Speciation: Genetic control

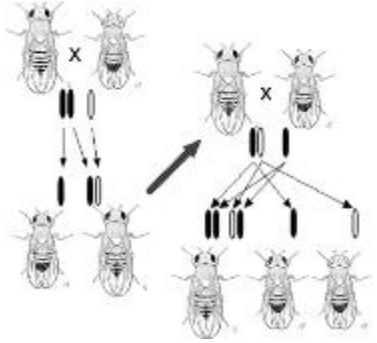
Some big questions on origin of species

- Why do these clusters not “fuse”- why don’t we see all the intermediates?
- How does geography affect species formation?
- **What is the genetic basis of species formation?**

Genetics of species formation = genetics of barrier traits

- By knowing genetic differences between species causing barrier traits, can see genetics of species formation

- … but can’t do genetics between species (easily) since, by definition, can’t do a “genetic cross”…

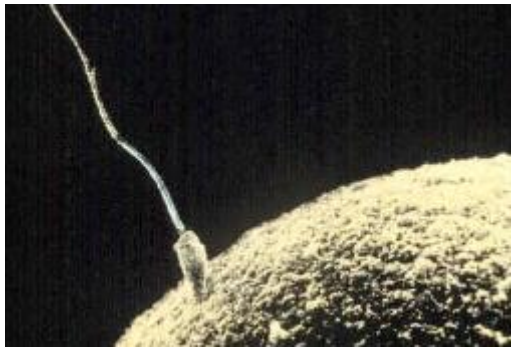


Get around this problem using incompletely separated species

- Again, barriers are not always “perfect”, and sometimes weaker in lab than in nature
- Often one sex is sterile/ dead, and can study the genetic basis of this by crosses to the other sex

Why are hybrids sterile???

- Hybrids only have the alleles of their parent species
- No gene “functions” to cause sterility
  - More likely disruption of a normal function
- Likely **interactions between allele(s) from one species with allele(s) from the other**
- Can *map* sterility within the genome through QTL mapping



Single gene speciation is very difficult

- Imagine heterozygotes (Aa) sterile
- Starting (ancestor) population AA
- What happens when mutation to “a” first arises?

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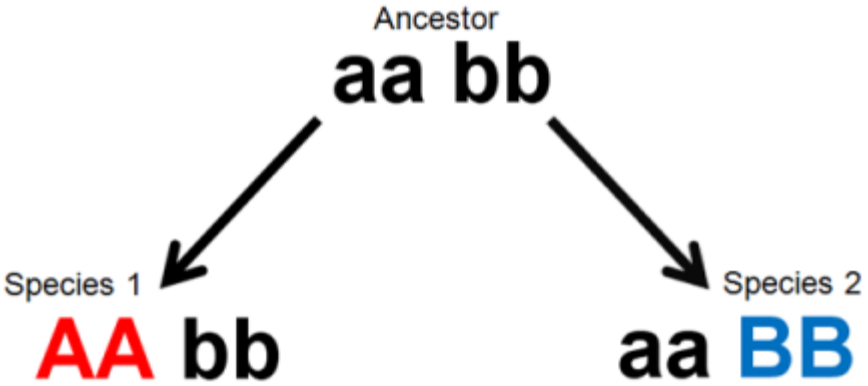
- **Underdominance**
  - Selection favors loss of rare allele

Workaround: epistasis between two (or more) loci

- “A” allele interacts with “B” allele to cause hybrid sterility



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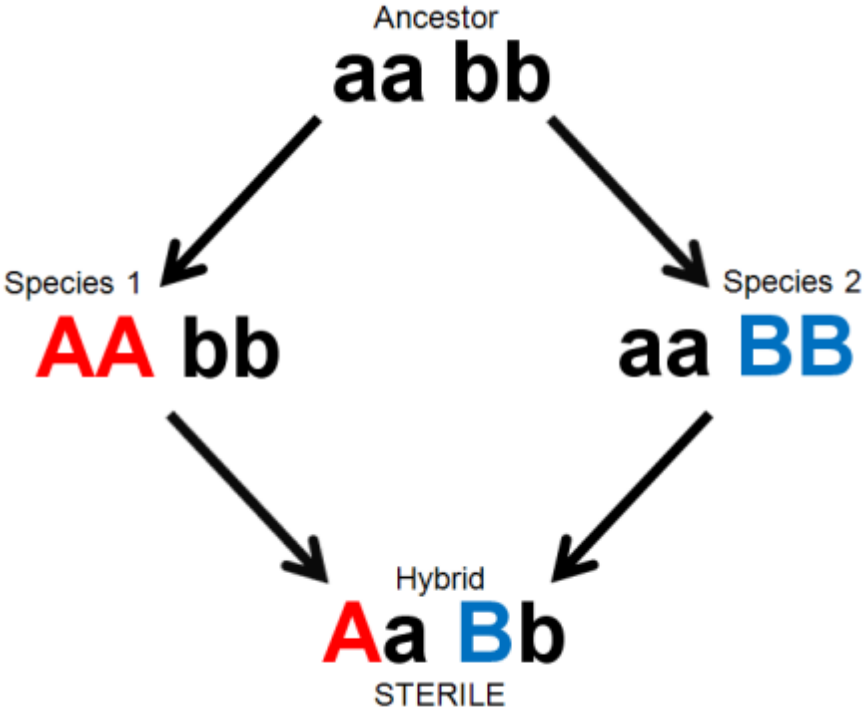
T. Dobzhansky



H.J. Muller

One big observation

- When one hybrid sex is sterile or inviable, it tends to be the XY sex!
  - Haldane's Rule (1921)
- One of the most consistent rules in evolutionary biology

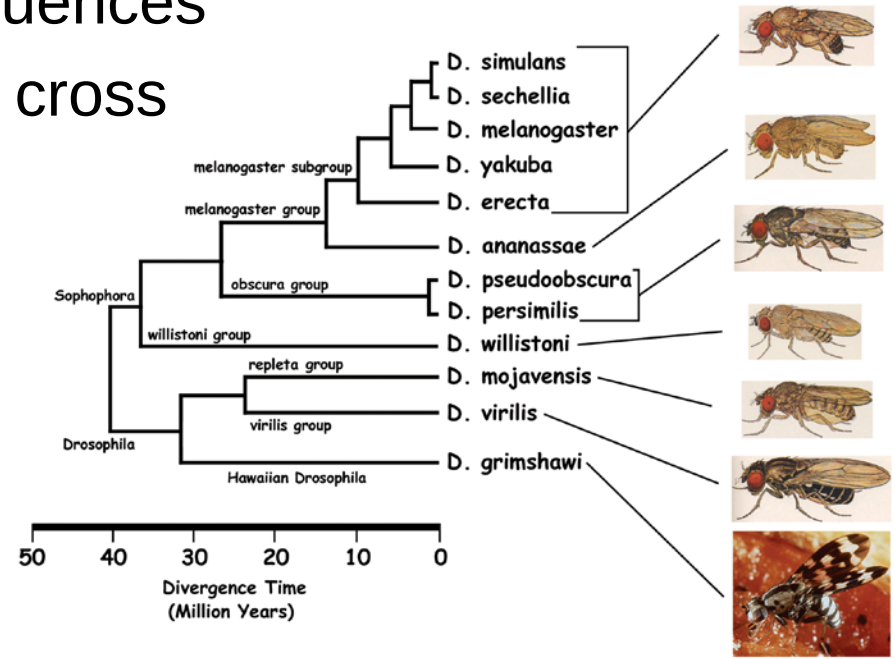
Explanation deciphered in last 20 years…

- Sex-chromosomes play a role

- 2-locus epistasis involving the **X-chromosomes** and **autosomes** causes hybrid sterility (and many other hybrid problems)

Workhorses of genetics: Drosophila fruit flies

- Thousands of species, including many recently diverged
- Genome sequences
- Easy to rear/ cross



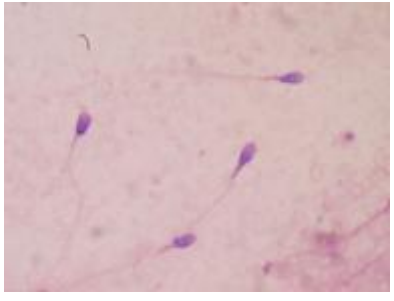
Evidence of natural selection!

- When we look at the genes causing hybrid sterility or hybrid inviability and apply tests (e.g., McDonald-Kreitman), we get a strong signature of directional selection.
- *Nup96*- causes inviability in hybrids of D. melanogaster/ D. simulans- example

	Within Sp	Between Sp
Nonsynonymous	27	27
Synonymous	108	34
		P=0.00056

… but why did natural selection cause genes to change in such a way as to make hybrids sterile?

- **Not** direct effect - incidental
- Big contributor may be for competitiveness in fertilization relative to other males - females of many species mate multiple times



Darwin was right!

- Hybrid sterility “is not a specially endowed quality, but is incidental on other acquired differences,” (p. 245) and is caused by a hybrid's “organization having been disturbed by two organizations having been compounded into one” (p. 266).

- Natural selection appears to be a major contributor.
- Also a major contributor to other barrier traits.

Quick recap:

- Sterility often results from an interaction between genes on the “X” and genes on autosomes.

- Recessivity of genes on X creates Haldane’s Rule

- Natural selection seems to be involved in driving these gene forms.

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IMPLICATIONS:

- Human-induced habitat destruction is reducing the number of species worldwide
  - Bad for humans in part because increases vulnerability to flood & drought, crop failure, spread of disease, and water contamination
- This research looks at the other end of the process: species formation → extinction

IMPLICATIONS:

- Not just losing existing species, but losing species that were “just beginning to form”
  - Lake Victoria cichlids choose mates by coloration
  - Turbidity (human-induced) in water reducing mate choice, so now mating more at random
  - Species that would have formed, now won’t…

Cyanobacteria,
Algal blooms, etc.

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