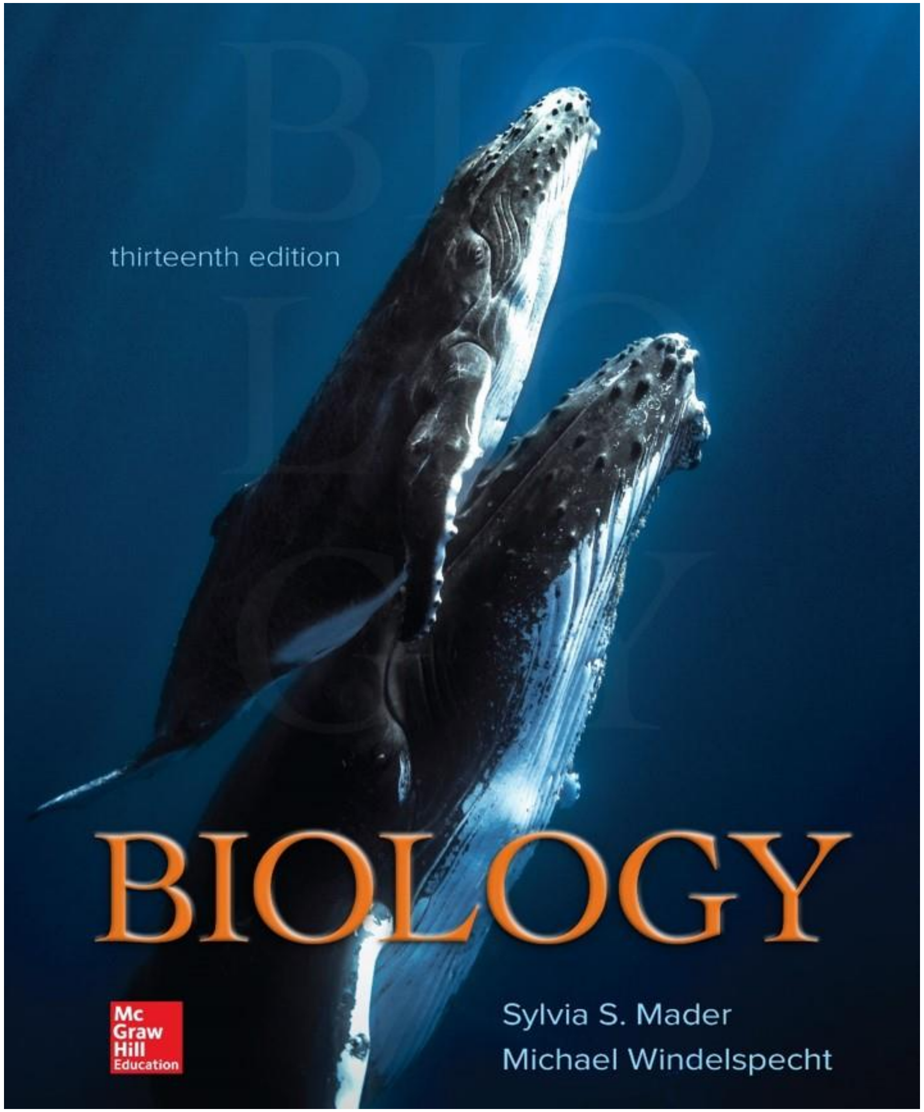

Biology

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Chapter 16
How Populations Evolve
Lecture Outline

See separate FlexArt PowerPoint slides for all figures and tables pre-inserted into PowerPoint without notes.

16.1 Genes, Populations, and Evolution

A **population** is a group of organisms of a single species occupying a particular area at the same time.

- Diversity exists among members of a population.

Population genetics is the study of this diversity in terms of allele differences.

- It evaluates the diversity of a population by studying genotype and phenotype frequencies over time.

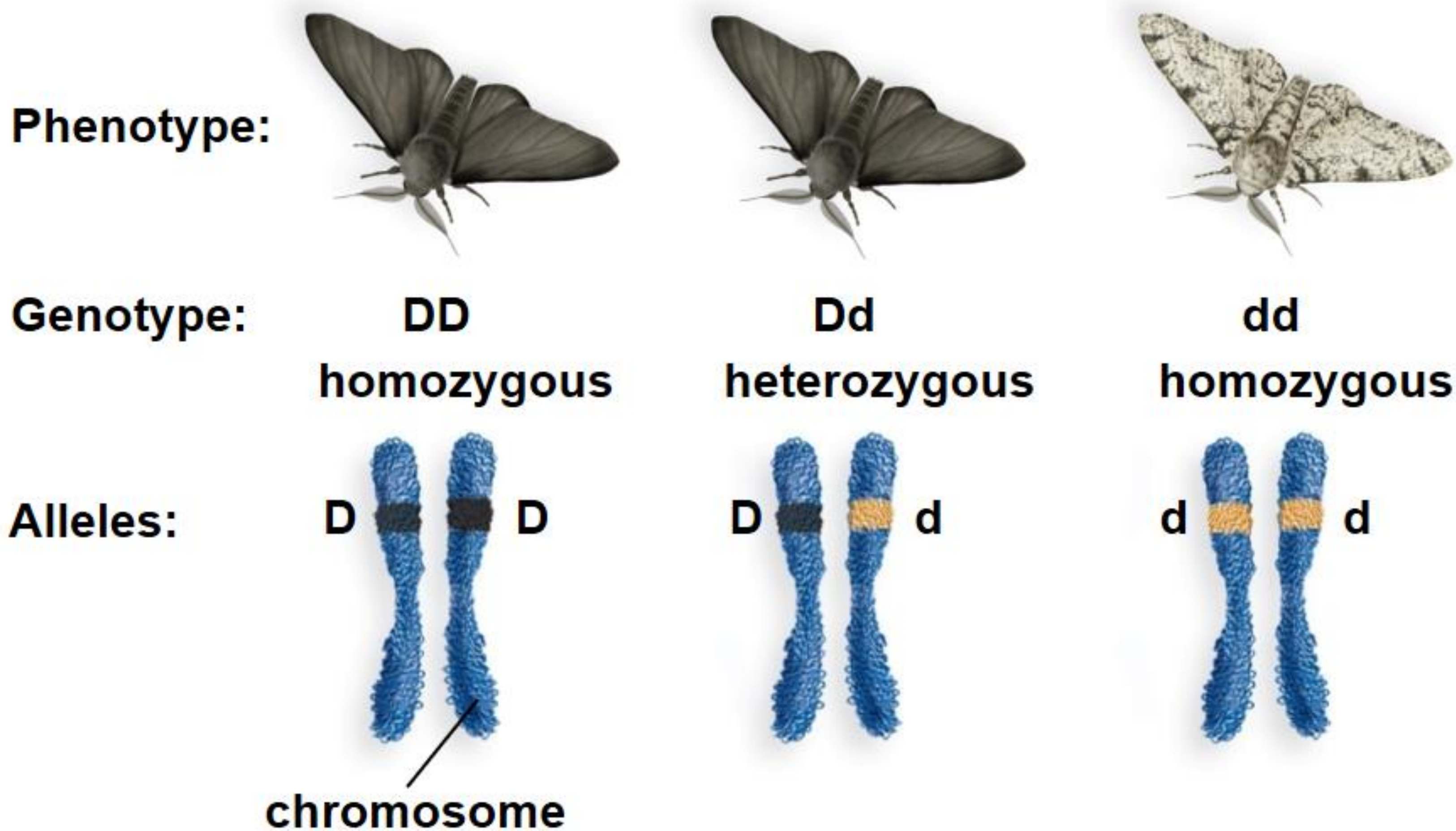
Genes, Populations, and Evolution (1)

In the 1930s, population geneticists began to describe variations in a population in terms of alleles.

Microevolution pertains to evolutionary changes within populations.

- Various alleles at all the gene loci in all individuals make up the **gene pool** of the population.
- The gene pool of a population can be described in terms of:
  - Genotype frequencies
  - **Allele frequencies**

The Genetic Basis of Body Color in the Peppered Moth

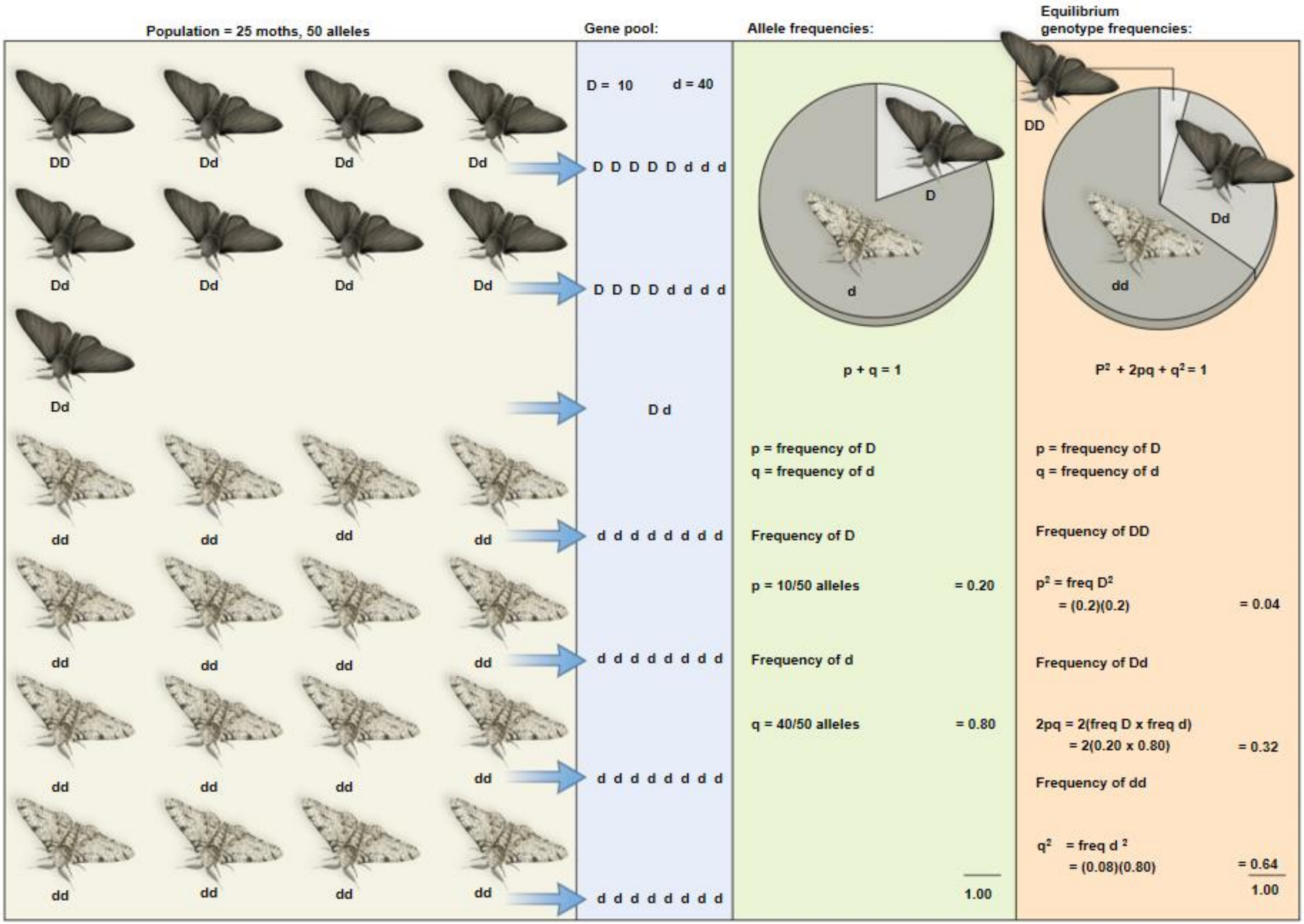


Genes, Populations, and Evolution (2)

Allele Frequencies

- It is the proportion of each allele within a population's gene pool.
- Frequencies of the dominant and recessive allele must add up to 1.
  - This relationship is described by the expression $p + q = 1$.
  - *p* is the frequency of one allele and *q* is the frequency of the other.
- Microevolution involves a change in these allele frequencies within populations over time.
  - If the gene frequencies do not change over time, microevolution has not occurred.

How Hardy-Weinberg Equilibrium Is Estimated

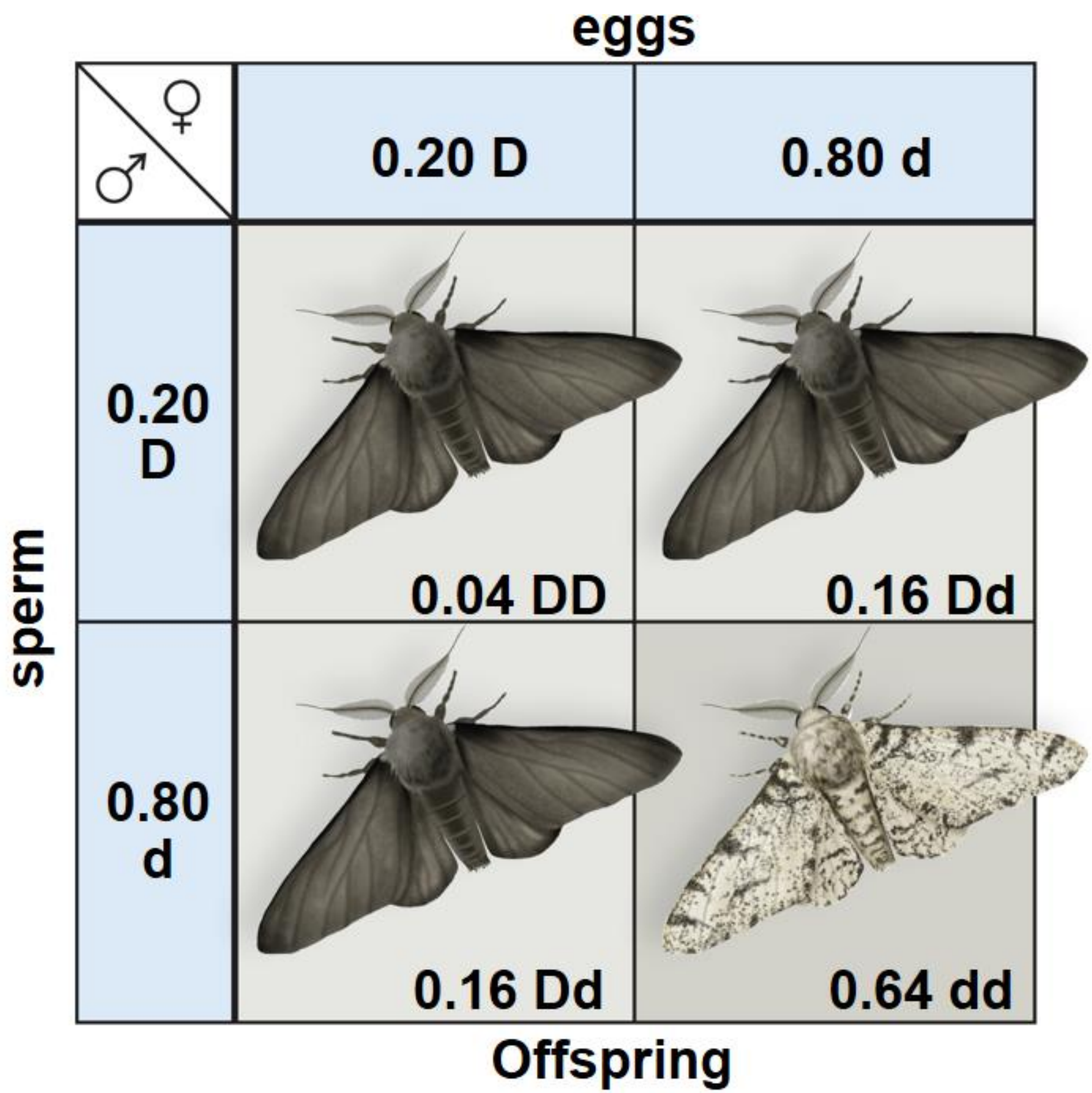


Genes, Populations, and Evolution (3)

The **Hardy-Weinberg Equilibrium** states that:

- Allele frequencies in a population will remain constant assuming
  - No Mutations
  - No Gene Flow
  - Random Mating
  - No Genetic Drift
  - No Selection

Hardy-Weinberg Equilibrium



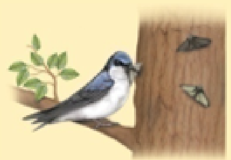
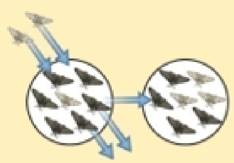
Genes, Populations, and Evolution (4)

Hardy-Weinberg Equilibrium:

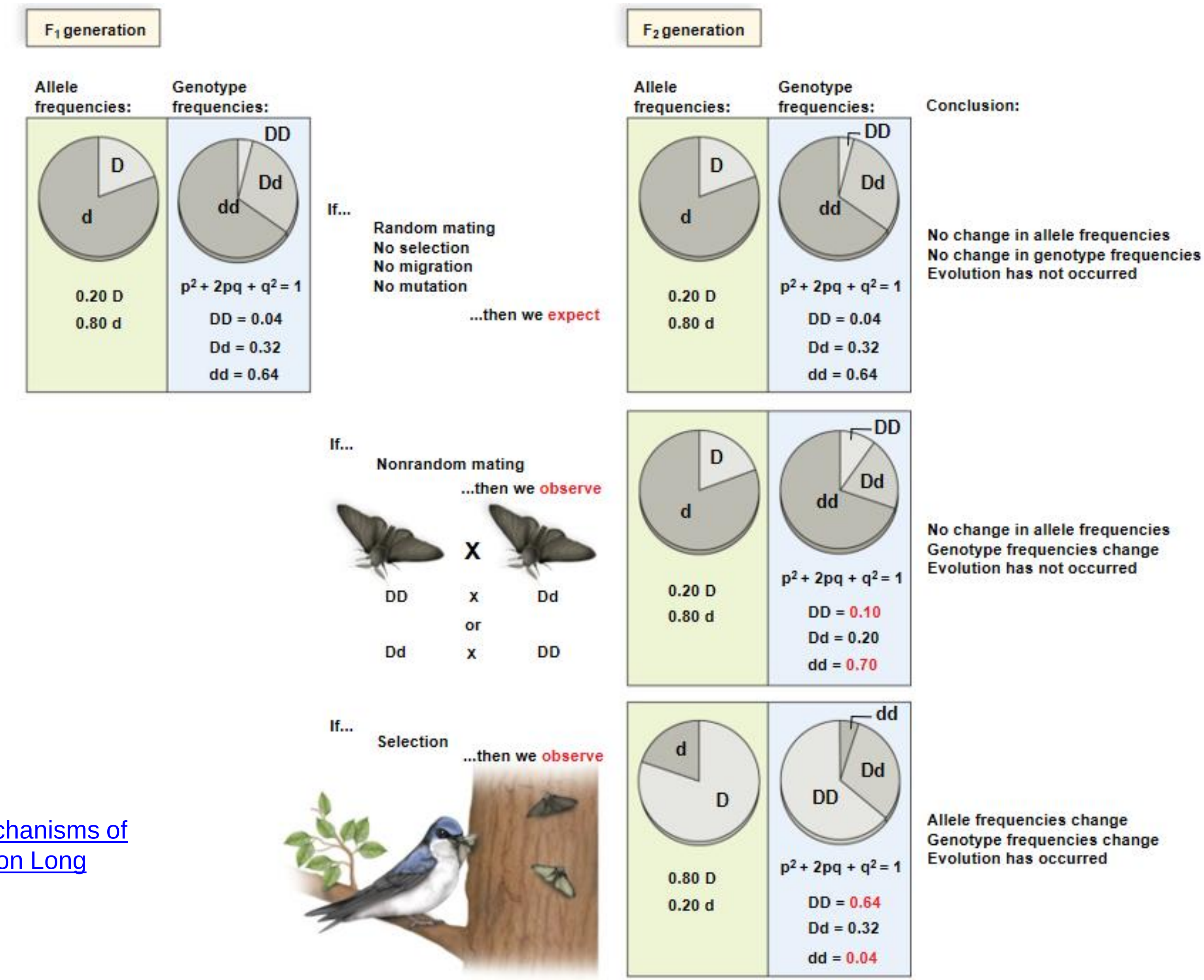
- Required conditions are rarely (if ever) met.
- Deviations from a Hardy-Weinberg equilibrium indicate that evolution has taken place.
  - Analysis of allele changes in populations over time determines the extent to which evolution has occurred.

Genes, Populations, and Evolution (5)

Table 16.1 Hardy-Weinberg proportions can be used to determine if evolution has occurred.

Hardy-Weinberg Condition	Deviation from condition	Effect of deviation on population	Expected deviation from HWE	Evolution occurred ?
Random mating	Nonrandom Mating 	Alleles do not assort randomly	Change in genotype frequencies	NO
No selection	Selection 	Certain alleles are selected for or against	Change in allele frequencies	Yes
No mutation	Mutation	Addition of new alleles	Change in allele Frequencies	YES
No migration	Immigration or emigration 	Individuals carry alleles into, or out of, the population	Change in allele frequencies	YES
Large population (no genetic drift)	Small population (genetic drift) 1. Bottleneck effect 2. Founder effect	Loss of allele diversity; some alleles may disappear	Change in allele frequencies	YES

Mechanisms of Microevolution



[Jump to Mechanisms of Microevolution Long Description]

Genes, Populations, and Evolution (6)

Causes of Microevolution

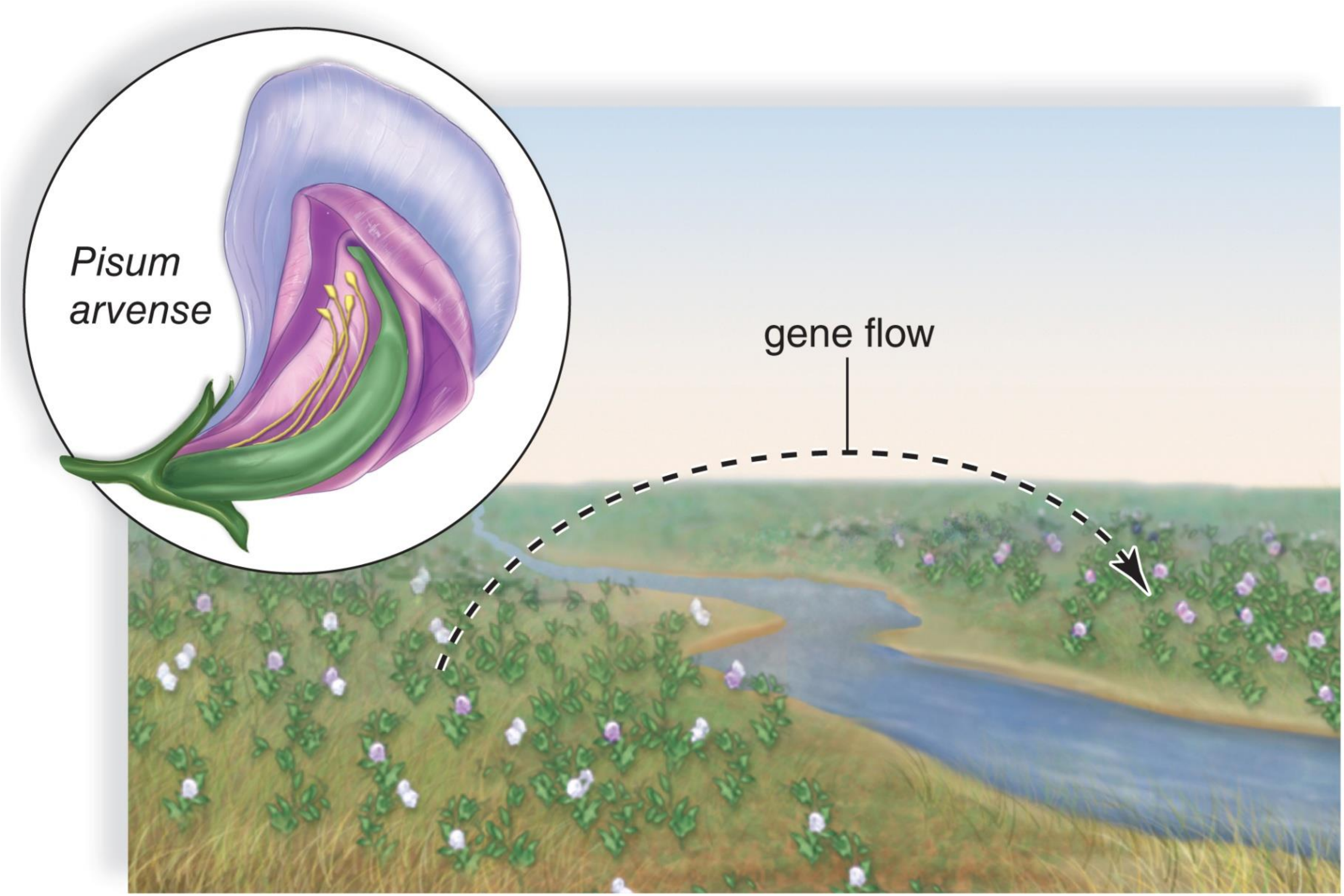
- Genetic mutations
  - Genetic mutations are the raw material for evolutionary change.
  - They provide new alleles.
  - Some mutations might be more adaptive than others.
    - Example: Genetic mutations affecting pigment color in peppered moths have provided the variation needed for natural selection to occur.

Genes, Populations, and Evolution (7)

Causes of Microevolution

- **Gene Flow** (gene migration)
  - Movement of alleles between populations when:
    - Gametes or seeds (in plants) are carried into another population
    - Breeding individuals migrate into or out of population
  - Continual gene flow reduces genetic divergence between populations.
  - If migration between populations doesn’t occur, the gene pools become more different over time.
    - The differences in the genetic makeup of these populations become so large that they become reproductively isolated and incapable of interbreeding.
    - This is the first step in species formation.

Gene Flow

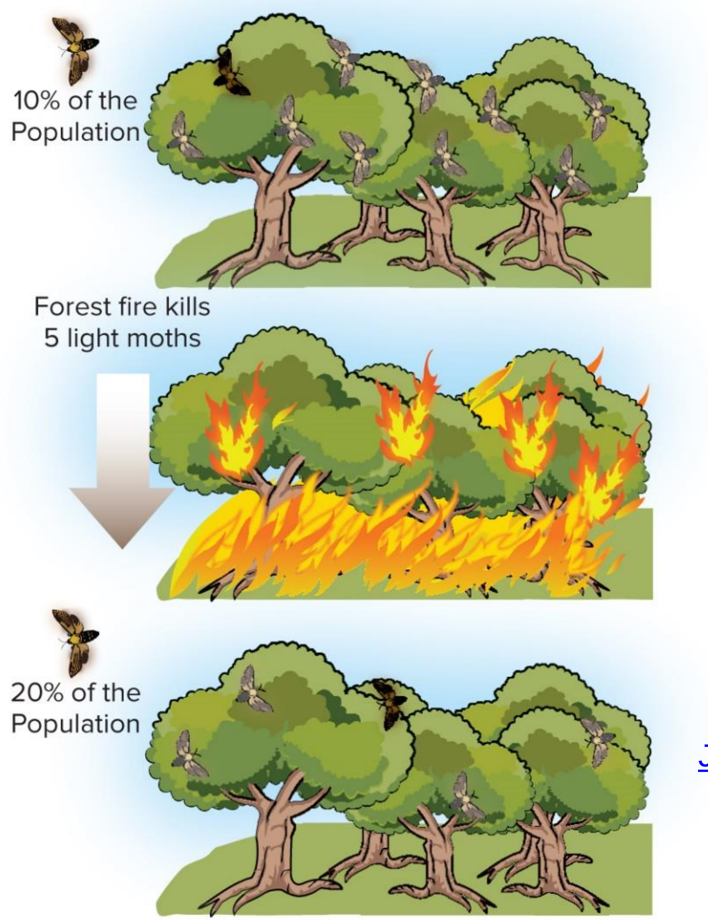


Genes, Populations, and Evolution (8)

Causes of Microevolution

- **Genetic Drift**
  - Changes in the allele frequencies of a population due to change rather than selection by the environment
  - Does not necessarily lead to adaptation to the environment
  - Occurs by disproportionate random sampling from population
    - Can cause the gene pools of two isolated populations to become dissimilar
    - Some alleles are lost and others become fixed (unopposed).
  - Likely to occur:
    - After a bottleneck
    - When severe inbreeding occurs, or
    - When founders start a new population
  - Stronger effect in small populations

Genetic Drift



Jump to Genetic Drift Long Description

Genes, Populations, and Evolution (9)

Bottleneck Effect

- A random event prevents a majority of individuals from entering the next generation.
- The next generation is composed of alleles that just happened to make it.
- It is mostly due to natural disasters or habitat loss.

Genes, Populations, and Evolution (10)

Founder Effect – a type of genetic drift

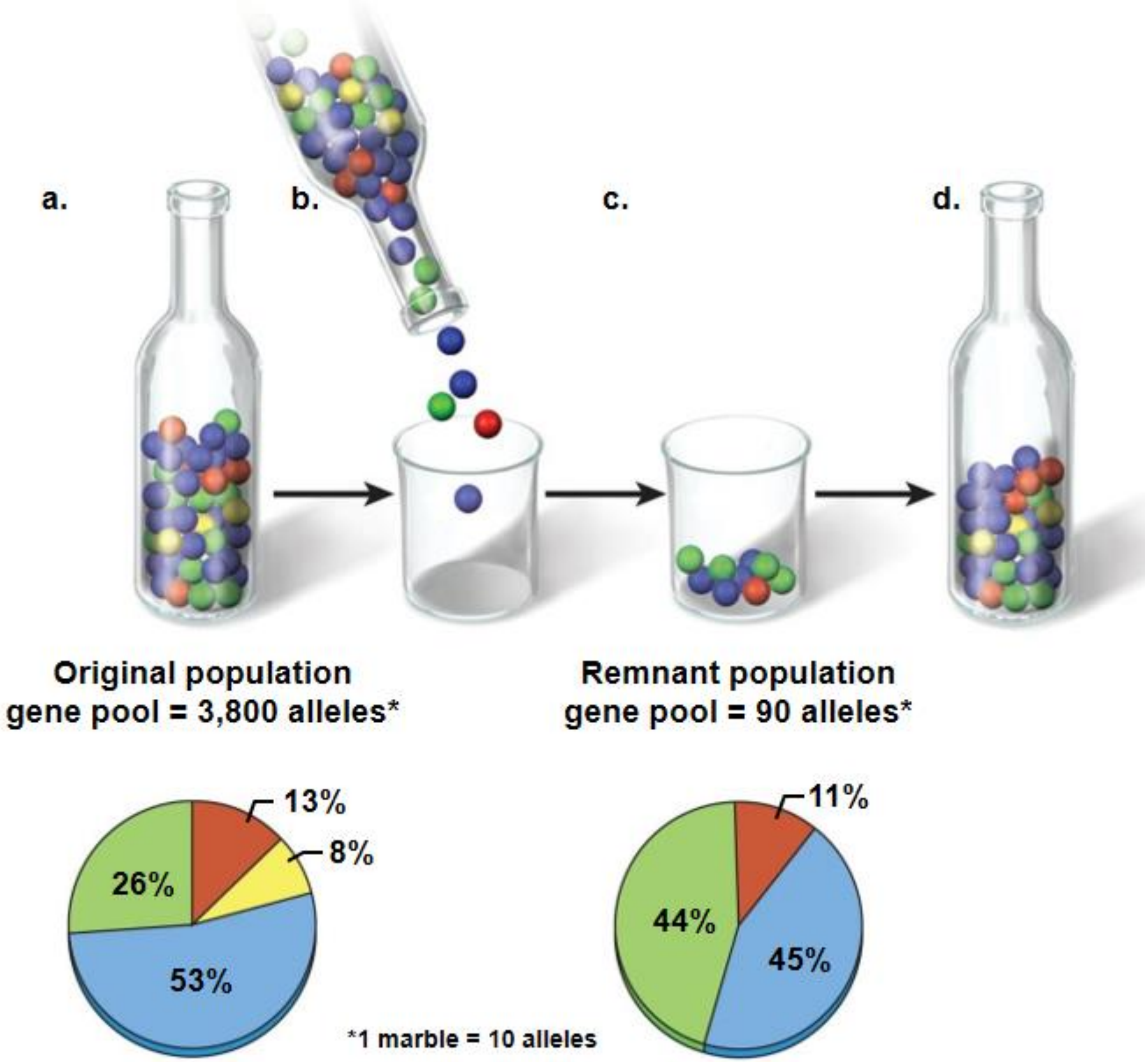
- A new population is started from just a few individuals.
- The alleles carried by population founders are dictated by chance.
- The gene pool of the small population is much different from the gene pool of the original population.

Genes, Populations, and Evolution (11)

Founder Effect – a type of genetic drift

- The greater the reduction in population size, the greater the effects on allele frequencies.
- Formerly rare alleles will either:
  - Occur at a higher frequency in the new population, or
  - Be absent in new population
- Higher than normal occurrence of inbreeding (mating between relatives) occurs.
  - Rare recessive disorders emerge more frequently in inbred populations.

Consequences of Bottleneck and Founder Effects



Genes, Populations, and Evolution (12)

Nonrandom Mating

- When individuals do not choose mates randomly
  - **Assortative mating:**
    - Individuals select mates with the same phenotype with respect to a certain characteristic.
    - Individuals reject mates with differing phenotype.
    - It increases the frequency of homozygotes for certain loci.
    - It can play an important role in the evolution of a population.
      - Example: On the island of Pingelap, nonrandom mating resulted in an increased frequency of colorblindness.

16.2 Natural Selection

Natural selection is the adaptation of a population to the biotic and abiotic environment.

- Requires:
  - Variation – The members of a population differ from one another.
  - Inheritance – Many differences are heritable genetic differences.
  - Differential Adaptiveness – Some differences affect survivability.
  - Differential Reproduction – Some differences affect the likelihood of successful reproduction.

Natural selection favors the variant that is most adaptive to the present environmental conditions.

Natural Selection (1)

Results in:

- A change in allele frequencies of the gene pool
- Improved fitness of the population

Major cause of microevolution

Natural Selection (2)

Most traits are **polygenic**; variations in the trait result in a bell-shaped curve.

Three types of selection occur:

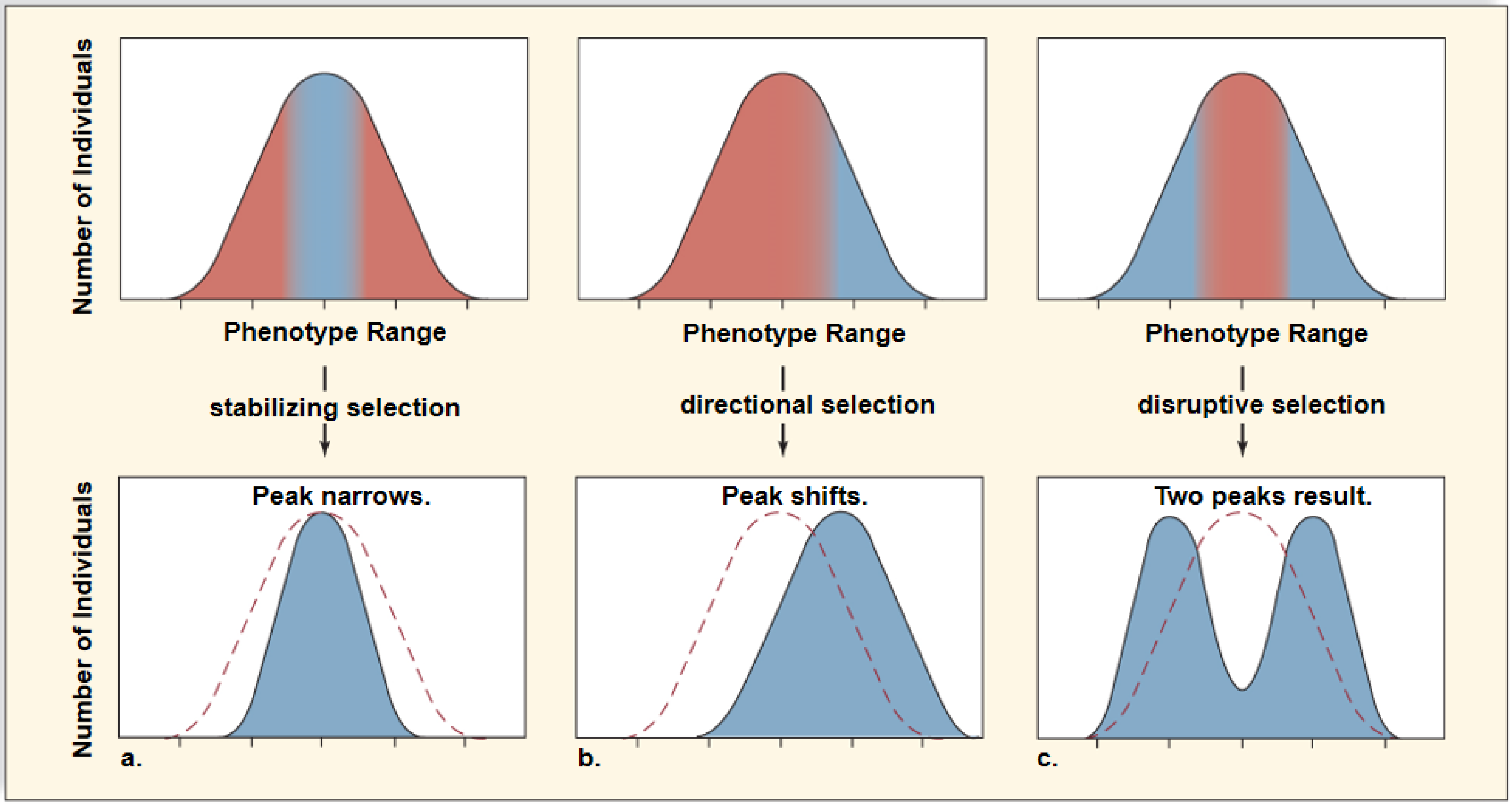
- **Directional Selection**
  - An extreme phenotype is favored.
  - The curve shifts in one direction.
    - Bacteria become resistant to antibiotics.

Natural Selection (3)

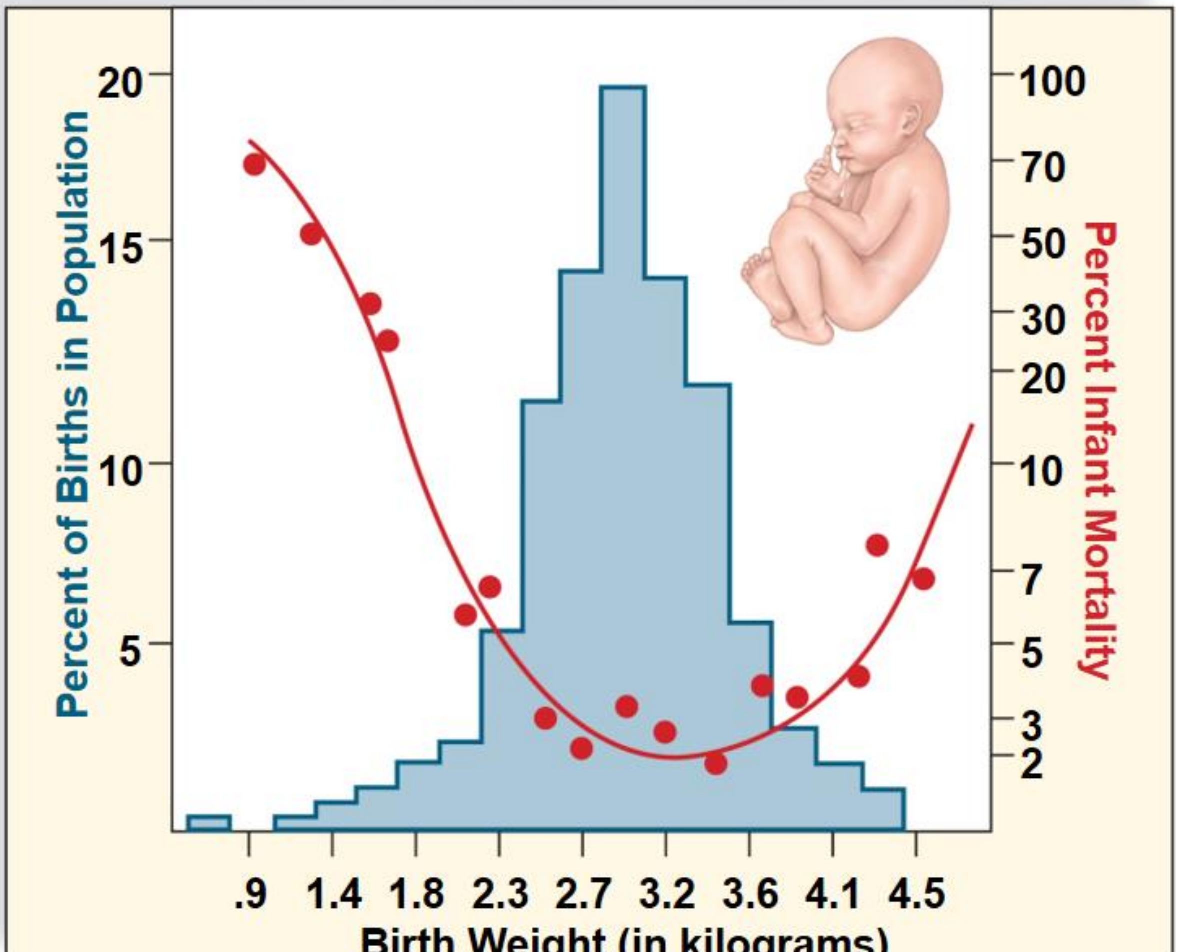
Three types of selection occur:

- **Stabilizing Selection**
  - An intermediate phenotype is the most adaptive for the given environmental conditions.
  - The peak of the curve increases and tails decrease.
  - Example: Human babies with low or high birth weight are less likely to survive.
- **Disruptive Selection**
  - Two or more extreme phenotypes are favored over the intermediate phenotype.
  - The curve has two peaks.
  - Example: British land snails vary because a wide geographic range causes selection to vary.

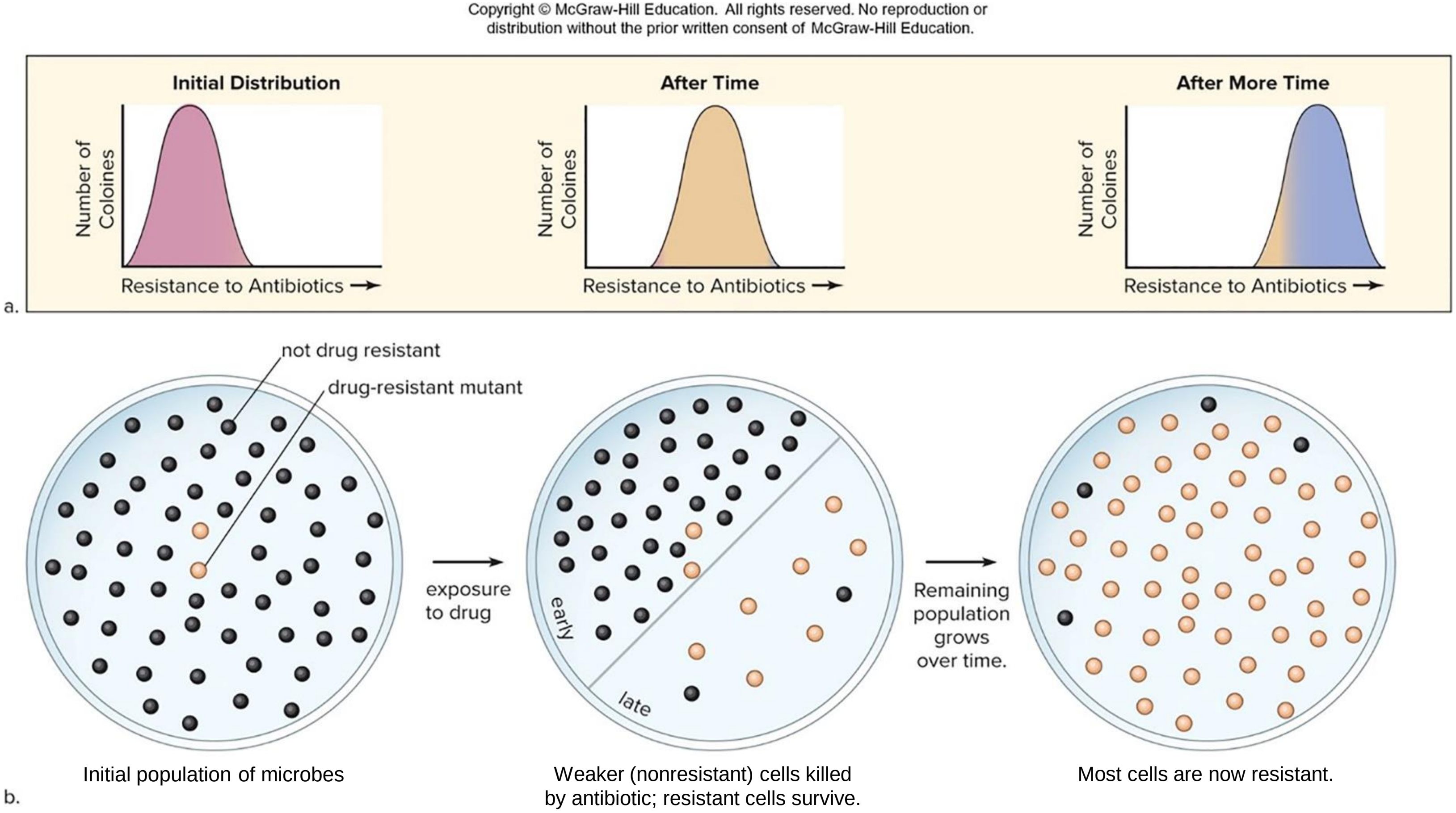
Three Types of Natural Selection



Human Birth Weight (Stabilizing Selection)

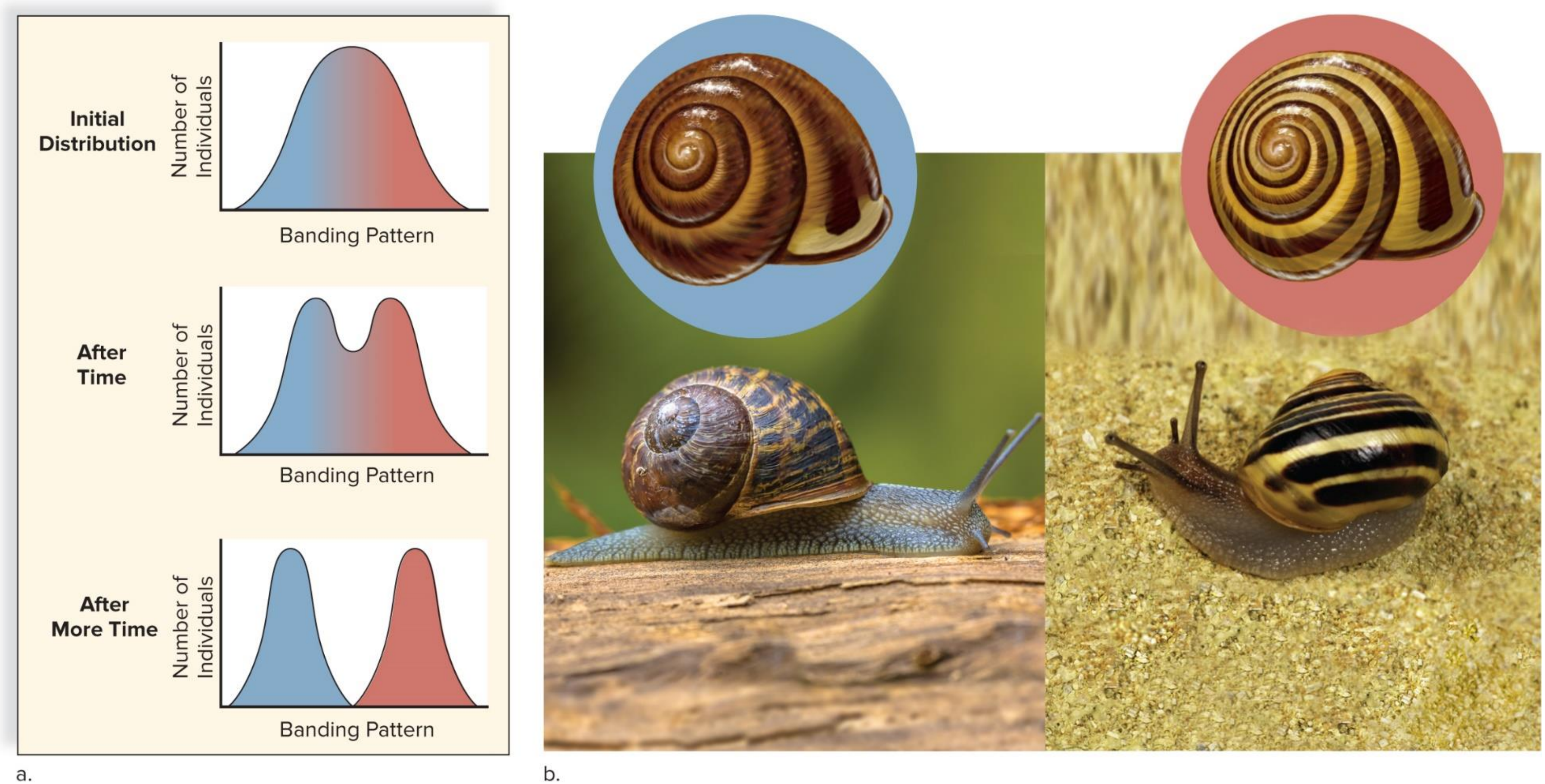


Directional Selection



Jump to Directional Selection Long Description

Disruptive Selection



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[Jump to Disruptive Selection Long Description]

Natural Selection (4)

Sexual selection – Adaptive changes in males and females lead to an increased ability to secure a mate.

- With males there is an increased ability to compete with other males for a mate.
- Females choose to select a male with the best **fitness** (ability to produce surviving offspring).

Natural Selection (5)

Female Choice

- Choice of a mate is a serious consideration because females produce few eggs.
  - *Good genes hypothesis:* Females choose mates on the basis of traits that improve the chance of survival.
  - *Runaway hypothesis:* Females choose mates on the basis of traits that improve male appearance.
  - Sexual dimorphism: Males and females differ in size and other traits.
    - Female choice can explain why male birds are more ornate than females.
    - Remarkable plumes of males may signify health and vigor.

Natural Selection (6)

Male Competition

- Males can father many offspring because they continuously produce sperm in great quantity.
- They compete to inseminate as many females as possible.
  - Cost-benefit analysis: Is access to mating worth the competition?

Dimorphism

The drab females tend to choose flamboyant males as mates.

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Jump to Dimorphism Long Description

Sexual Selection: Competition

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Jump to Sexual Selection: Competition Long Description

Sexual Selection: Competition Between Male Red Deer

a.

b.

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Jump to Sexual Selection: Competition Between Male Red Deer Long Description

Maintenance of Diversity (4)

Heterozygote Advantage

- It assists the maintenance of genetic, and therefore phenotypic, variations in future generations.
- Sometimes recessive alleles confer an advantage to heterozygotes.
  - In sickle-cell disease, heterozygous individuals don’t die from sickle-cell disease, and they don’t die from malaria.
  - The sickle-cell anemia allele is detrimental in homozygote.
  - However, heterozygotes are more likely to survive malaria.
  - The sickle-cell allele occurs at a higher frequency in malaria-prone areas.
    - Malaria is caused by a protozoan parasite that lives in and destroys red blood cells of a homozygous normal individual (no sickle-cell allele).
    - Heterozygotes (one sickle-cell allele) have an advantage.
    - This is a form of stabilizing selection.

Sickle-Cell Disease