Chapter 23—The Evolution of Populations

Due to chance and sorting…

Genetic Variation within a Population

Individuals are selected, but populations evolve

I. Population Genetics

- Modern Synthesis (neo-Darwinism—1940s)
  - Integration of natural selection & Mendelian inheritance (genetics)

  - Comprehensive theory of evolution emphasizing:
    - Natural selection
    - Gradualism
    - Populations as the units of evolutionary change

Population Genetics: genetic changes in populations

- Evolution of populations is really measuring changes in allele frequency
  - all the alleles in a population = <u>gene pool</u>
  - <u>allele frequency</u> = how many **A vs. a** in a population
    - (A = .40, a = .60)
- Factors that alter allele frequencies in a population:
  - natural selection
  - genetic drift (chance events)
    - founder effect
    - bottleneck effect
  - gene flow (migration)
  - mutation

(we'll return to these later. ☺)

Hardy-Weinberg equilibrium

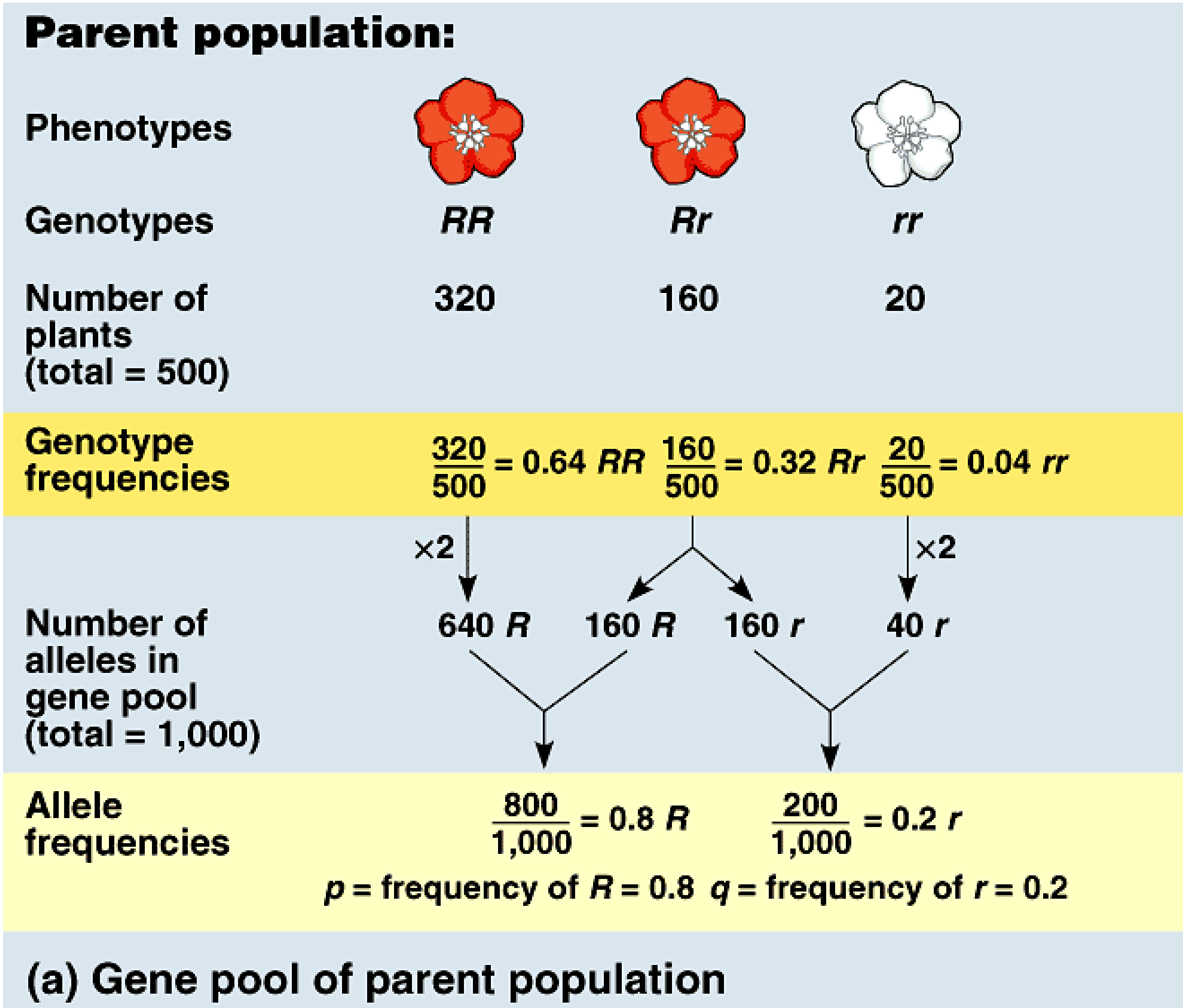
- **<u>Hypothetical</u>, <u>non-evolving</u> population**
  - **preserves allele frequencies (no changes!)**
  - **useful model to measure if forces are acting on a population**
    - **(Is evolution happening?)**

  - **natural populations <u>rarely</u> in H-W equilibrium (because they are evolving!)**

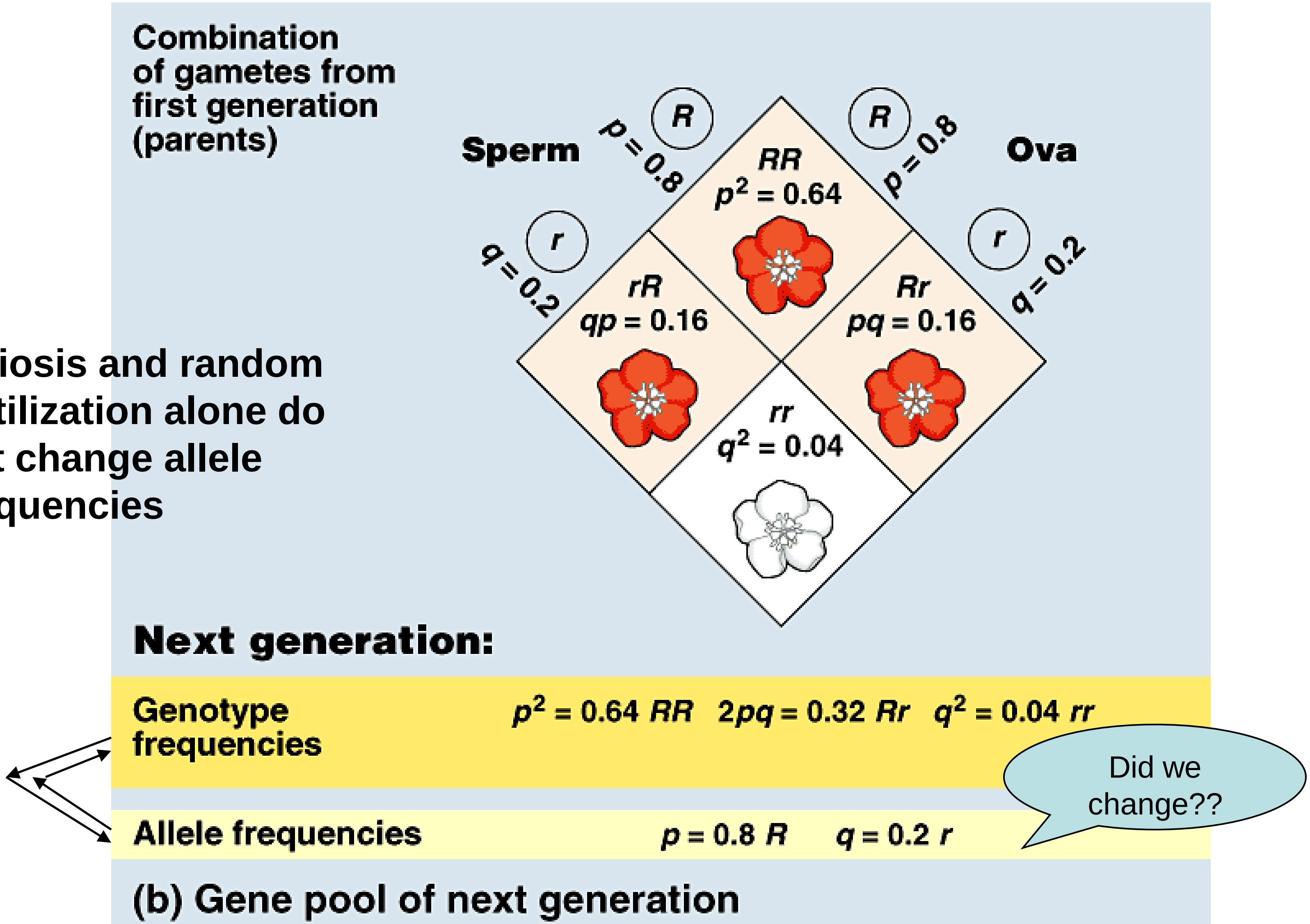
Hardy-Weinberg Theorem

- **<u>Alleles</u>**
  - **frequency of dominant allele = p**
  - **frequency of recessive allele = q**
    - **frequencies must add to 100%, so:**
      - $p + q = 1$
- **<u>Individuals</u>**
  - **frequency of homozygous dominant = p^2**
  - **frequency of homozygous recessive = q^2**
  - **frequency of heterozygotes = $2pq$**
    - **frequencies must add to 100%, so:**
      - $p^2 + 2pq + q^2 = 1$

Calculating Allele Frequencies



Meiosis and random fertilization alone do not change allele frequencies



Card Shuffling Analogy

To be in H-W Equilibrium, a population must have:

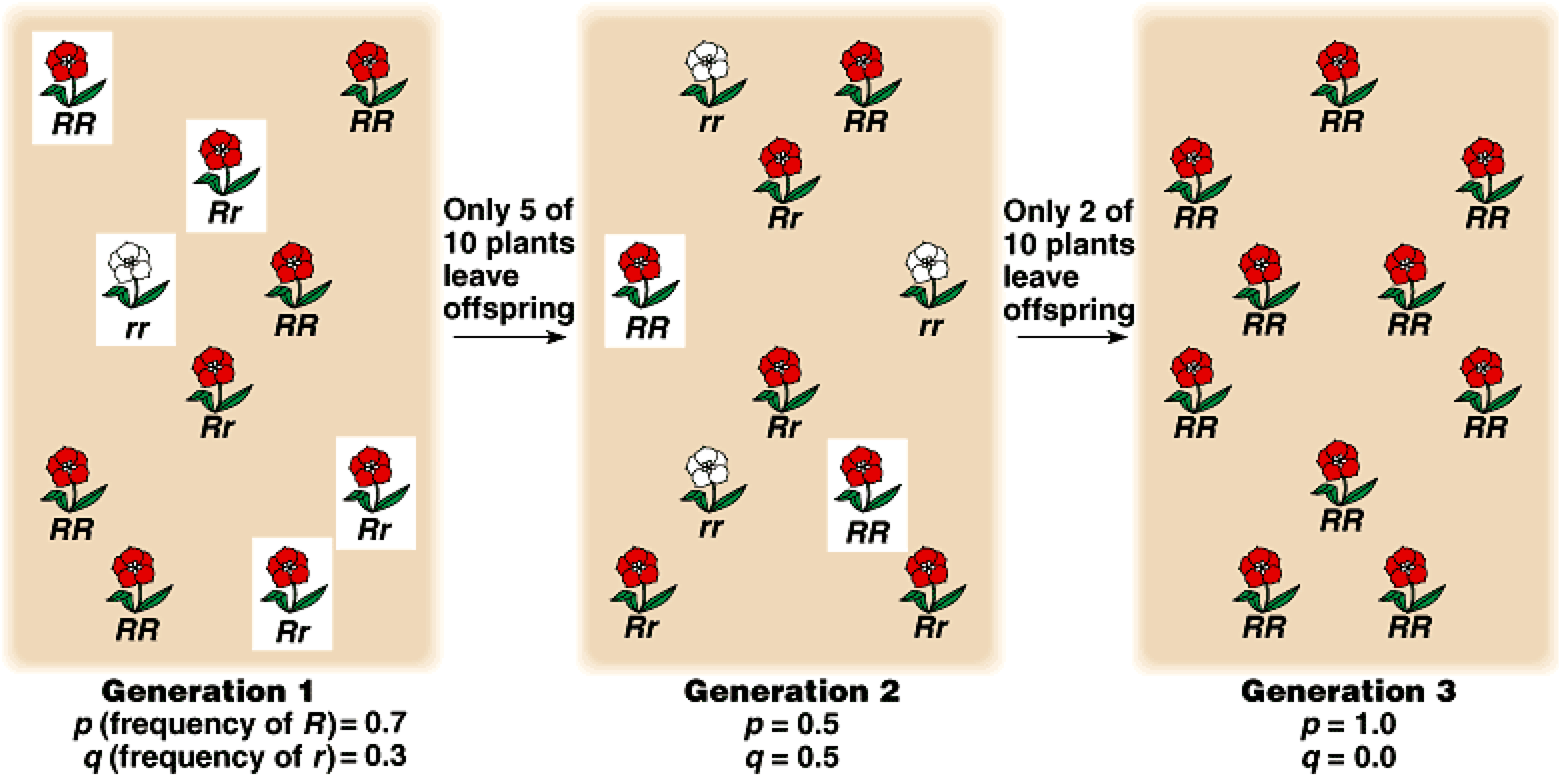
1. **Very large population size (no genetic drift)**
2. **No migration (no gene flow)**
3. **No net mutations**
4. **Random mating (no competition)**
5. **No natural selection**

- **<u>Natural populations</u> are not in H-W equilibrium, so allele frequencies <u>change</u>, & <u>evolution</u> is occurring**

II. Causes of Microevolution

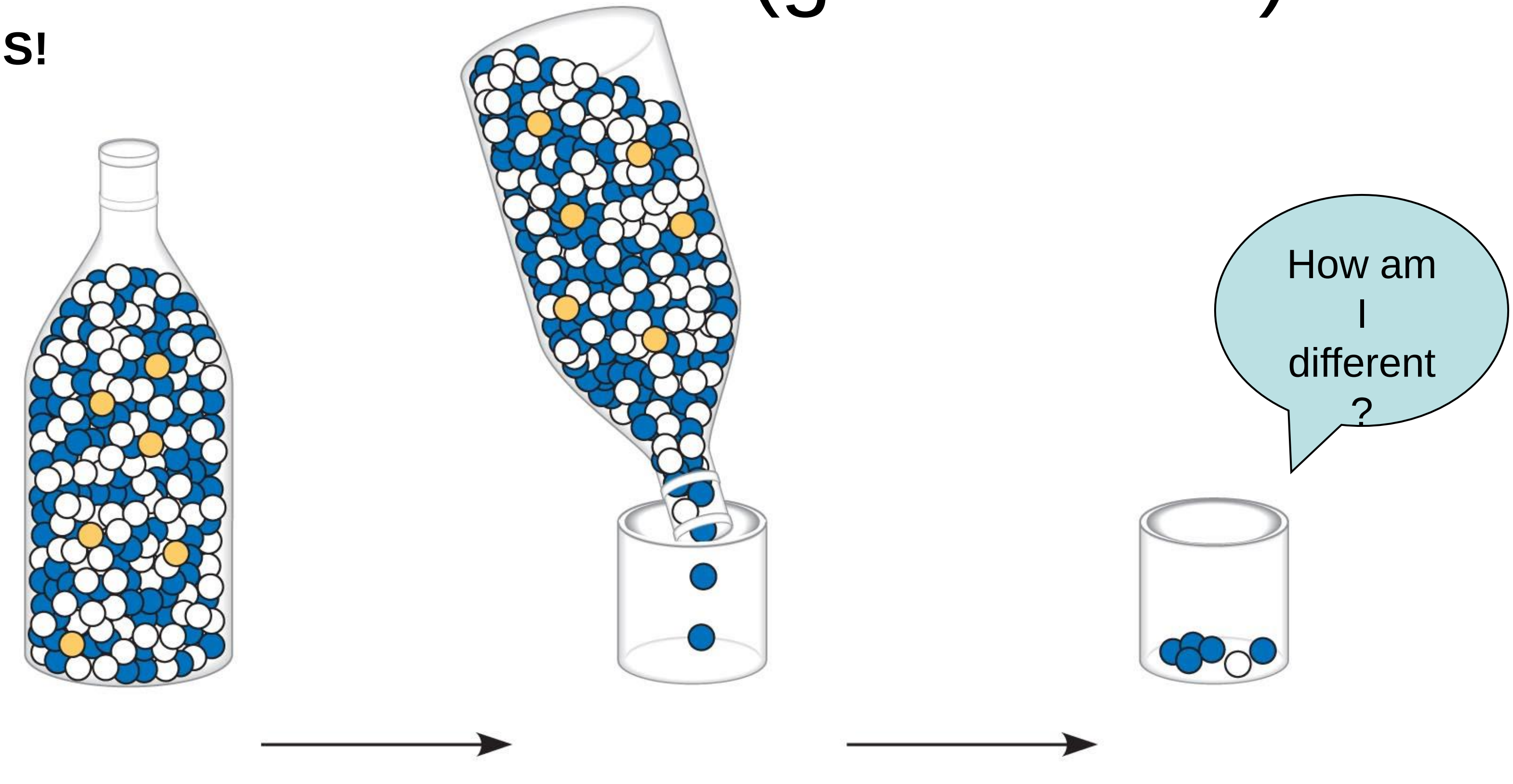
1. Genetic Drift—
   - Change in a population's allele freq. due to chance
   - Affects populations of small size
   - Over time can eliminate some alleles completely
     - 2 Types:
       - Bottleneck Effect:
       - Founder Effect:

Genetic Drift



Bottleneck Effect (genetic drift)

CHEETAHS!



Original population | **Bottlenecking event** | **Surviving population**

- Natural disaster/human influence causes drastic reduction in population size
- Surviving population is genetically different than original population
- Reduces overall genetic variability (alleles can be lost)

Founder Effect (genetic drift)

Reduced genetic variability due to colonization of a isolated habitat by a limited number of individuals from a parent population

Bad recessive alleles can become more common than in original population

Figure 38-12 AN AMISH CHILD WITH ELLIS–VAN CREVELD SYNDROME.
The child has shortened limbs and six fingers on each hand. All the Amish with this syndrome are descendants of a single couple that helped found the Amish community in Lancaster County, Pennsylvania, in 1744. Because of inbreeding in the isolated community, the recessive trait is now common.

2. <u>Natural Selection</u>

- Differential success in reproduction due to environmental pressure
- Allele freq. in next generation different than in current population
- Accumulates and maintains <u>favorable</u> genotypes in populations

3. Gene Flow

- Genetic exchange due to migration of individuals or gametes between populations
- Reduces differences between populations
  - i.e. blending of human ethnic groups

4. Mutation

- **Mutation = original source of genetic variation**
  - **new genes & new alleles originate only by mutation**
  - **only mutations to sex cells can be passed on**
- **Mutation changes DNA sequence → changes amino acid sequence → changes protein**
  - **change structure? change function?**
- **Changes in protein may change phenotype & therefore change fitness**
  - **mutations are random and rare, often with negative effects, but sometimes beneficial**

III. Genetic Variation = raw material for natural selection

- Mutation & Sexual Recombination—
  - Random processes that <u>create variation</u> in the gene pool of a population

Types of organisms most effected by mutations in the short term?

(microorganisms- viruses/bacteria)

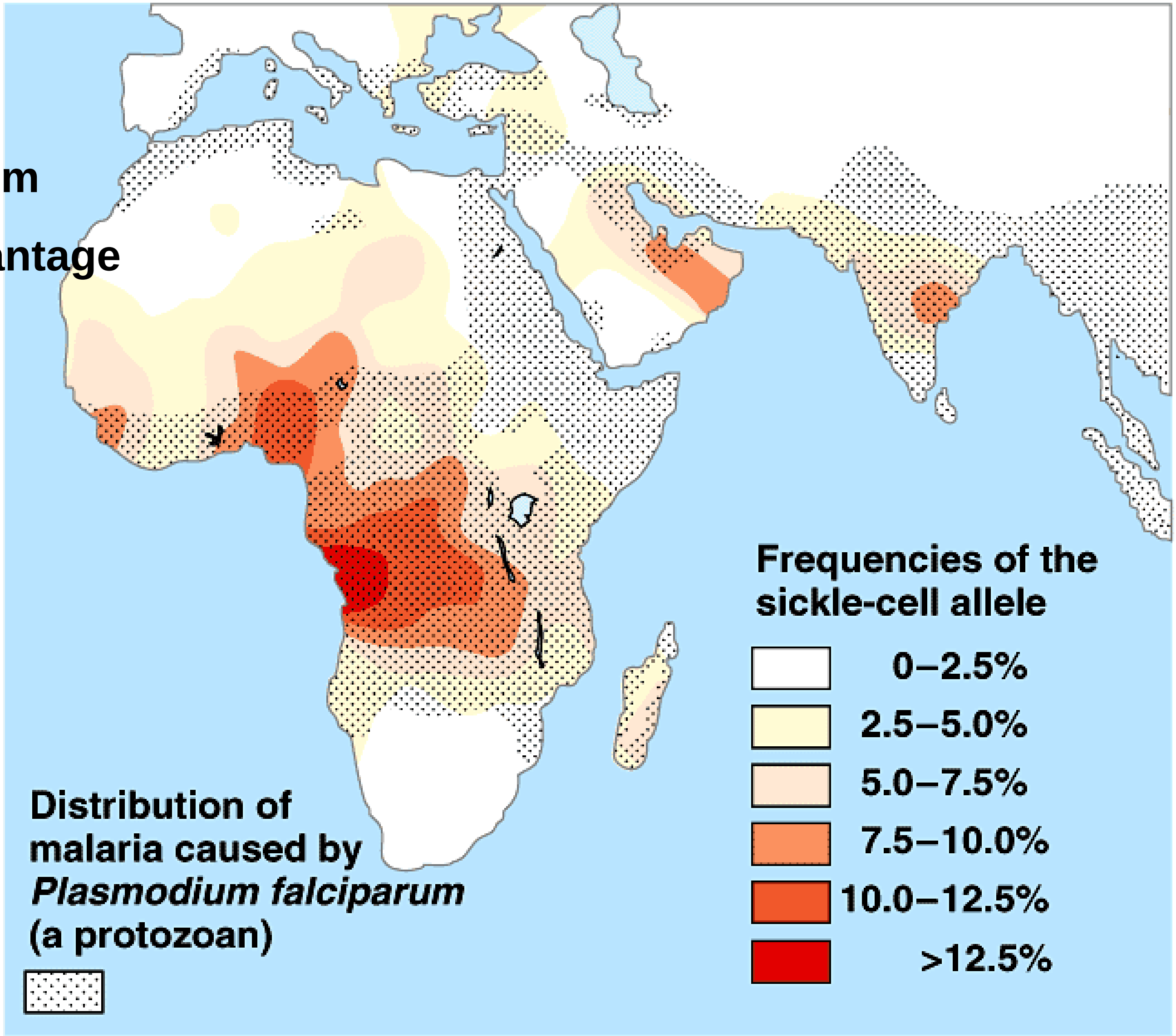
Types of organisms most effected by recombination in the short term?

(plants & animals)

Sexual reproduction recombines alleles into new arrangements in every offspring (think siblings)

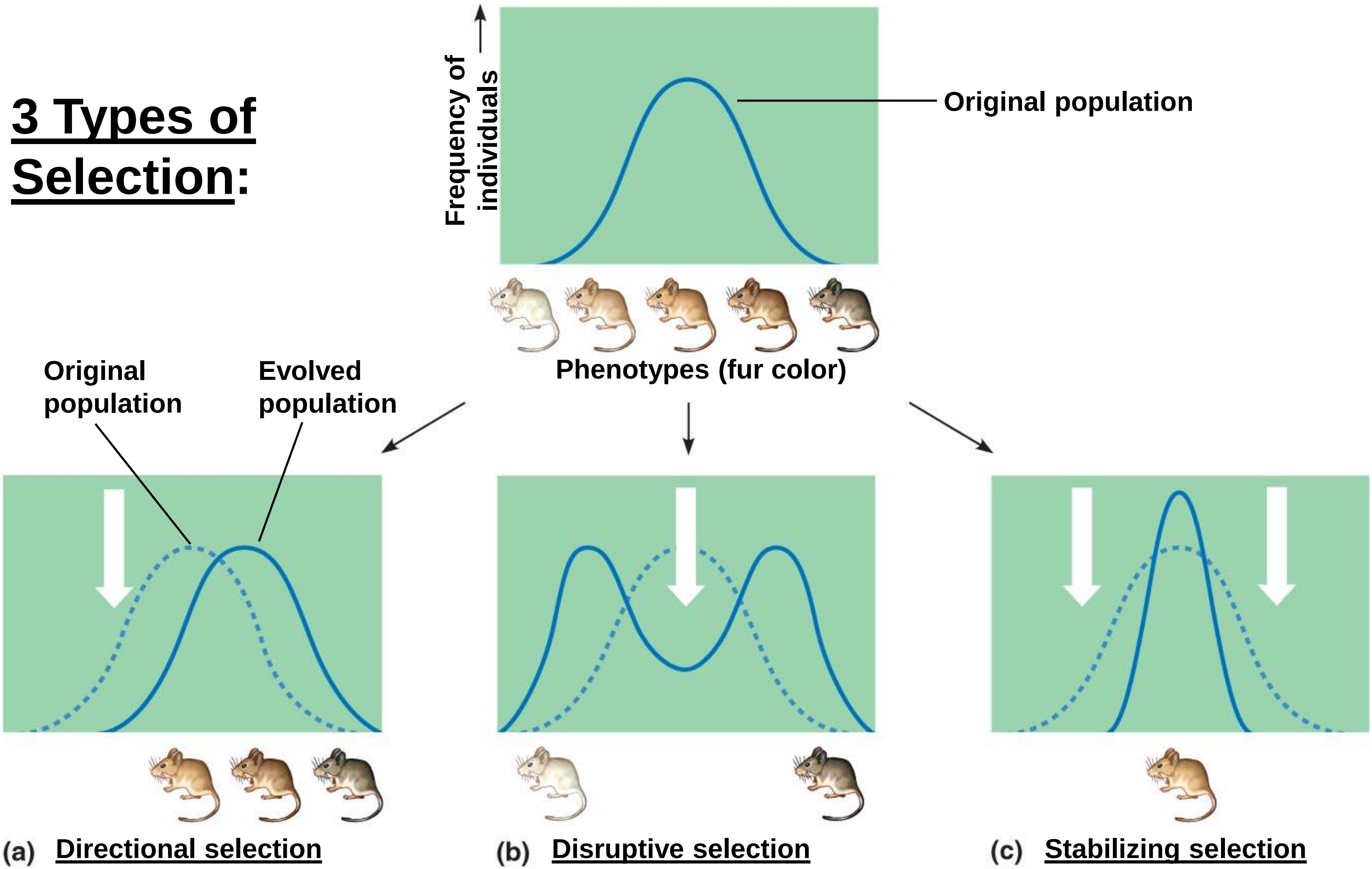
What preserves genetic variation?

- **Diploidy**
- **Balanced Polymorphism**
    - **Heterozygote advantage**
- **Neutral Variation**

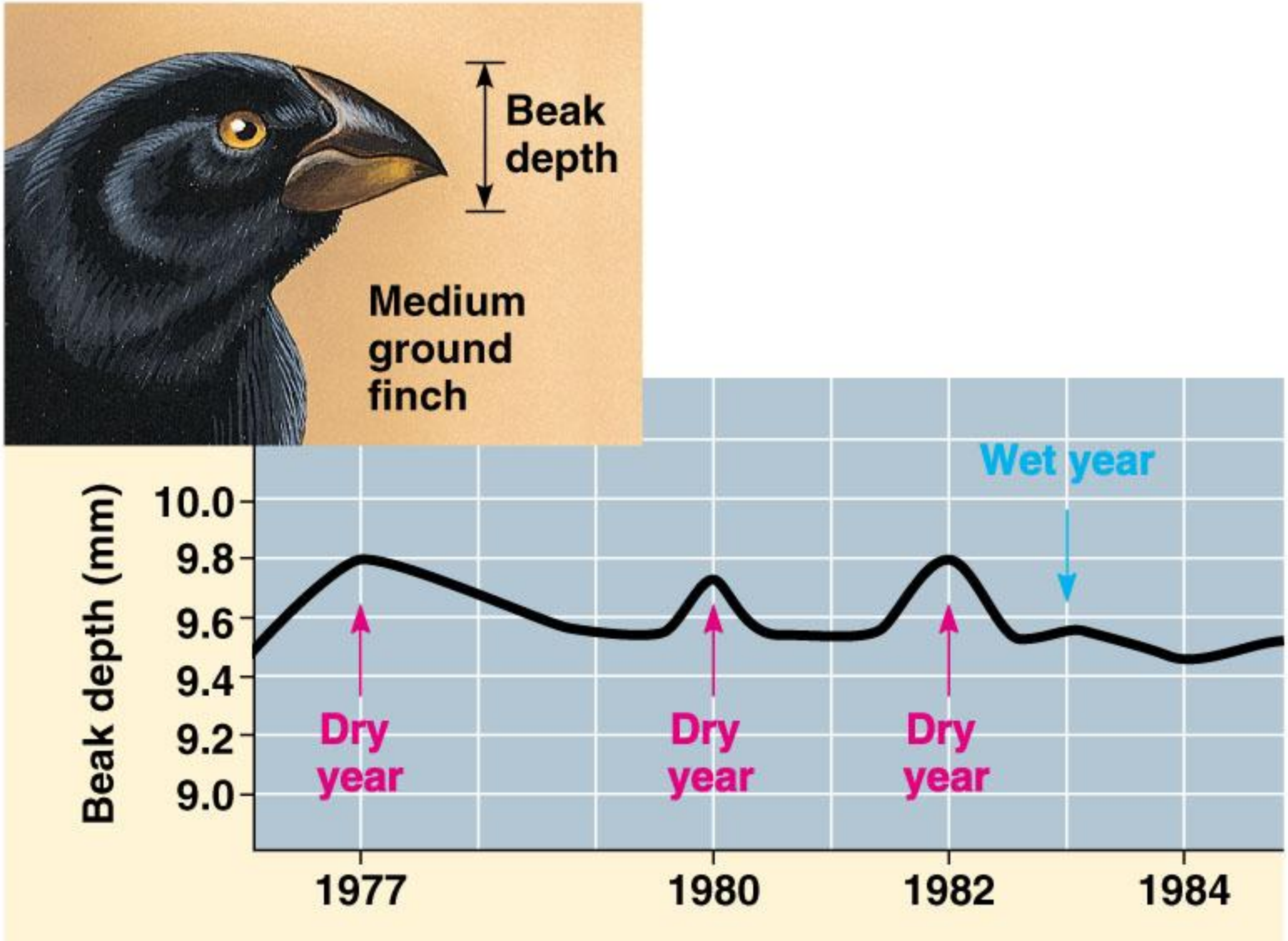


IV. A Closer Look at Natural Selection

<u>3 Types of Selection</u>:



Directional Selection



Intrasexual Selection vs. Intersexual Selection

Can natural selection make perfect organisms?

NO!

- Evolution is limited by historical constraints
- Adaptations are often compromises
- Not all evolution is adaptive
- Selection can only edit existing variations