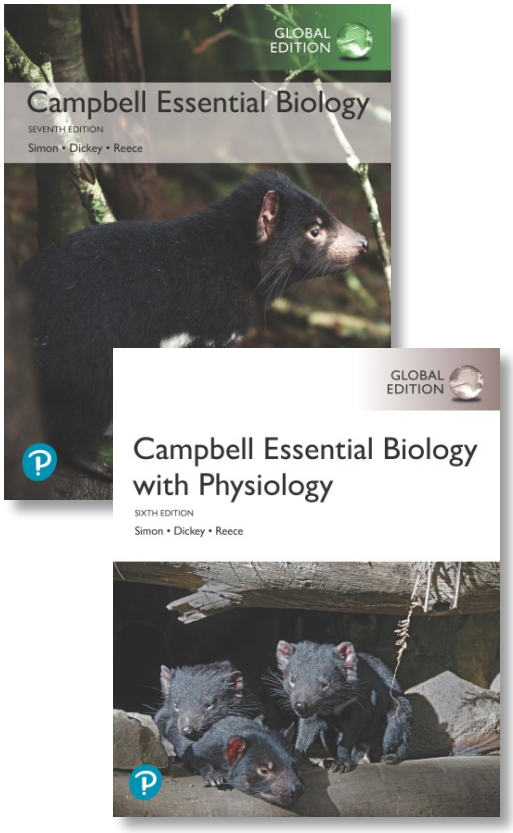
Campbell Essential Biology, Seventh Edition, Global Edition and Campbell Essential Biology with Physiology, Sixth Edition, Global Edition



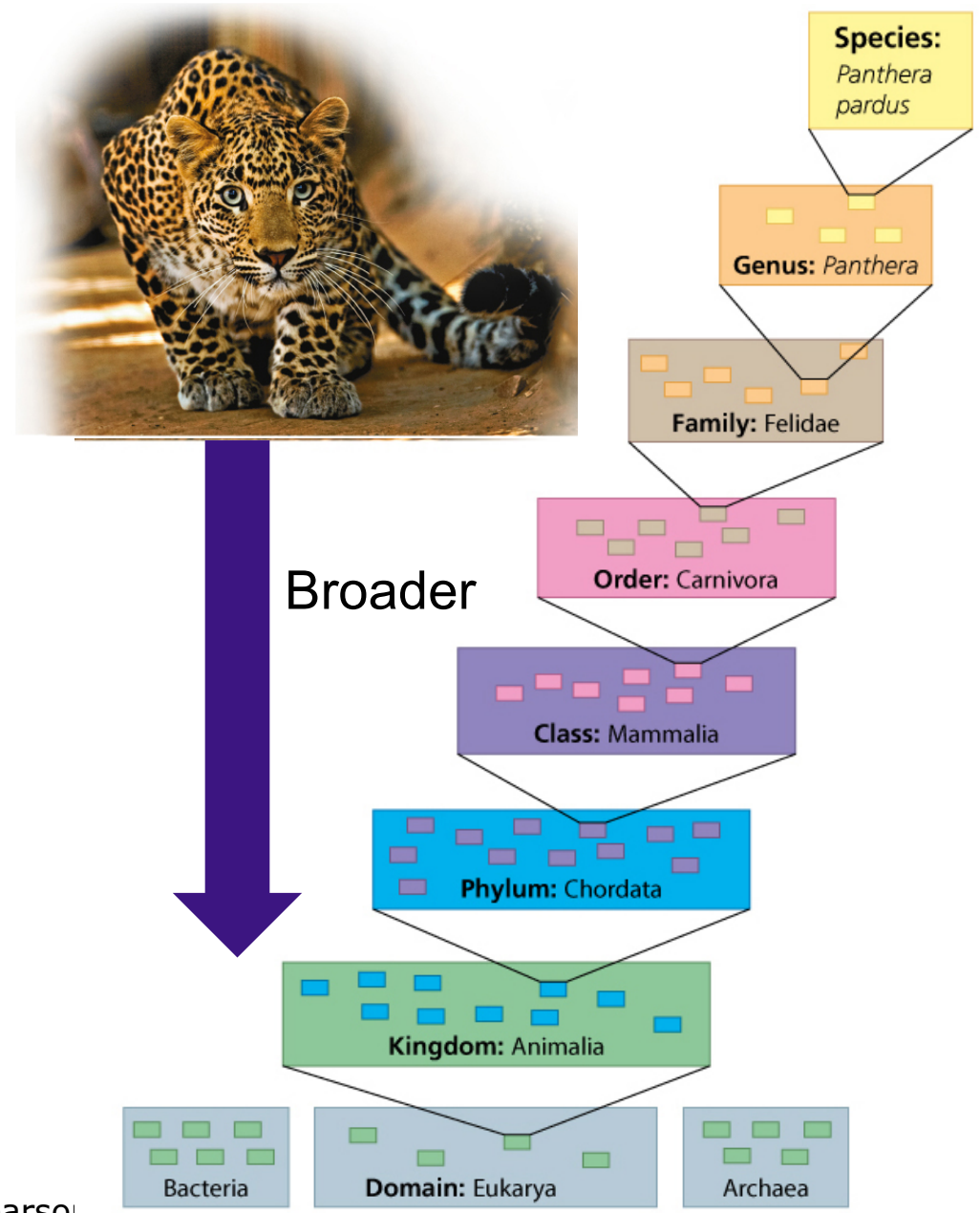
Chapter 13
How Populations Evolve

PowerPoint® Lectures created by Edward J. Zalisko, Eric J. Simon, Jean L. Dickey, and Jane B. Reece

Pearson

The Diversity of Life

- For all of human history, people have named, described, and classified the inhabitants of the natural world.
- **Taxonomy** is the branch of biology concerned with identifying, naming, and classifying species. (taxis(“order”)+nomos(“rule” or “law)”



Taxonomic hierarchy

Mechanisms of Evolution

- Darwin proposed a scientific mechanism for *how* life evolves, a process he called **natural selection**.
  - In natural selection, individuals with certain inherited traits are more likely to survive and reproduce than are individuals with other traits.

https://www.youtube.com/watch?v=7VM9YxmULuo

Mechanisms of Evolution

- Darwin proposed a scientific mechanism for *how* life evolves, a process he called **natural selection**.
  - In natural selection, individuals with certain inherited traits are more likely to survive and reproduce than are individuals with other traits.
  - ➔ Based on the habitats of the ancestor, the surviving population in each habitat will be different
  - ➔ Resulting in diverse modifications, or **evolutionary adaptations**, that fit them to specific ways of life in their environment.
- Natural selection does not lead to perfectly adapted organisms. A trait that is favorable in one situation may be useless—or even detrimental—in different circumstances.

Why does Natural Selection occur?

1) Limited resources ➔ the production of more individuals than the environment can support leads to a struggle for existence ➔ only some offspring survive in each generation.
2) Changes in environment

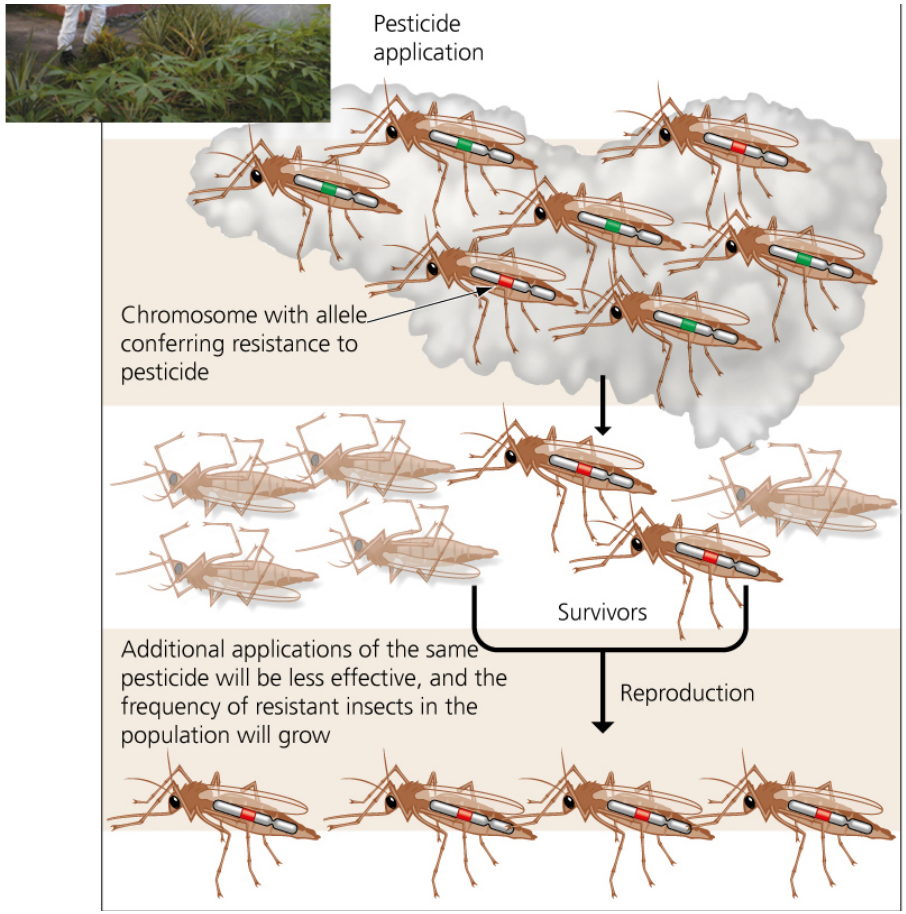
- In the process of natural selection, individuals whose traits better enable them to obtain food, escape predators, or tolerate physical conditions will survive and reproduce more successfully, passing these adaptive traits to their offspring

Why does Natural Selection occur?

1) Limited resources ➔ the production of more individuals than the environment can support leads to a struggle for existence ➔ only some offspring survive in each generation.
2) Changes in environment (next pages)

Examples of Natural selection : DTT- resistant Mosquitoes

- In 1955, the World Health Organization (WHO) attempted to eradicate malaria by using DDT, a recently developed pesticide,
- Although DDT immediately killed most mosquitoes, survivors gave rise to new DDT-resistant populations—an example of evolution in action.



Natural selection does not affect individual organism
➔ It is a population that evolves over time as adaptive traits become more common

Examples of Natural selection
: blue-footed booby

- Only natural selection consistently leads to adaptive evolution, evolution that results in organisms better suited to their environment.
  - The bird's body and bill are streamlined like a torpedo, minimizing friction as it dives.
  - Its large tail functions as a brake.
  - Female boobies prefer males with the brightest blue feet.

Sexual Selection

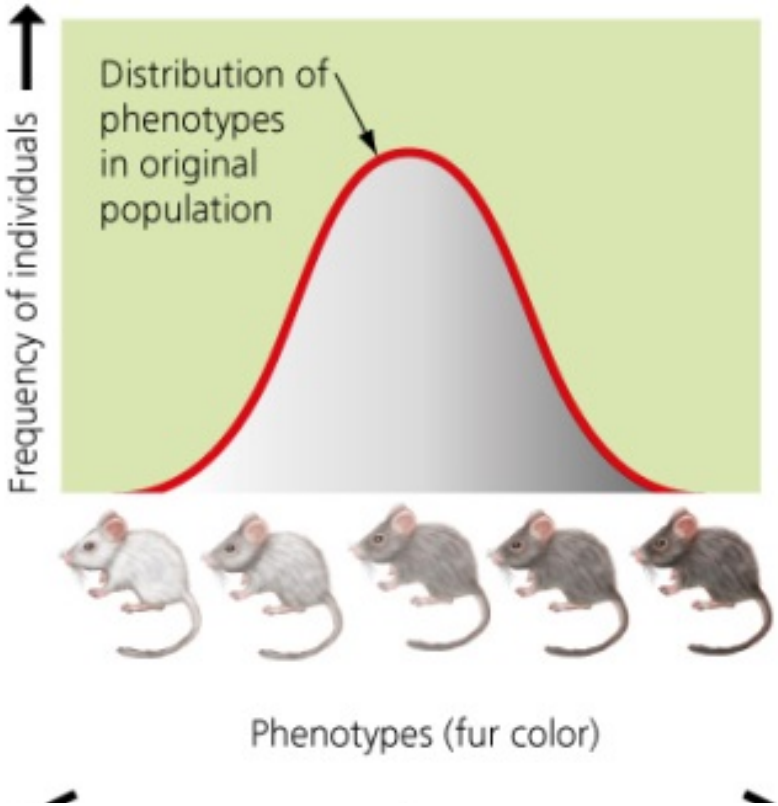
- **Sexual selection** is a form of natural selection in which individuals with certain traits are more likely than other individuals to obtain mates.
- In a more common type of sexual selection, individuals of one sex (usually females) are choosy in selecting their mates.

Three General Outcomes of Natural Selection

https://www.youtube.com/watch?v=vCHdT9MWIaA

Three General Outcomes of Natural Selection (1 of 2)

- If we graph the coat color of a population of mice, we get a bell-shaped curve.
- If natural selection favors certain fur-color phenotypes over others, the populations of mice will change over the generations and three general outcomes are possible.



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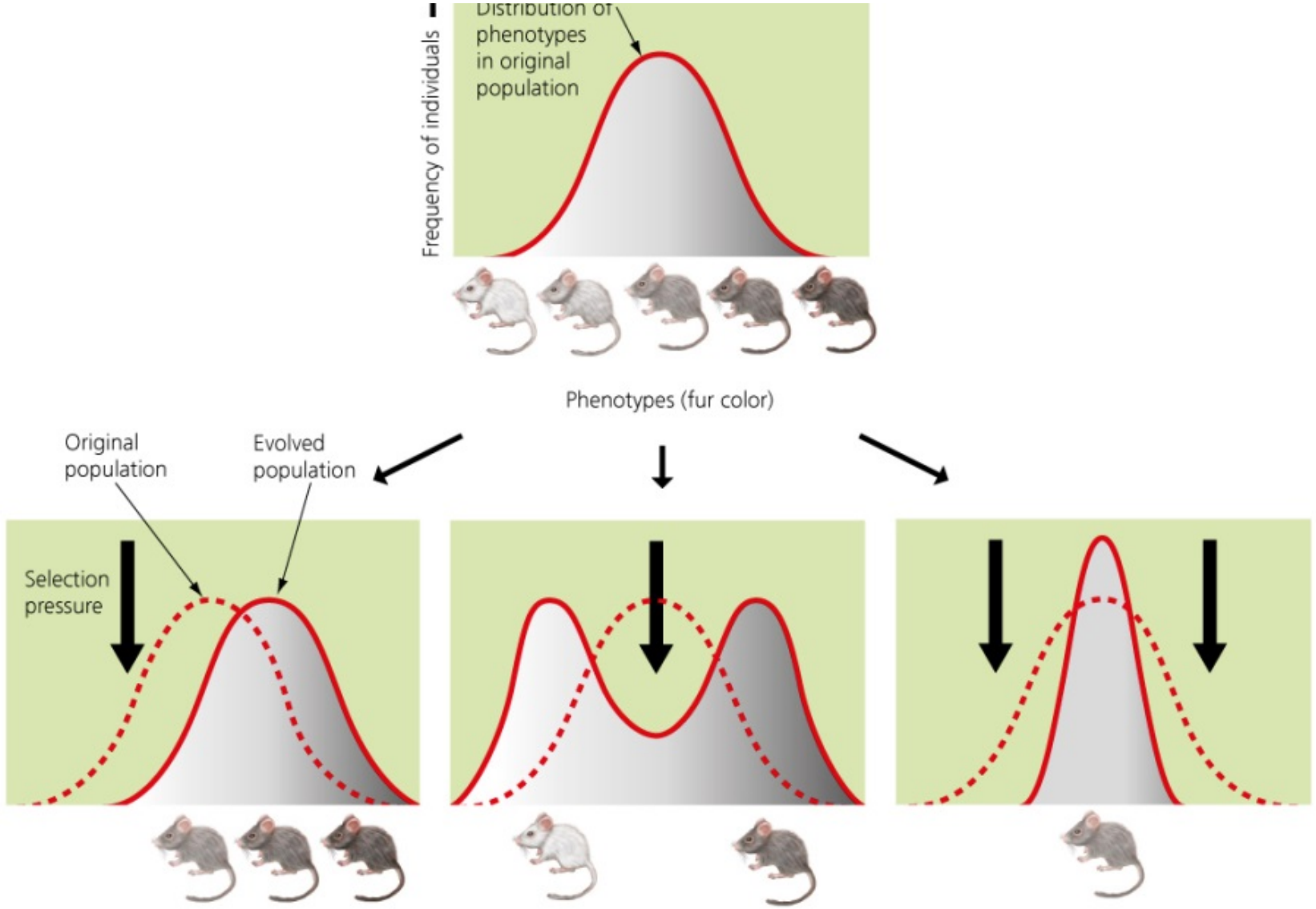

Directional selection

Darker

shifts the overall makeup to one extreme phenotype

Disruptive selection

light soil with dark rocks

balance between two or more contrasting phenotypic forms

Stabilizing selection

Medium color environment

favors intermediate phenotypes, occurs in relatively stable environments

Most common

Molecular basis for natural selection

Natural selection involves passing the specific traits to the offspring

➔ Thus, this requires Genetic variation

Source of Genetic variation

1. Mutation

- Mutation is the ultimate source of the genetic variation because new alleles originate by mutation, a change in the nucleotide sequence of DNA.
  - In multicellular organisms, however, only mutations in gametes can be passed to offspring and affect a population's genetic variability.

- A change as small as a single nucleotide in a protein-coding gene can have a significant effect on phenotype, as in sickle-cell disease.
- Often Mutation that affects a protein's function is harmful.

  ➔ however, on rare occasions, a mutated allele may

  1) improve the adaptation of an individual to its environment

  2) enhance its reproductive success.
- This kind of effect is more likely when the environment is changing in such a way that mutations that were once disadvantageous are favorable under the new conditions

Source of Genetic variation

1. Mutation

- Chromosomal mutations that delete, disrupt, or rearrange many gene loci at once are almost certain to be harmful.
- But duplication of a gene or small pieces of DNA through errors in meiosis can
  - provide an important source of genetic variation and
  - eventually lead to new genes with novel functions.
- In prokaryotes, mutations can quickly generate genetic variation in a population, and because bacteria are haploid, with a single allele for each gene, a new allele can have an effect immediately.
- Animals and plants
  - average about one mutation in every 100,000 genes per generation,
  - have long time spans between generations, and
  - have diploid genomes that prevent most mutations from significantly affecting genetic variation from one generation to the next.

Source of Genetic variation

2. Process of Sexual Reproduction

- In organisms that reproduce sexually, most genetic variation in a population results from the unique combination of alleles that each individual inherits.
- Fresh assortments of existing alleles arise every generation from three random components of sexual reproduction:
    1. independent orientation of homologous chromosomes at metaphase I of meiosis,
    2. crossing over, and
    3. random fertilization.

Oher mechanisms of Evolution in addition to Natural Selection

- The three main causes of evolutionary change are
  1. natural selection,
  2. genetic drift, and
  3. gene flow.
- Natural selection is the most important, because it is the only process that promotes adaptation.

https://www.youtube.com/watch?v=SRWXEMII0_U

From 5’

Genetic Drift

- **Genetic drift** is a change in the gene pool of a small population due to chance

- The smaller population ➔ the higher changes of the offspring do not follow the general rule of probability

https://www.youtube.com/watch?v=W0TM4LQmoZY

Genetic Drift

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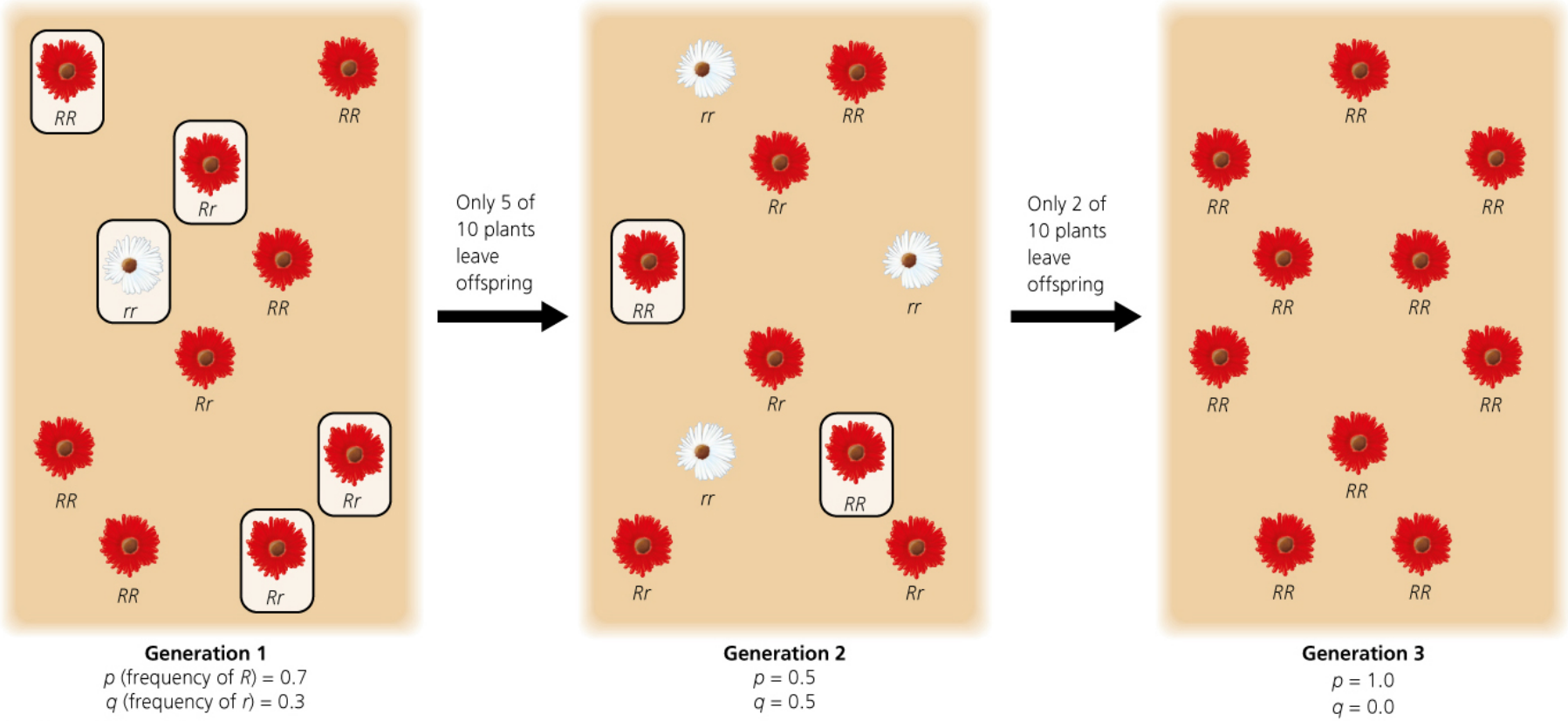


Generation 1
p (frequency of R) = 0.7
q (frequency of r) = 0.3

Generation 2
p = 0.5
q = 0.5

Generation 3
p = 1.0
q = 0.0

Genetic Drift

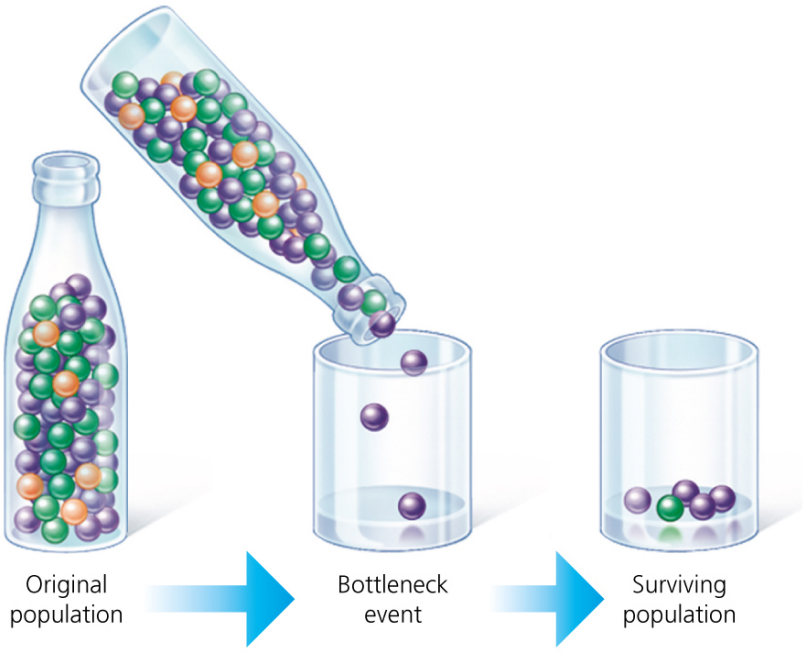
- **What could cause the shrink of population down to a size that could lead to genetic drift?**
  - **Bottle neck effect**
  - **Founder effect**

The Bottleneck Effect

The bottleneck effect is an example of genetic drift.

It results from a drastic reduction in population size which decreases the overall genetic variability in a population,

➔ results in a loss of individual variation and hence adaptability



- Cheetahs appear to have experienced at least two genetic bottlenecks:
  1. during the last ice age, about 10,000 years ago, and
  2. during the 1800s, when farmers hunted the animals to near extinction.
- With so little variability, cheetahs today have a reduced capacity to adapt to environmental challenges.

The Bottleneck Effect

- The **founder effect**
  - is likely when a few individuals colonize an isolated habitat,
  - represents genetic drift in a new colony, and
  - E.g. Amish community ➔ intermarriage ➔ genetically separated from the large population ➔high frequency of certain genetic disorders

Oher mechanisms of Evolution in addition to Natural Selection

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  3. gene flow.

Gene Flow

- **Gene flow**
  - is another source of evolutionary change,
  - is genetic exchange with another population,
  - may result in the gain or loss of alleles, and
  - tends to reduce genetic differences between populations.

The pollen of some plants can be carried by the wind for hundreds of miles, allowing gene flow to occur between distant populations

Oher mechanisms of Evolution in addition to Natural Selection

Summary

https://www.youtube.com/watch?v=SRWXEMII0_U

Whatch entire video at home

Analyzing Gene Pools (1 of 2)

- Imagine a wildflower population with two varieties of colors.
  - An allele for red flowers : *R*, dominant
  - An allele for white flowers: *r*, recessive
  - Now, let's say that 80%, or 0.8, of all flower-color loci in the gene pool have the *R* allele ➔ *p* will represent the relative frequency of the *R* allele in the population.
  - Because there are only two alleles the frequency, called q, for the other allele r will be 0.2

Allele frequencies	$p + q = 1$

Analyzing Gene Pools (1 of 2)

- Gene pool?

  all copies of every type of allele at every locus in all members of the populations

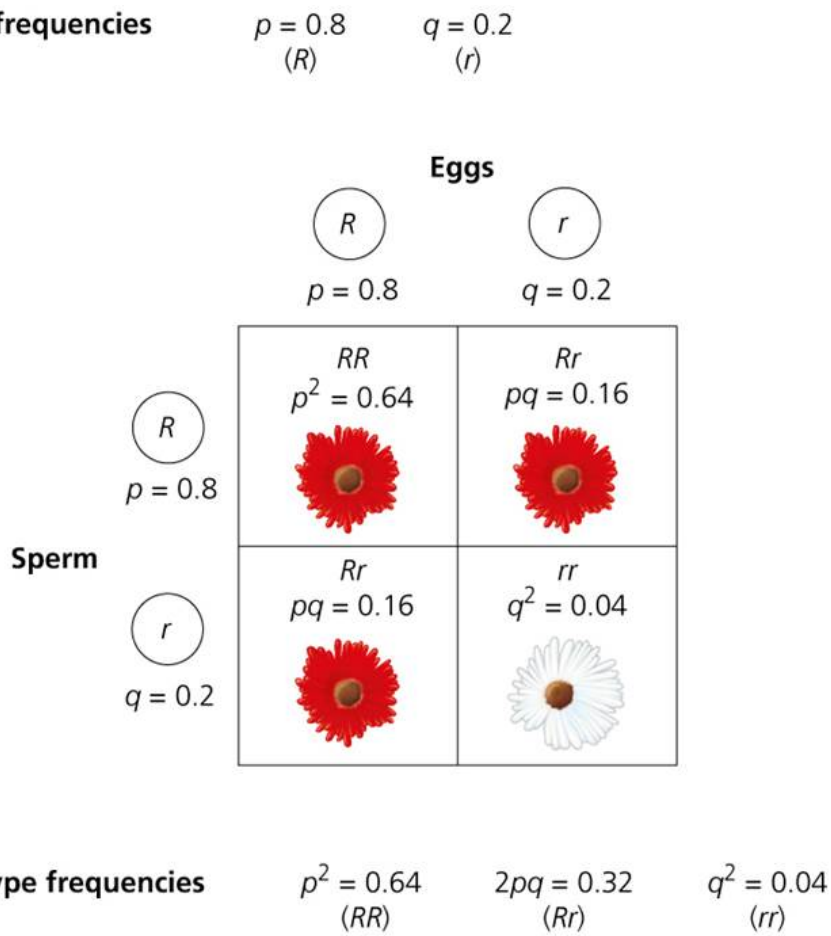
Analyzing Gene Pools (1 of 2)

- How can we calculate the frequencies of the genotypes (Assumption: gene pool completely stable)

$$p^2 + 2pq + q^2 = 1$$

Dominant homozygotes — Heterozygotes — Recessive homozygotes

Hardy-Weinberg equation



Whatch this right after the class for review

https://www.youtube.com/watch?v=SRWXEMlI0_U

Population Genetics and Health Science

- Public health scientists use the Hardy-Weinberg equation to calculate the percentage of a human population that carries the allele for certain inherited diseases.
- Phenylketonuria (PKU) is a recessive allele that prevents the breakdown of the amino acid phenylalanine and occurs in about one out of every 10,000 babies born in the United States.
- People with PKU must strictly regulate their dietary intake of the amino acid phenylalanine.