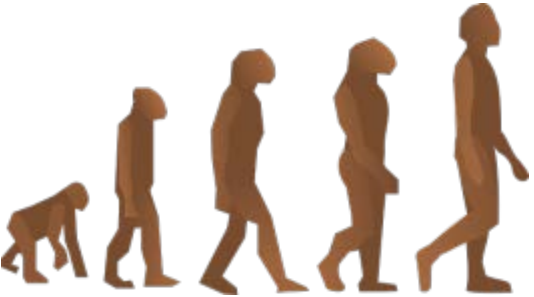
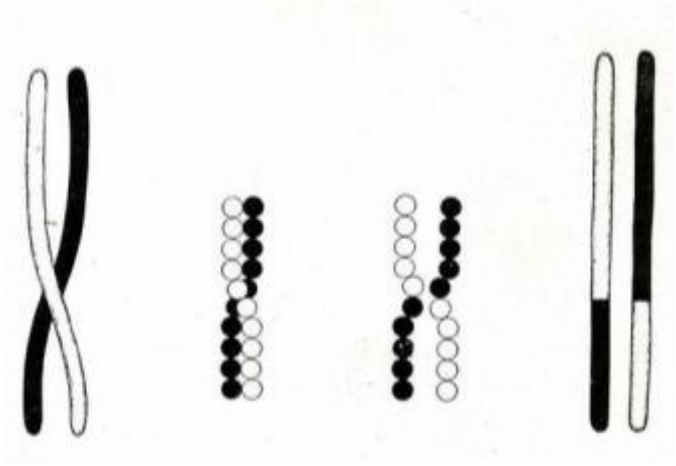
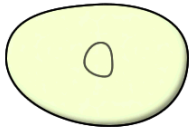
Evolutionary advantages of sex and recombination



Today's Subtitle: **Still more reasons that recombination rocks!**

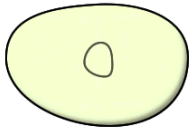


Asexual reproduction vs. sexual reproduction



- Asexual reproduction: fission, budding, parthenogenesis (offspring from unfertilized eggs)
  - Produces “clones”, genetically identical
- Sexual reproduction: union of genetic material from two distinct gametes
  - Genetic material then shuffled in their gametes by…

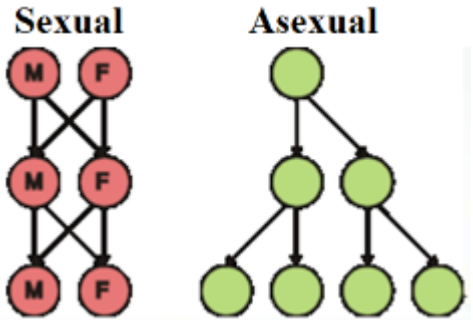
Asexual reproduction vs. sexual reproduction



- Asexual reproduction: fission, budding, parthenogenesis (offspring from unfertilized eggs)
  - Produces “clones”, genetically identical
- Sexual reproduction: union of genetic material from two distinct gametes
  - Genetic material then shuffled in their gametes by **recombination**!!!

Benefits of asexual reproduction

- With asexual reproduction, every individual can make babies directly
  - With sexual, just female
- With asexual reproduction, no need to “find mates”
  - With sexual, need mates
- With asexuality, offspring get **all** your genes
  - With sexual, half



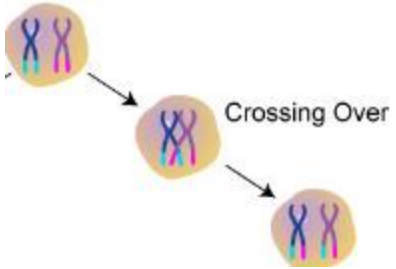
BUT, sexual reproduction is very common…

- In many animal, plant, and fungal species, we see only sexual reproduction

- In those that **do** have asexual reproduction, it's often not complete
  - Will, every few generations, reproduce sexually

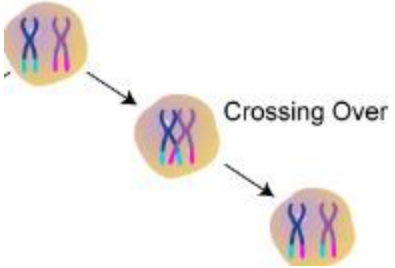
- **Many benefits of asexuality…**
  why sex common?

The benefits come from recombination!



- **REASON 1:** Recombination makes **combinations of alleles** across two or more loci that may be **advantageous**.
  - *Especially* important with epistasis (interactions between loci) favoring a specific combination of alleles at the two loci

The benefits come from recombination!



- **Example- advantageous combination**

  Starting population aabb. Best genotype has A & B

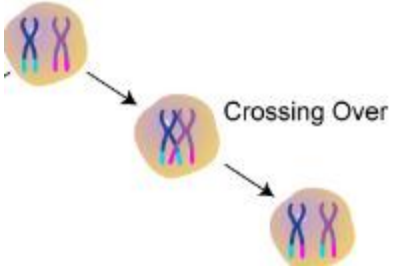
  Mutations a to A rare

  Mutations b to B rare

  aabb aaBb aabb aabb aabb aabb Aabb

  Aabb aabb aabb aabb aaBb aabb aabb

The benefits come from recombination!



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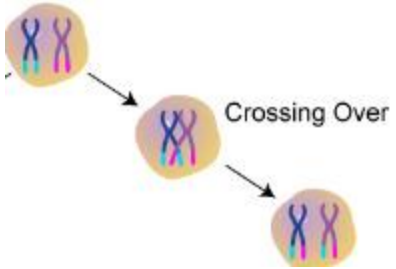
  How would put genotype AaBb together???

The benefits come from recombination!



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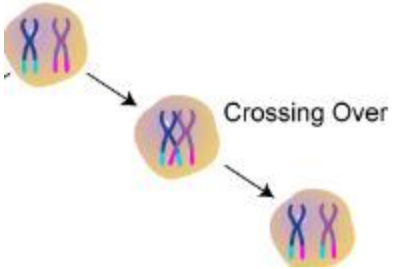
  How would put genotype AaBb together???

  Without recombination, need to wait a long time…

  RECOMBINATION ACCELERATES ADAPTATION!

The benefits come from recombination!



- **REASON 2:** Recombination helps get rid of bad mutations to create mutation-free offspring.

Without recombination, mutations accumulate…

Generation 0 

Number of deleterious mutations per individual that generation

Generation 10

Generation 20

Generation 30

Generation 40

/ = mutation

Without recombination, mutations accumulate…

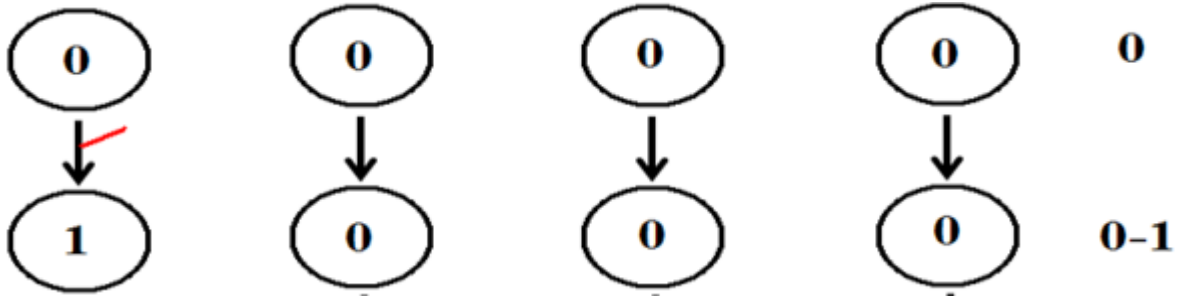
Generation 0

Generation 10

Generation 20

Generation 30

Generation 40



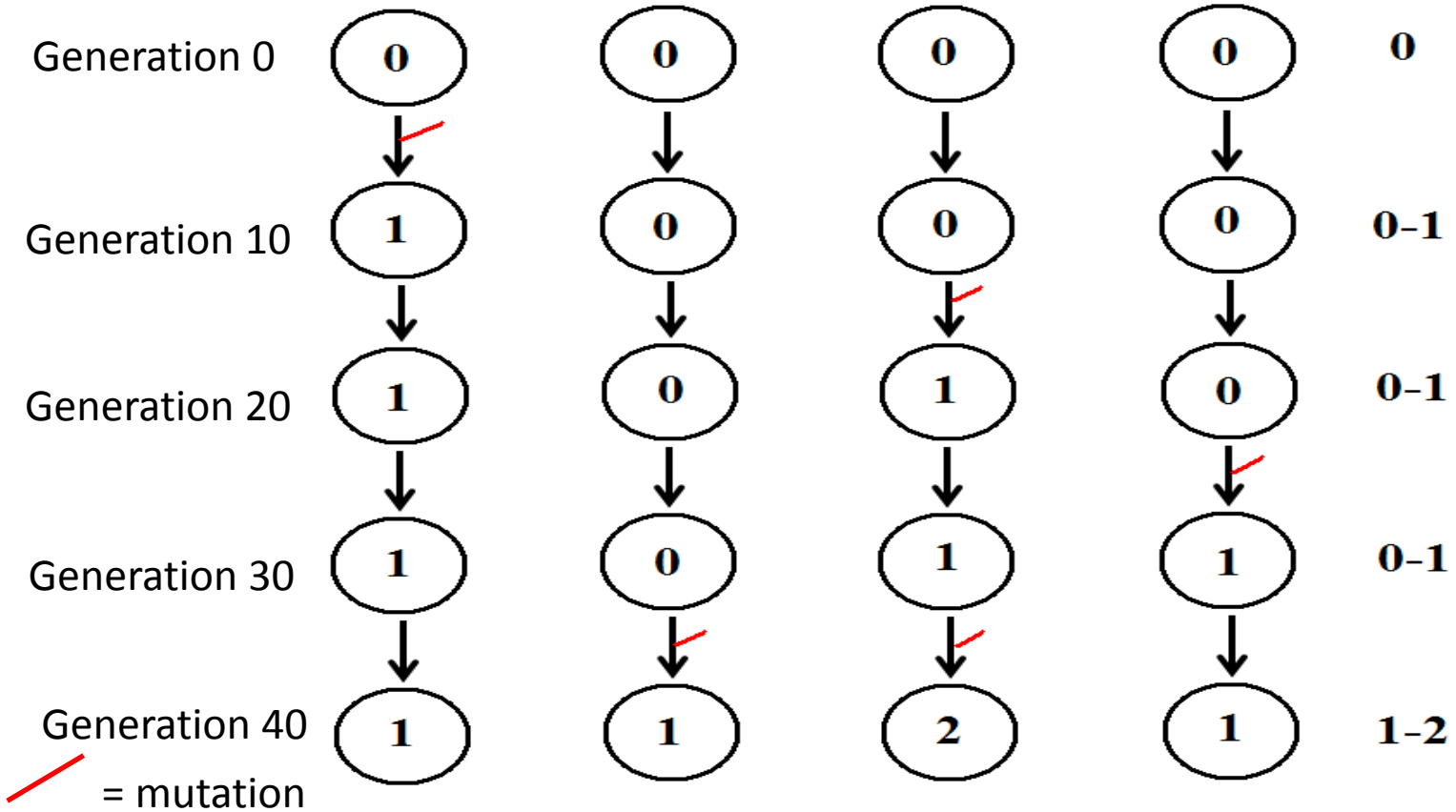
0

0–1

Number of deleterious mutations per individual that generation

/ = mutation

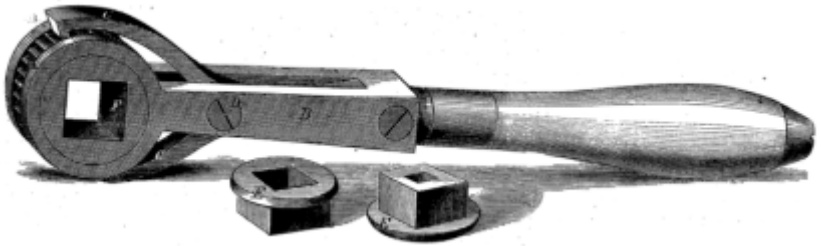
Without recombination, mutations accumulate…



… and the population gets worse (sicker) and worse every generation

- After lose zero-mutation group, population continues to get worse, and all individuals have more and more mutations

- Process called “Muller’s ratchet”



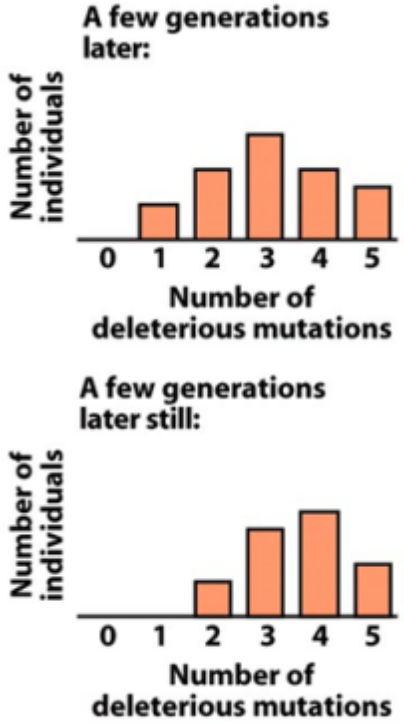


Figure 8-20 Evolutionary Analysis, 4/e

… but WITH recombination, get *some* offspring without bad mutations

AaBbccdd x aabbCcDd 2

Red = bad mutation

… but WITH recombination, get *some* offspring without bad mutations

AaBbccdd x aabbCcDd 2

Some worse:	AaBbCcDd	4
Some comparable:	AabbccDd	2
Some **better**:	aabbccdd	0!

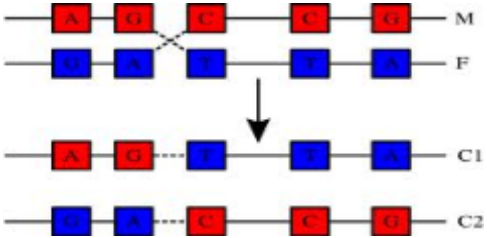
Better ones have more offspring, and population is healthier!

Zero-mutation class can be "re-created" with recombination.

Red = bad mutation

Overall, recombination is good…

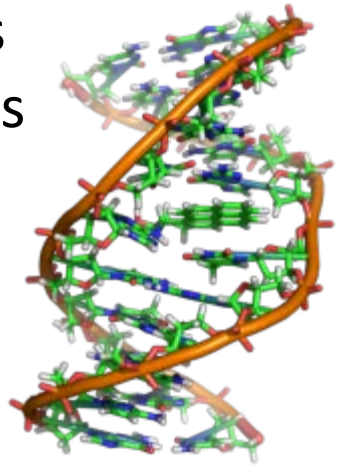
- Despite many costs of sex
  - Recombination can produce advantageous combinations of alleles
  - Recombination can accelerate adaptation
  - Recombination allows the population to “unload” itself from bad mutations (stopping the “ratchet”)
  - Recombination may be *particularly* helpful in variable environments



… but how does recombination affect molecular evolution?

- We've shown recombination
  - Can combine good mutations
  - Helps selection get rid of bad mutations from a population

- But what about how it affects variation in **neutral** sequences (have no effect on fitness)



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