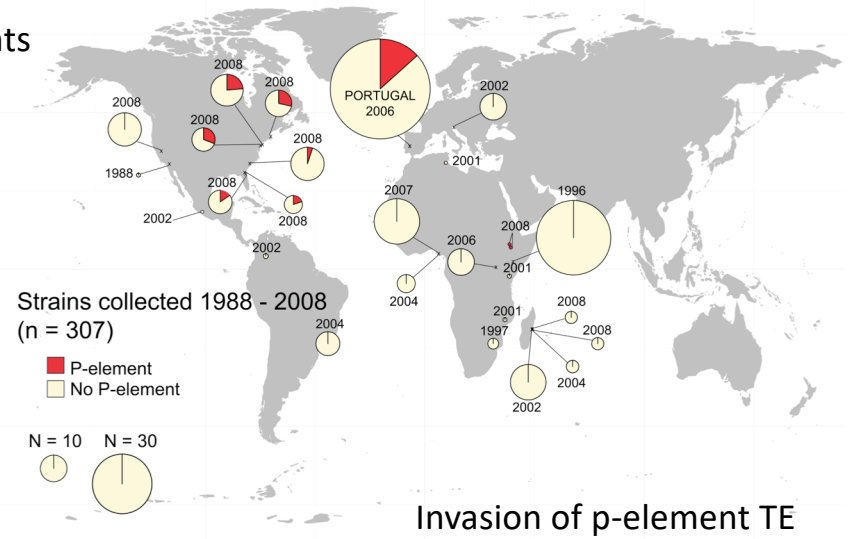


Anxolabéhère D, Kidwell MG, Periquet G. Molecular characteristics of diverse populations are consistent with the hypothesis of a recent invasion of *Drosophila melanogaster* by mobile P Elements. Mol Biol Evol. 1988;5: 252–269. pmid:2838720

M no p-elements
P/Q p-elements present



Spread of p-element transposable elements

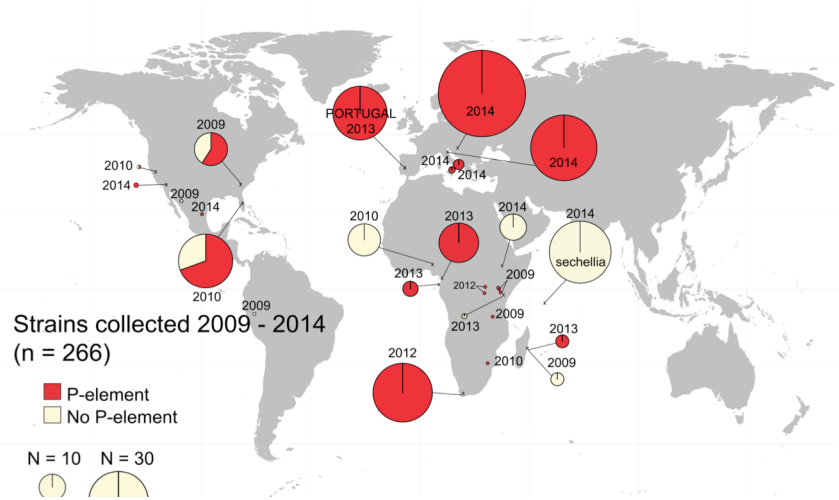


Invasion of p-element TE
In *Drosophila simulans*

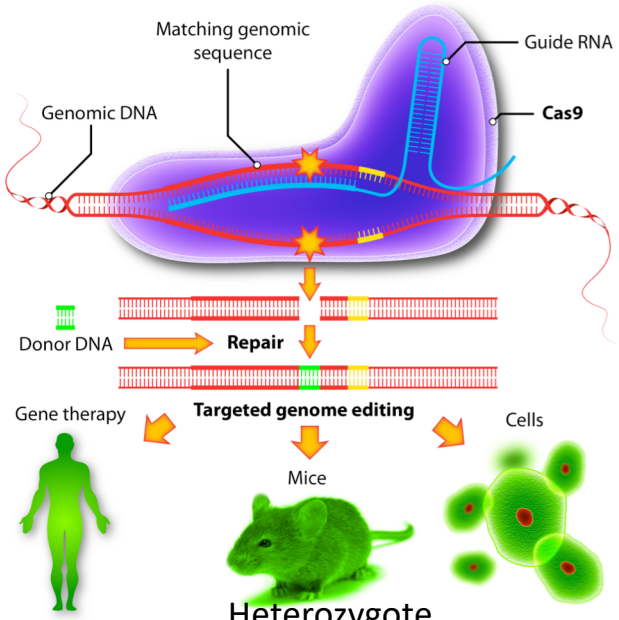
Hybrid Dysgenesis in *Drosophila simulans* Associated with a Rapid Invasion of the *P*-Element

Tom Hill, Christian Schlötterer, Andrea J. Betancourt

Published: March 16, 2016 • http://dx.doi.org/10.1371/journal.pgen.1005920



But TEs not truly “spiteful”



CRISPR-Cas9

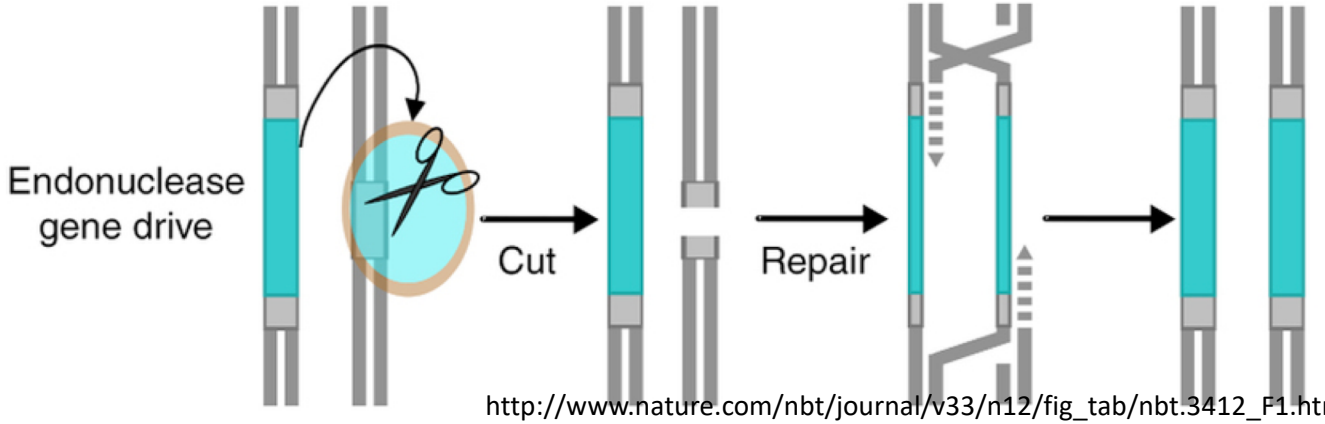
Very precise method for genome-editing

Emmanuelle Charpentier & Jennifer Doudna

Heterozygote for insertion

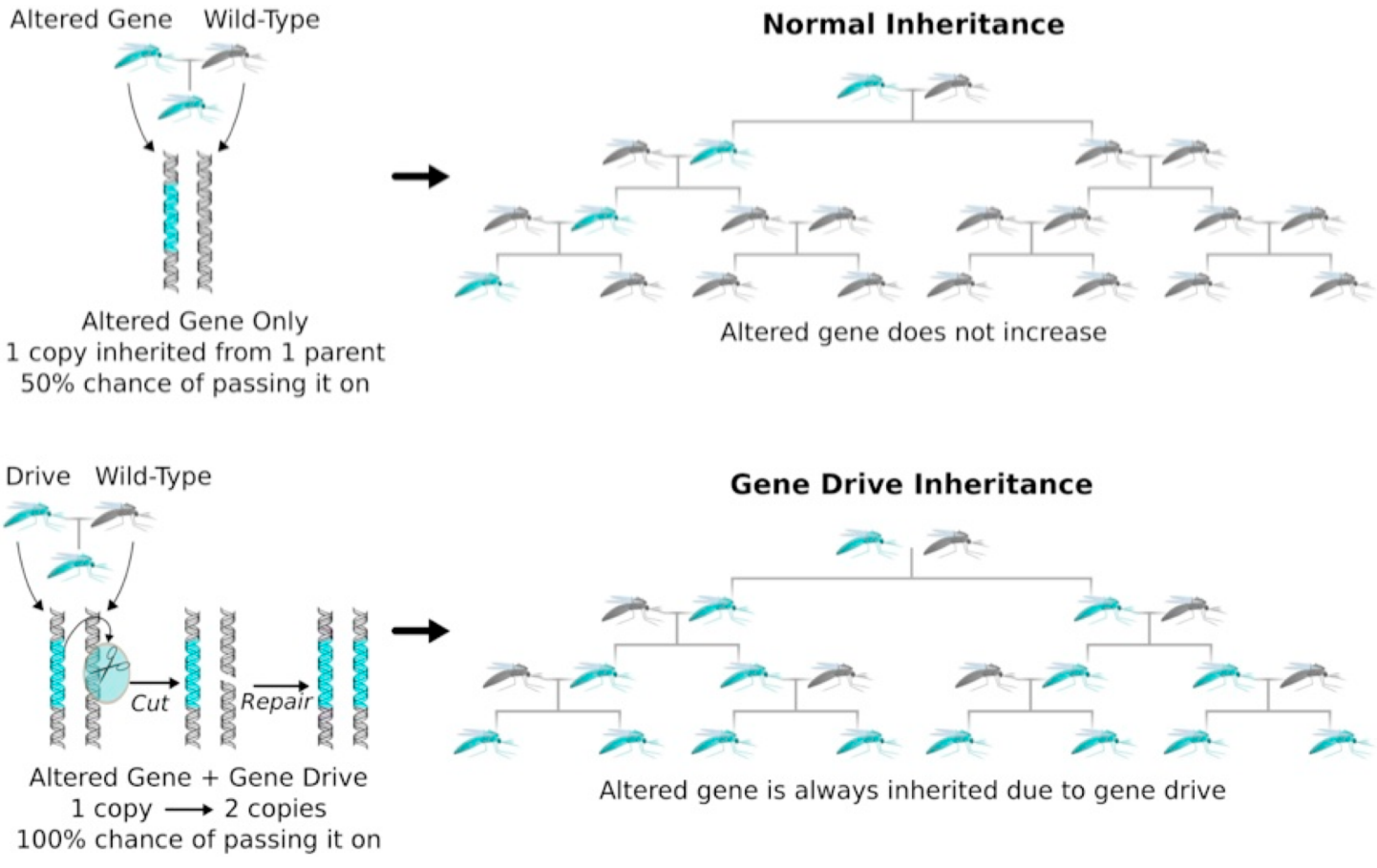
Homozygote for insertion

a

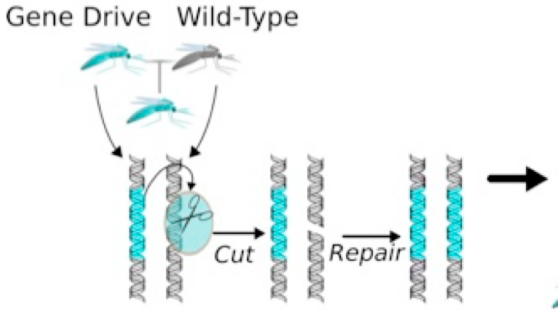


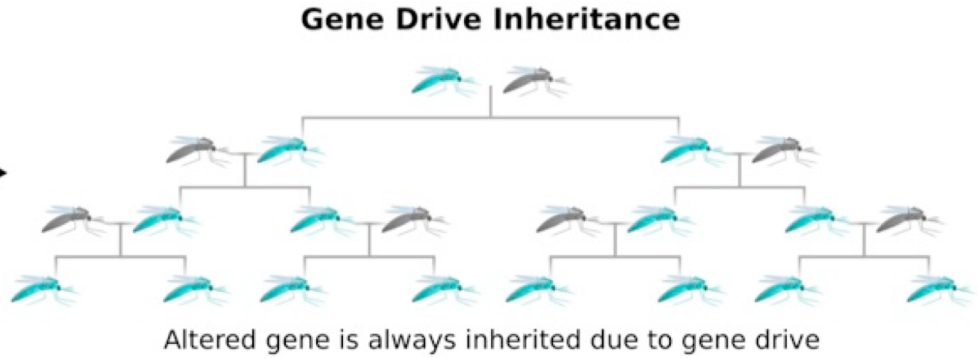
http://www.nature.com/nbt/journal/v33/n12/fig_tab/nbt.3412_F1.html

CRISPR-based Gene drive



CRISPR-based Gene drive





Panel Endorses 'Gene Drive' Technology That Can Alter Entire Species

By **AMY HARMON** JUNE 8, 2016

mosquitoes infecting native Hawaiian birds with malaria

weed (e.g. Palmer amaranth) that has become resistant to herbicides and cause huge problems for some farmers.

Mosquitoes (*Aedes aegypti*) to control zika/malaria