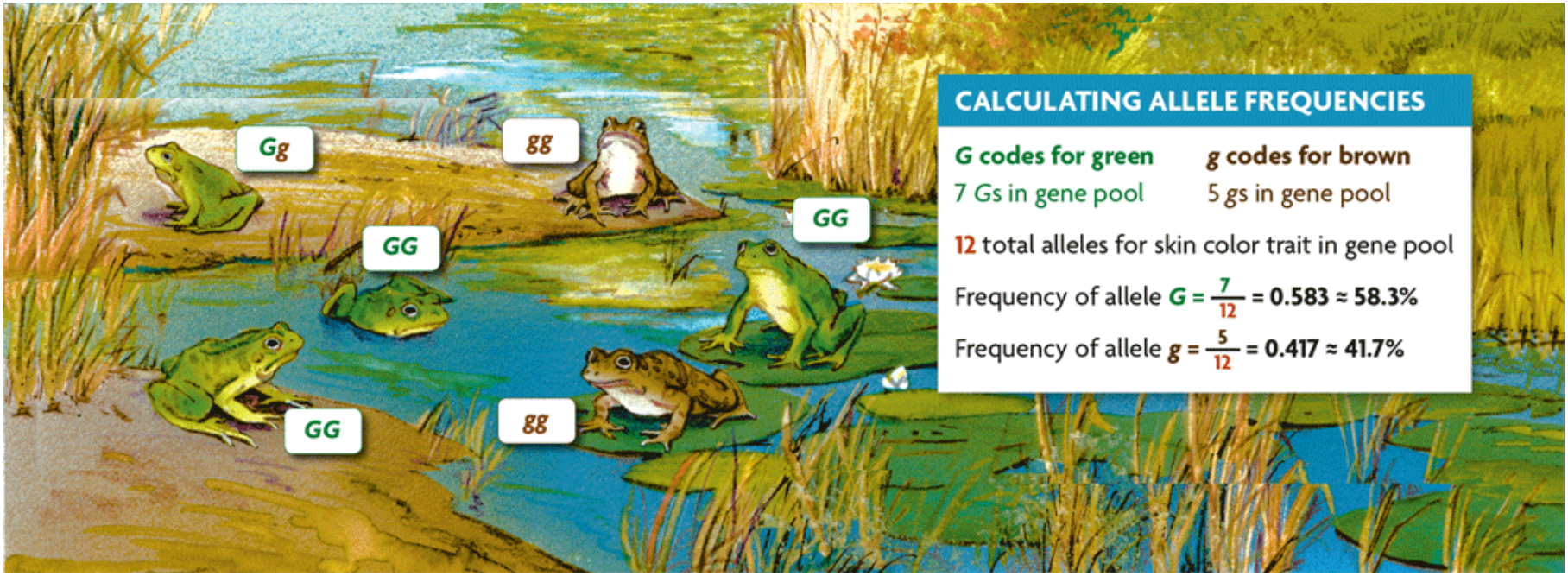
KEY CONCEPT

A population shares a common gene pool.

Genetic variation in a population increases the chance that some individuals will survive.

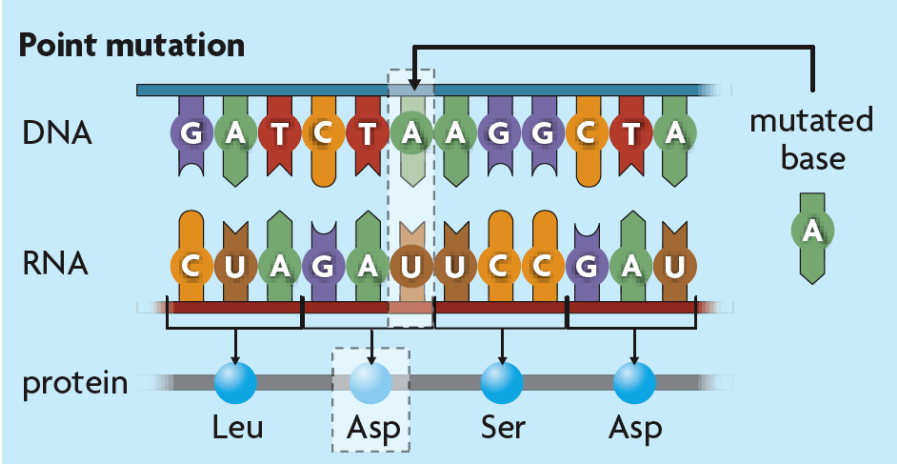
- Genetic variation leads to phenotypic variation.
- Phenotypic variation is necessary for natural selection.
- Genetic variation is stored in a population's gene pool.
  - made up of all alleles in a population
  - allele combinations form when organisms have offspring

- Allele frequencies measure genetic variation.
  - measures how common allele is in population
  - can be calculated for each allele in gene pool

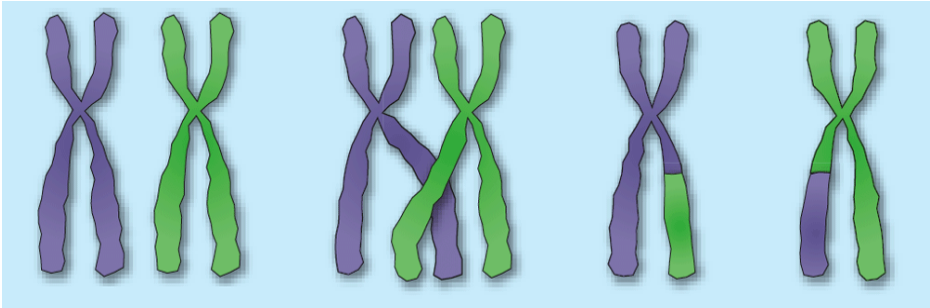


Genetic variation comes from several sources.

- Mutation is a random change in the DNA of a gene.
  - can form new allele
  - can be passed on to offspring if in reproductive cells



- Recombination forms new combinations of alleles.
  - usually occurs during meiosis
  - parents' alleles arranged in new ways in gametes



Genetic variation comes from several sources.

- Hybridization is the crossing of two different species.
  - occurs when individuals can't find mate of own species
  - topic of current scientific research

<u>Microevolution</u> is evolution within a population.

- observable change in the allele frequencies
- can result from natural selection

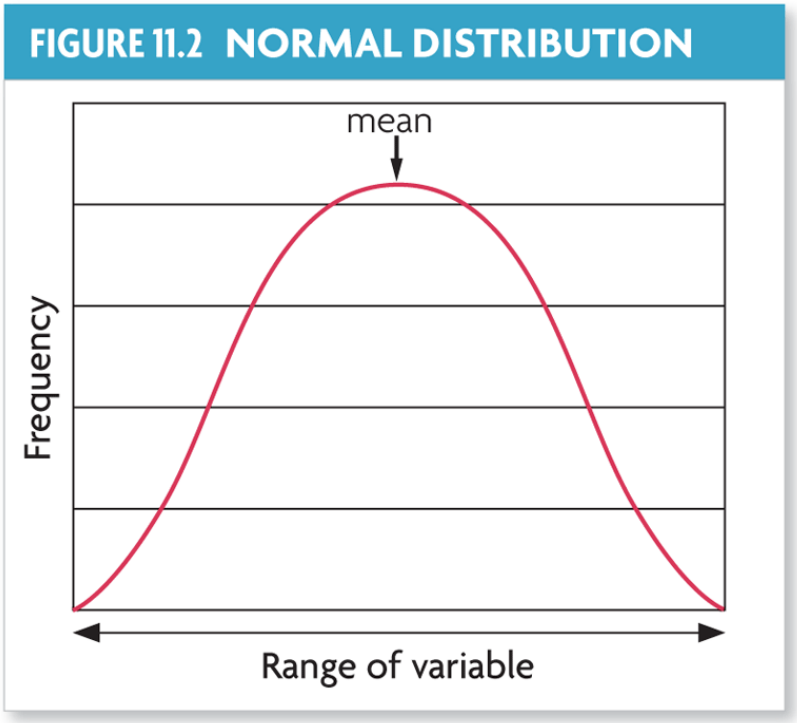
Natural selection explains how evolution can occur.

- There are four main principles to the theory of natural selection.
  - Variation
  - overproduction
  - adaptation
  - descent with modification

- Fitness is the measure of survival ability and ability to produce more offspring.

Natural selection acts on distributions of traits.

- A normal distribution graphs as a bell-shaped curve.
  - highest frequency near mean value
  - frequencies decrease toward each extreme value

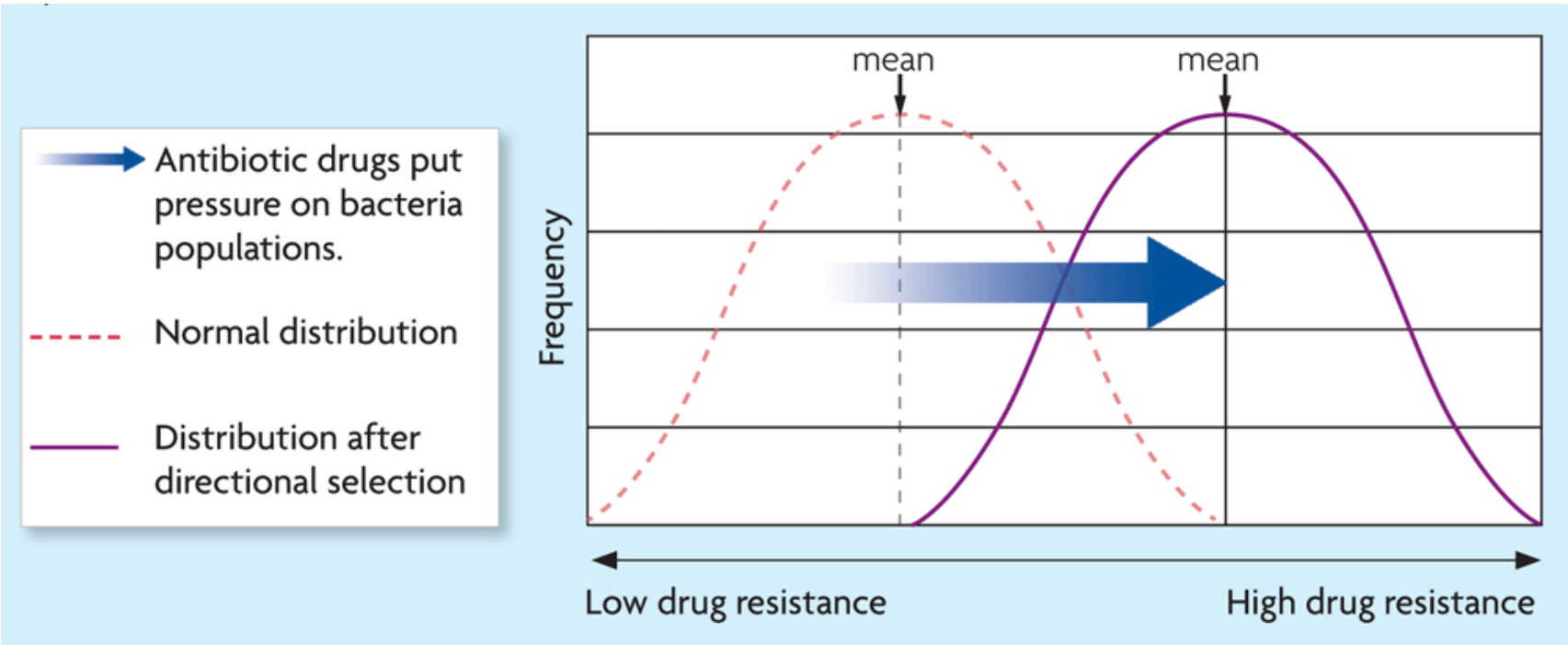


- Traits not undergoing natural selection have a normal distribution.

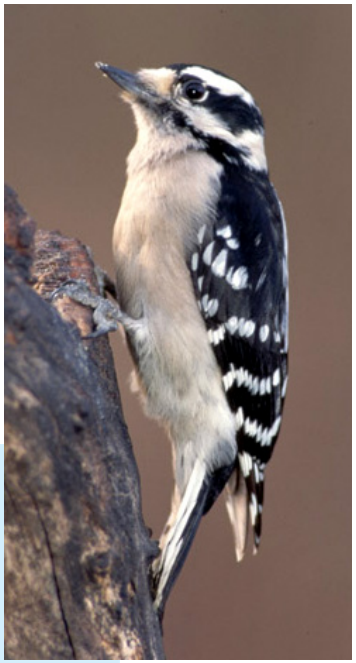
There are three ways Natural Selection can change the distribution of a trait.

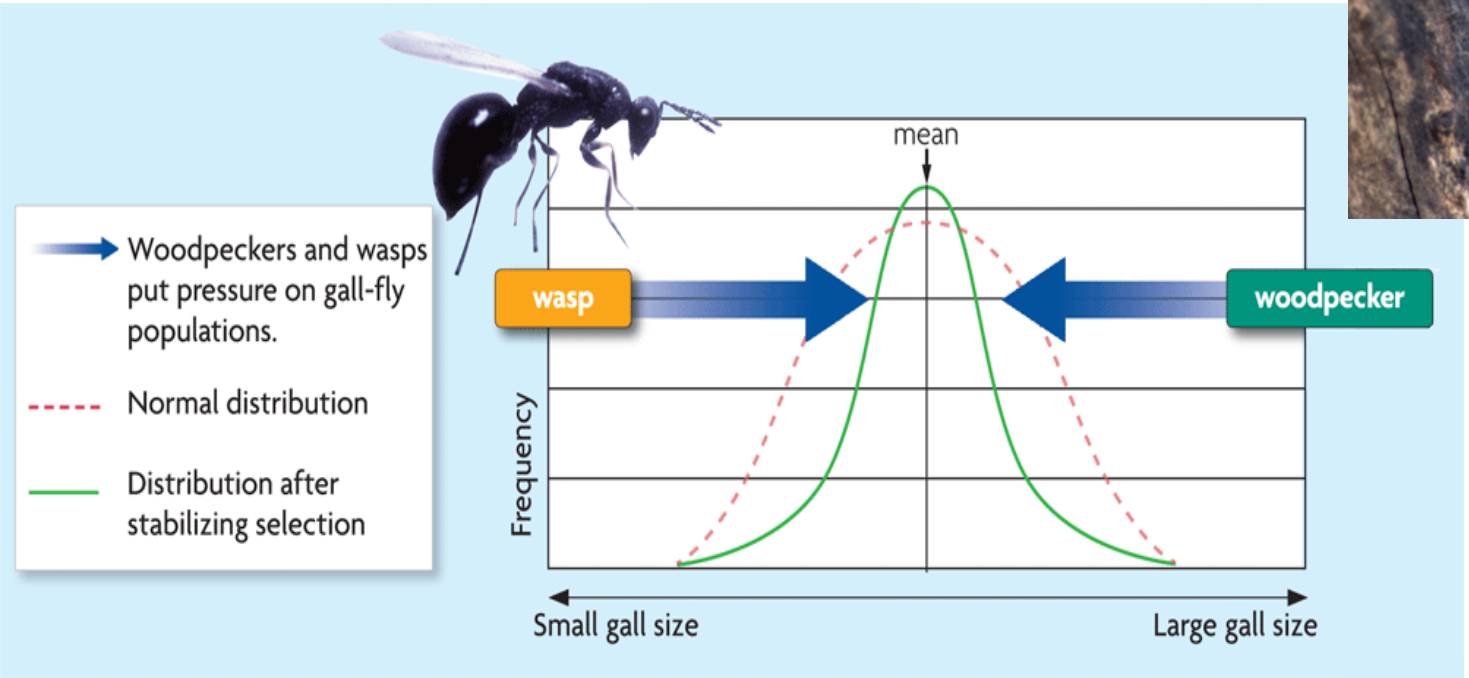
- Directional Selection
- Stabilizing Selection
- Disruptive Selection

- Natural selection can take one of three paths.
  - Directional selection favors phenotypes at one extreme.

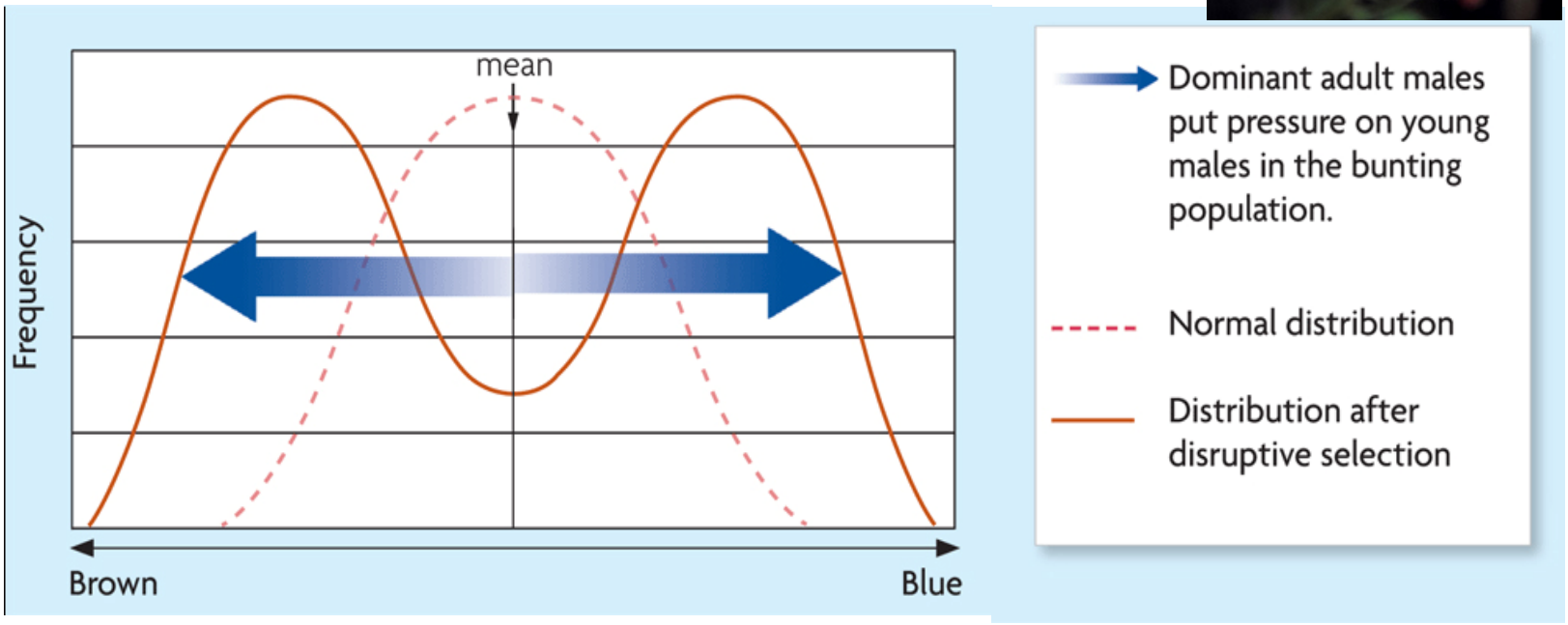


- Natural selection can take one of three paths.
  - Stabilizing selection favors the intermediate phenotype.





- Natural selection can take one of three paths.
  - Disruptive selection favors both extreme phenotypes.



KEY CONCEPT

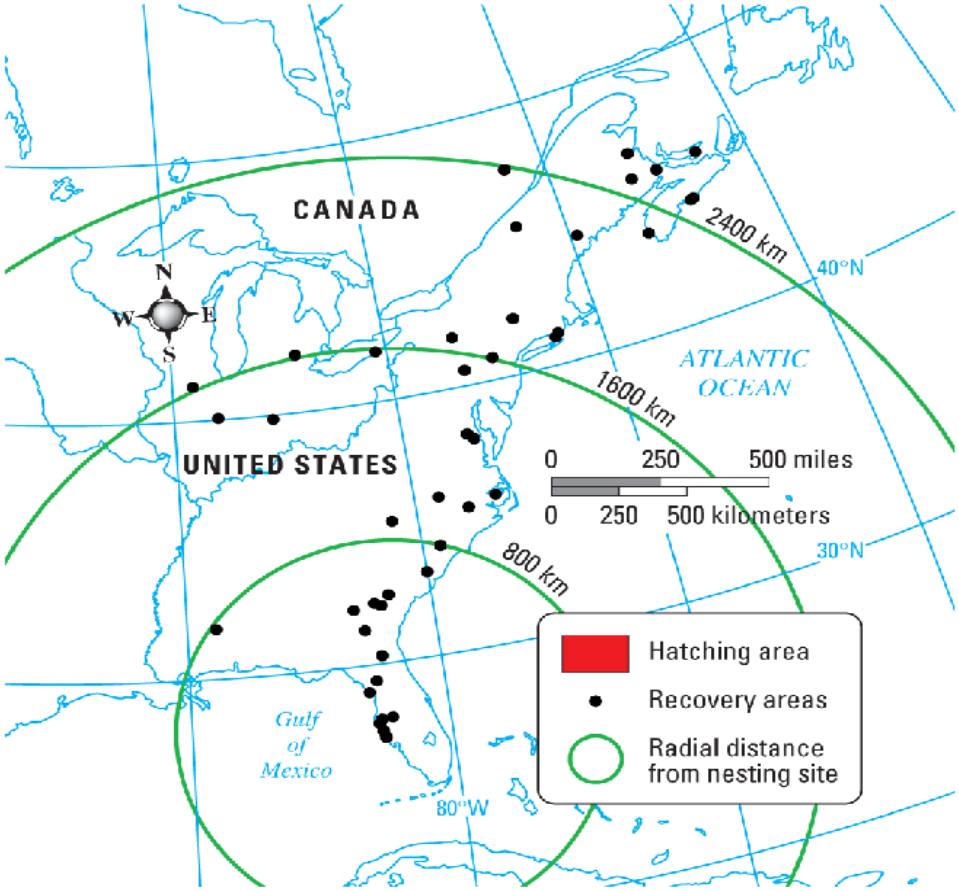
Populations, not individuals, evolve.

KEY CONCEPT

Natural selection is not the only mechanism through which populations evolve.

Gene flow is the movement of alleles between populations.

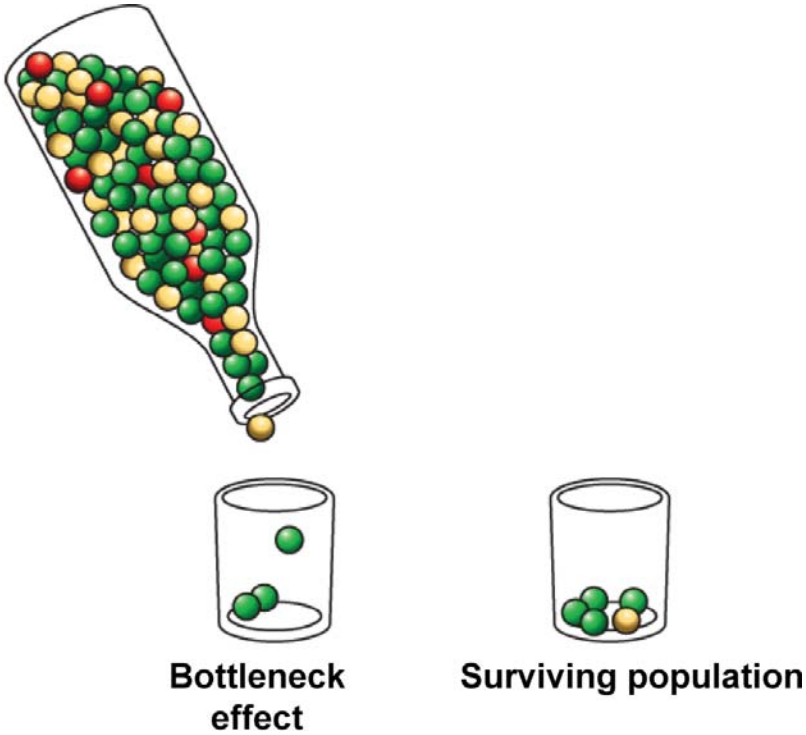
- Gene flow occurs when individuals join new populations and reproduce.
- Gene flow keeps neighboring populations similar.
- Low gene flow increases the chance that two populations will evolve into different species.



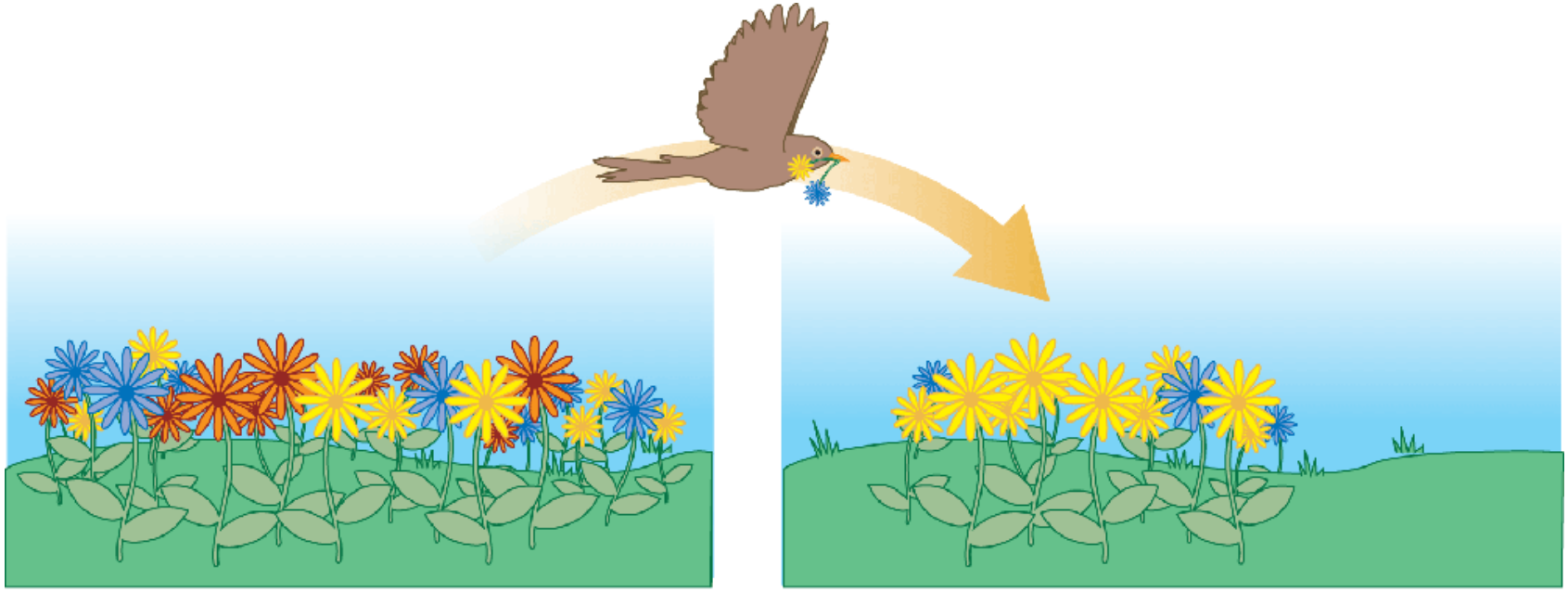
bald eagle migration

Genetic drift is a change in allele frequencies due to chance.

- Genetic drift causes a loss of genetic diversity.
- It is most common in small populations.
- A population bottleneck can lead to genetic drift.
  - It occurs when an event drastically reduces population size.
  - The bottleneck effect is genetic drift that occurs after a bottleneck event.



- The founding of a small population can lead to genetic drift.
  - It occurs when a few individuals start a new population.
  - The founder effect is genetic drift that occurs after start of new population.



- Genetic drift has negative effects on a population.
  - less likely to have some individuals that can adapt
  - harmful alleles can become more common due to chance

Sexual selection occurs when certain traits increase mating success.

- Sexual selection occurs due to higher cost of reproduction for females.
  - males produce many sperm continuously
  - females are more limited in potential offspring each cycle

- There are two types of sexual selection.
  - intrasexual selection: competition among males
  - intersexual selection: males display certain traits to females

KEY CONCEPT

Hardy-Weinberg equilibrium provides a framework for understanding how populations evolve.

- **Hardy-Weinberg equilibrium describes populations that are not evolving.**
  - Biologists use models to study populations.
  - Hardy-Weinberg equilibrium is a type of model.

- **Hardy-Weinberg equilibrium describes populations that are not evolving.**
  - Genotype frequencies stay the same if five conditions are met.
    - very large population: no genetic drift
    - no emigration or immigration: no gene flow
    - no mutations: no new alleles added to gene pool
    - random mating: no sexual selection
    - no natural selection: all traits aid equally in survival

- **Hardy-Weinberg equilibrium describes populations that are not evolving.**
  - Real populations rarely meet all five conditions.
    - Real population data is compared to a model.
    - Models are used to studying how populations evolve.

The Hardy-Weinberg equation is used to predict genotype frequencies in a population.

- Predicted genotype frequencies are compared with actual frequencies.
  - used for traits in simple dominant-recessive systems
  - must know frequency of recessive homozygotes
  - $p^2 + 2pq + q^2 = 1$

	p	q
p	p^2	pq
q	pq	q^2

VARIABLES

p = frequency of allele *T* (dominant allele)

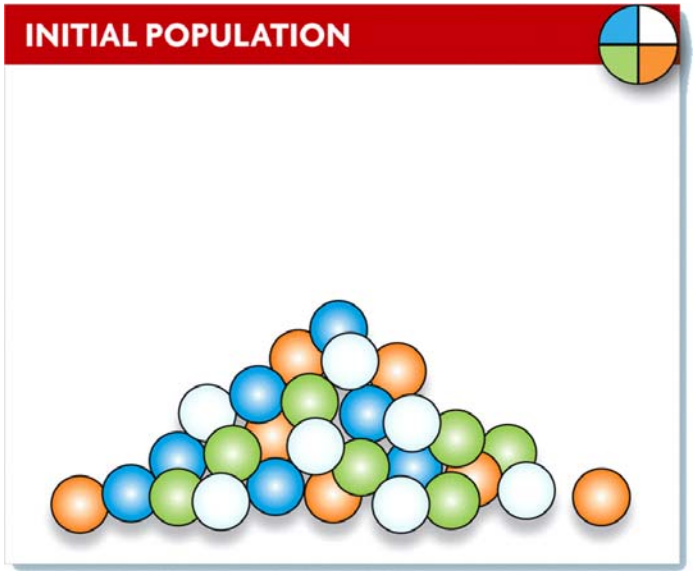
q = frequency of allele *t* (recessive allele)

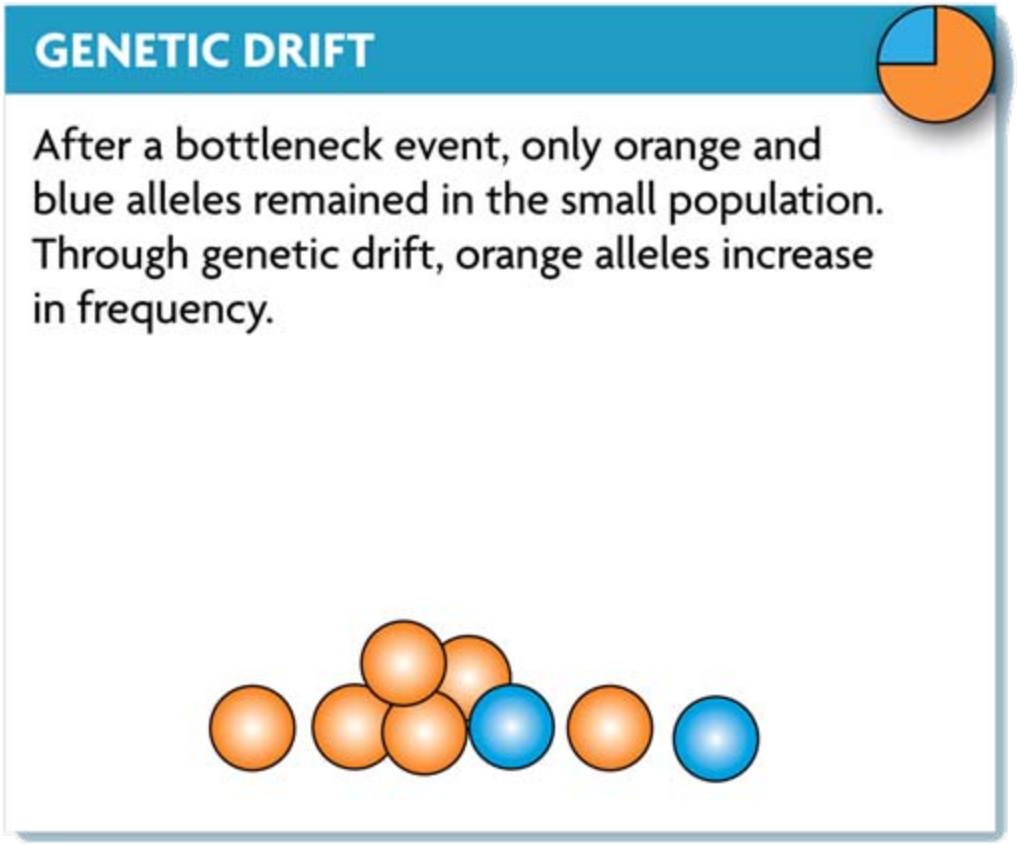
p^2 = frequency of fish with *TT* (dominant homozygous genotype)

$2pq$ = frequency of fish with *Tt* (heterozygous genotype)

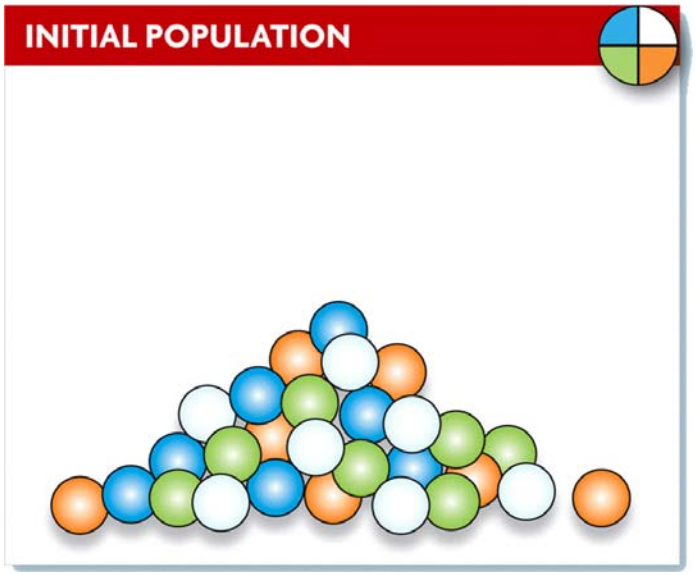
q^2 = frequency of fish with *tt* (recessive homozygous genotype)

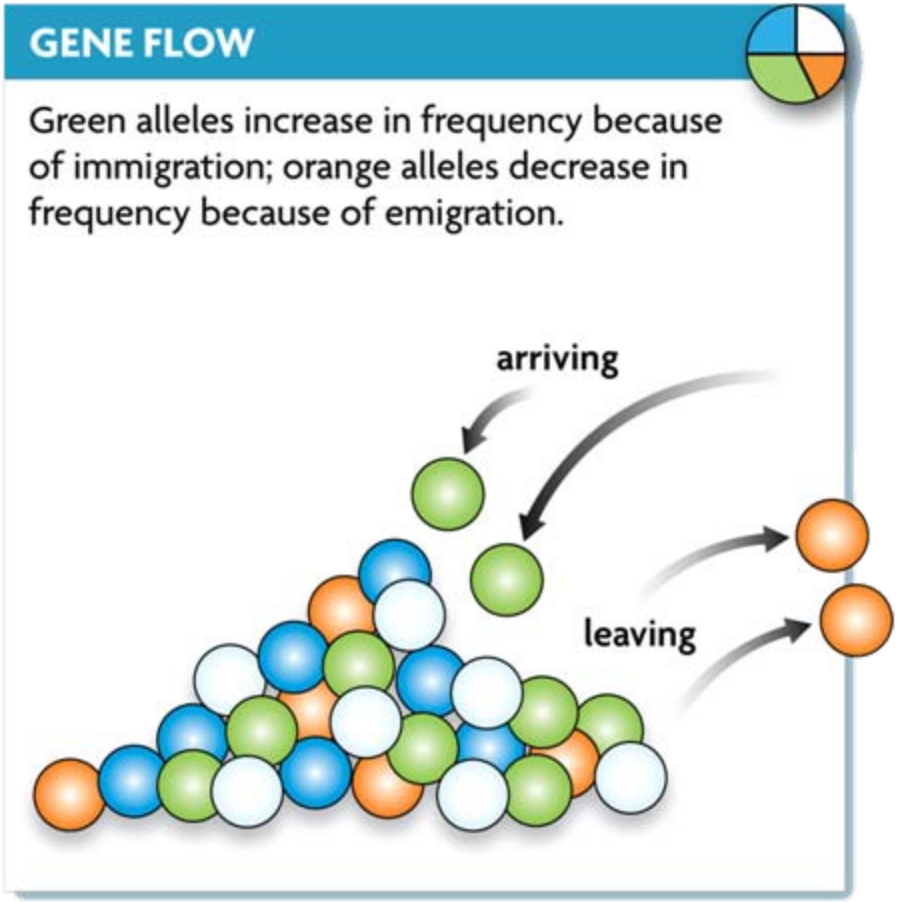
- Genetic drift changes allele frequencies due to chance alone.



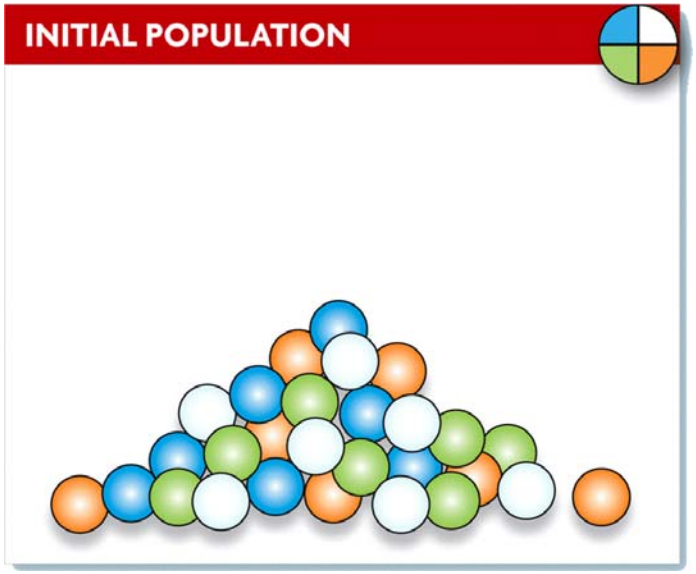


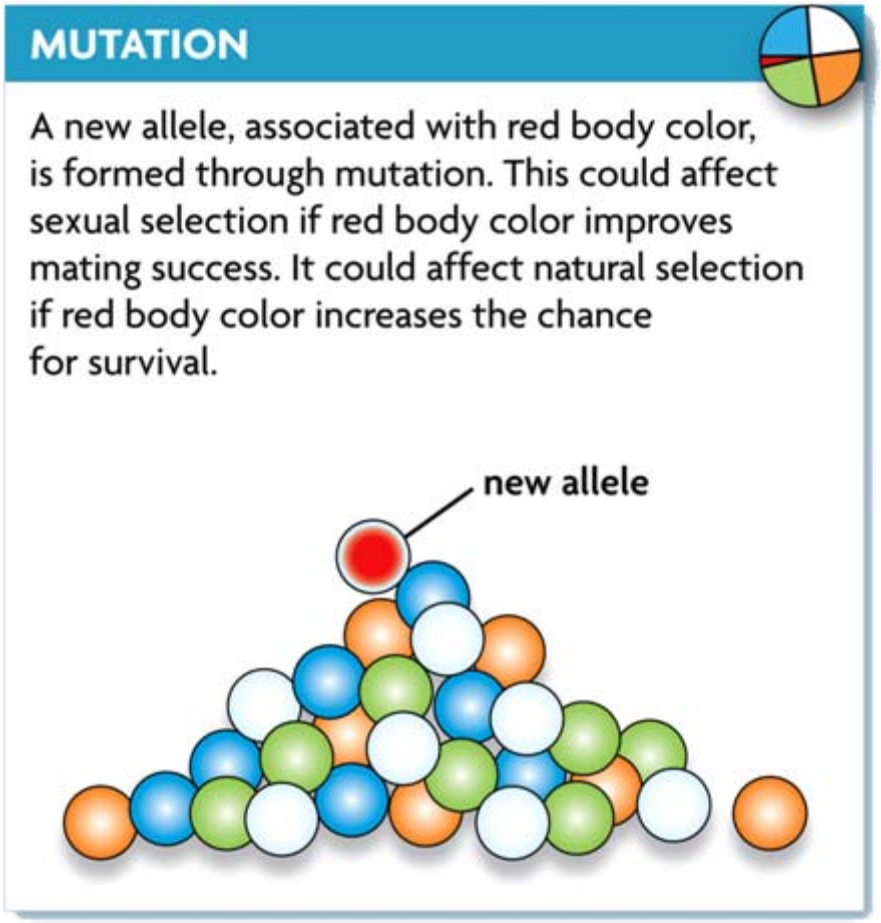
- Gene flow moves alleles from one population to another.



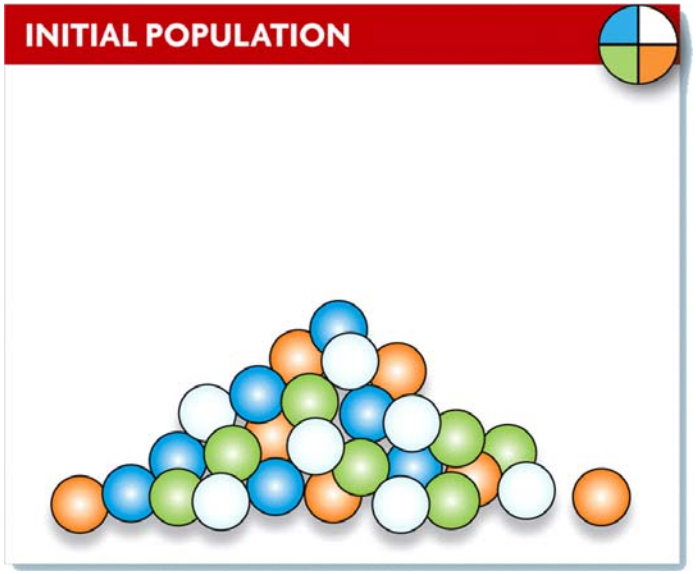


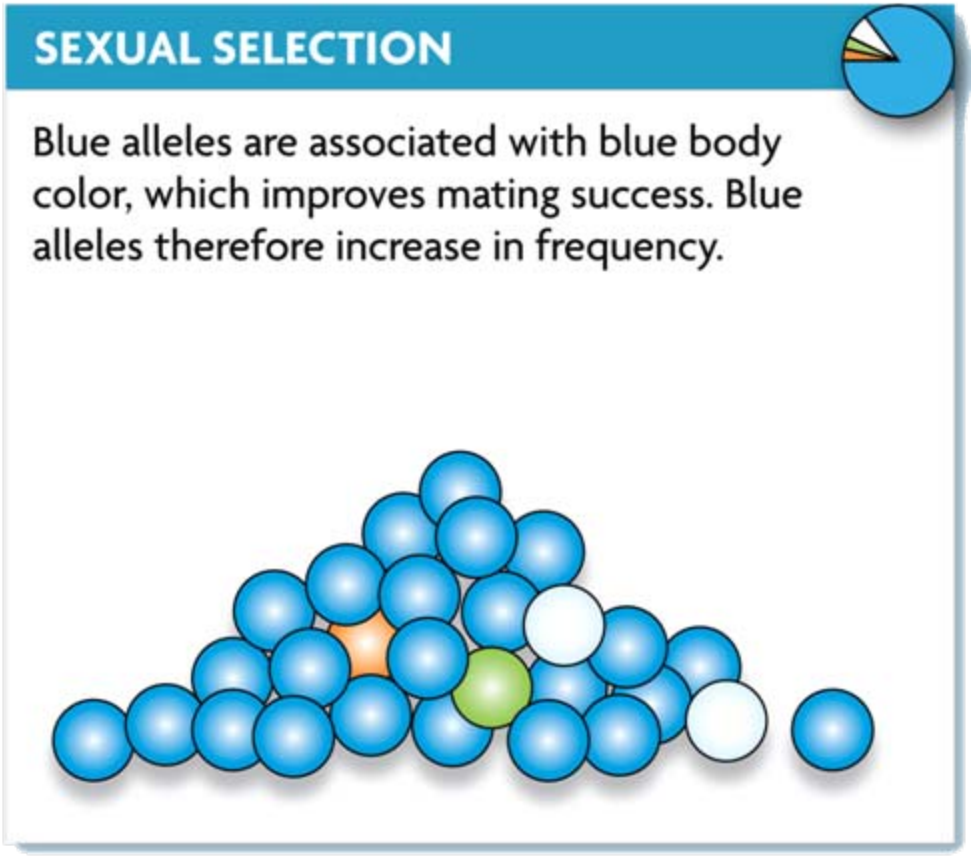
- Mutations produce the genetic variation needed for evolution.



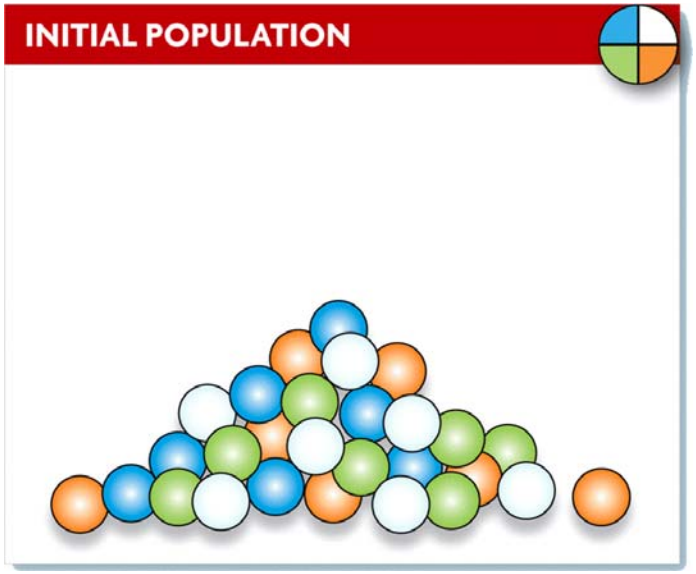


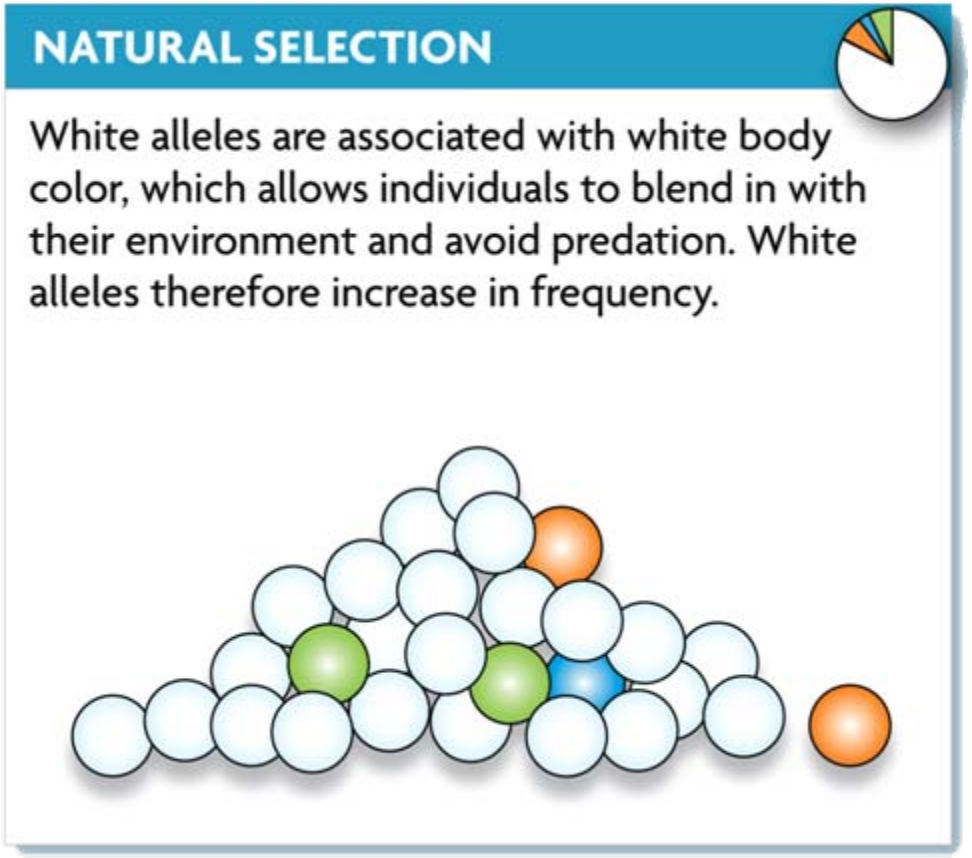
- Sexual selection selects for traits that improve mating success.





- Natural selection selects for traits advantageous for survival.





- In nature, populations evolve.
  - expected in all populations most of the time
  - respond to changing environments

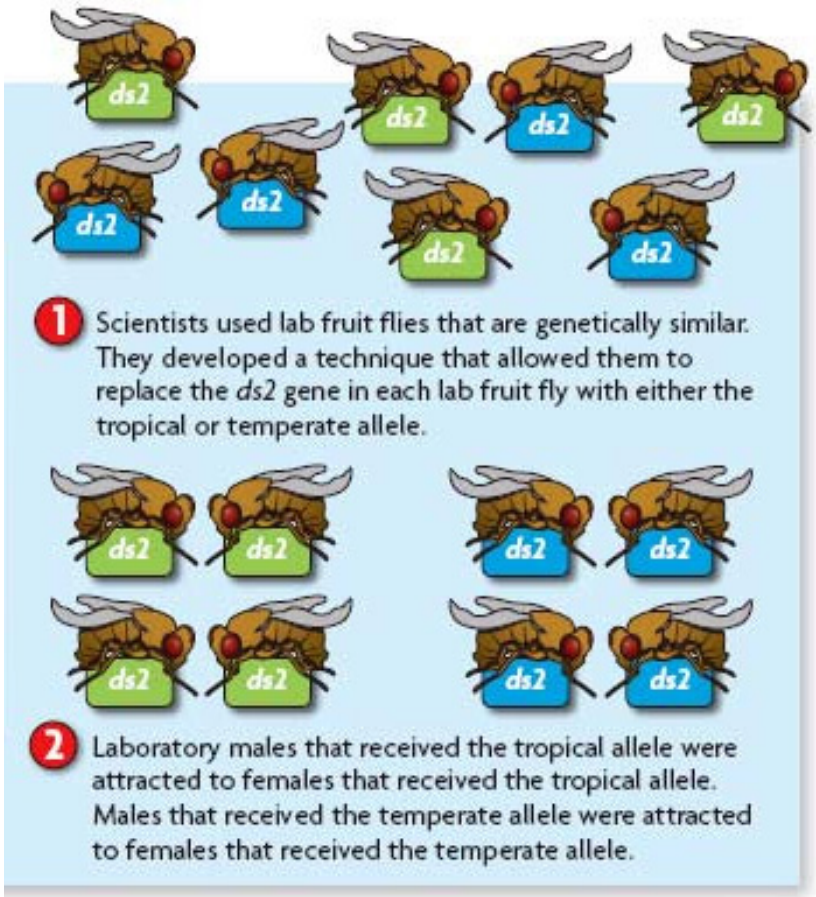
KEY CONCEPT

New species can arise when populations are isolated.

The isolation of populations can lead to speciation.

- Populations become isolated when there is no gene flow.
  - Isolated populations adapt to their own environments.
  - Genetic differences can add up over generations.

- Reproductive isolation can occur between isolated populations.
  - members of different populations cannot mate successfully
  - final step to becoming separate species

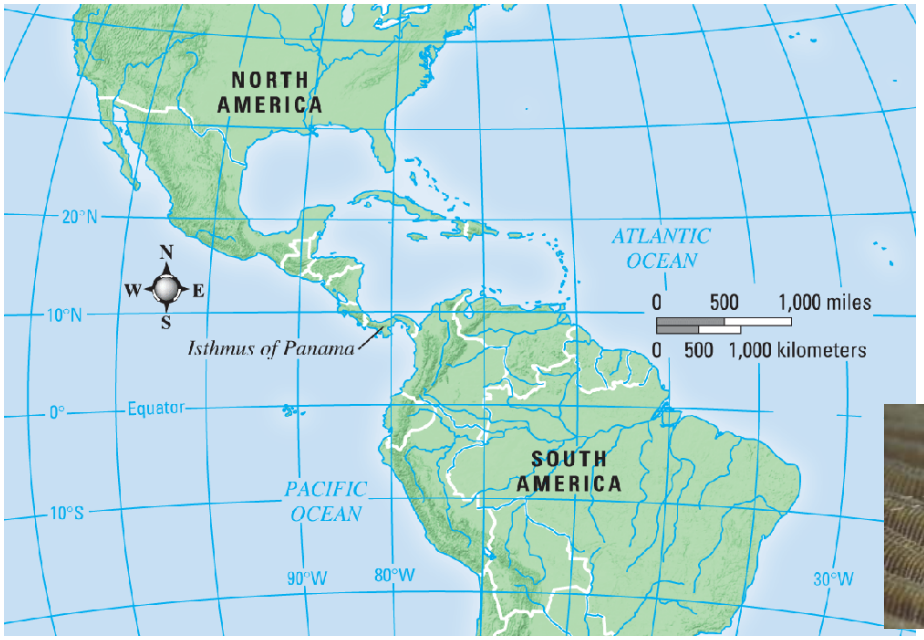


- Speciation is the rise of two or more species from one existing species.

Populations can become isolated in several ways.

- Behavioral barriers can cause isolation.
  - called behavioral isolation
  - includes differences in courtship or mating behaviors

- Geographic barriers can cause isolation.
  - called geographic isolation
  - physical barriers divide population



- Temporal barriers can cause isolation.
  - called temporal isolation
  - timing of reproductive periods prevents mating

KEY CONCEPT

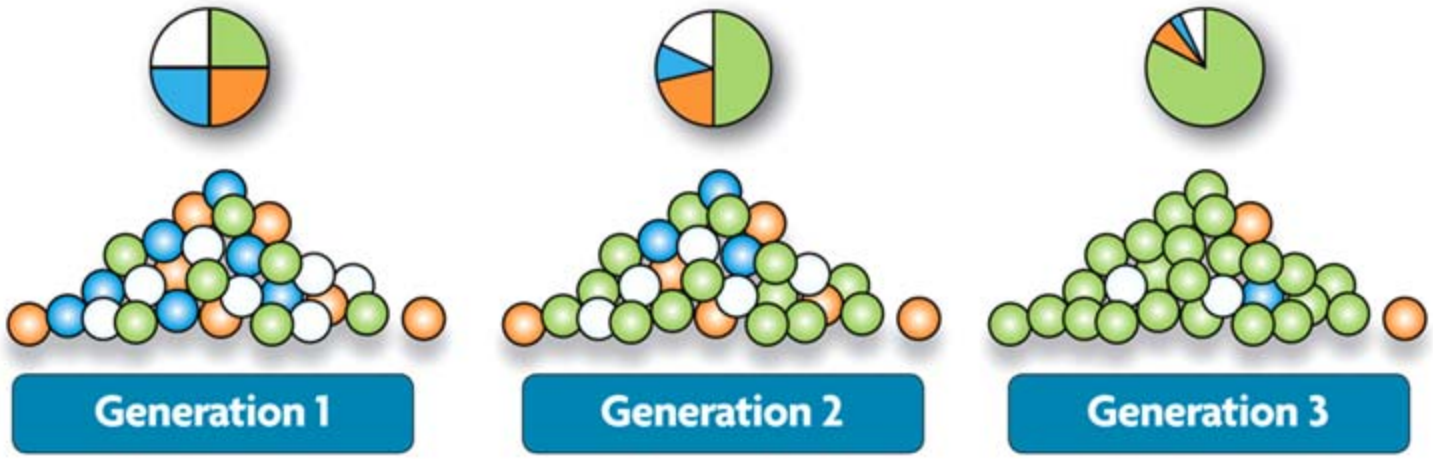
Evolution occurs in patterns.

Evolution through natural selection is not random.

- Natural selection can have direction.
- The effects of natural selection add up over time.

FIGURE 11.14 PATTERNS IN NATURAL SELECTION

In this hypothetical population, green body color is favored by natural selection. With each generation, alleles associated with green body color increase in frequency. Over time, more and more individuals in the population will have the advantageous phenotype.

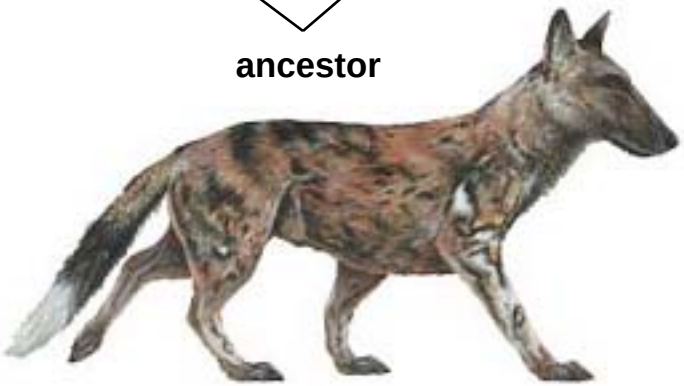


- Convergent evolution describes evolution toward similar traits in unrelated species.

- Divergent evolution describes evolution toward different traits in closely related species.

kit fox **red fox**

ancestor



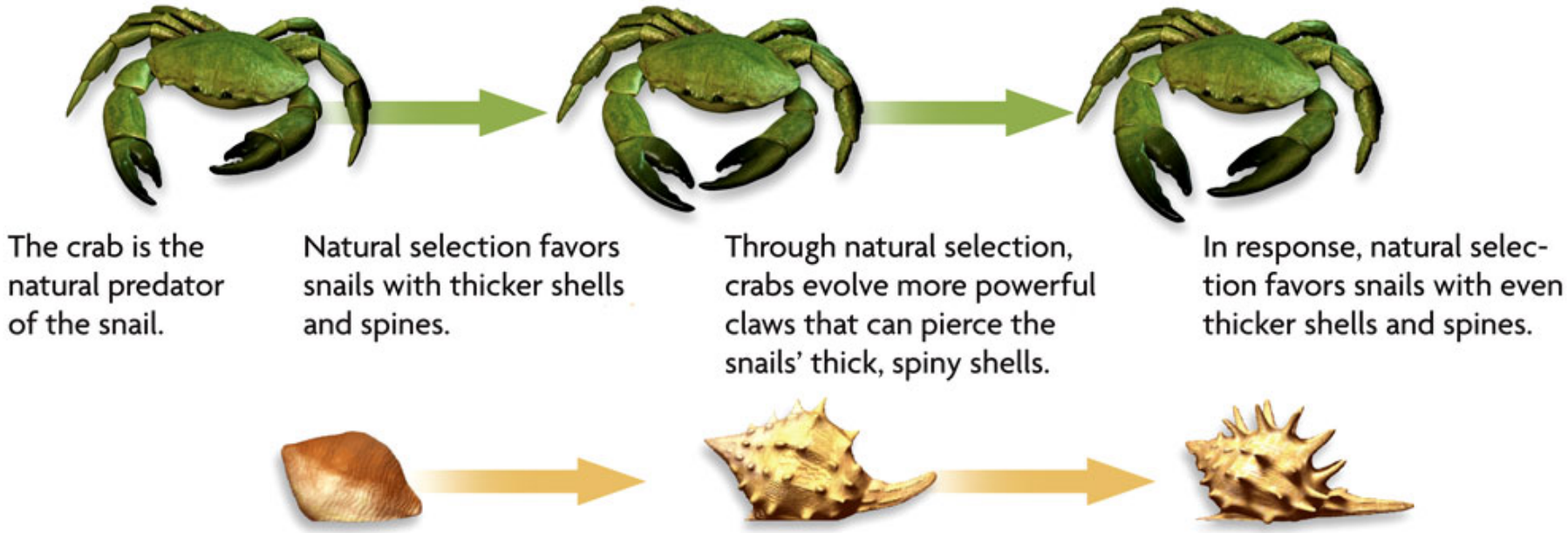
How do convergent and divergent evolution illustrate the directional nature of natural selection?

Species can shape each other over time.

- Two or more species can evolve together through coevolution.
  - evolutionary paths become connected
  - species evolve in response to changes in each other

- Coevolution can occur in beneficial relationships.

- Coevolution can occur in competitive relationships, sometimes called evolutionary.

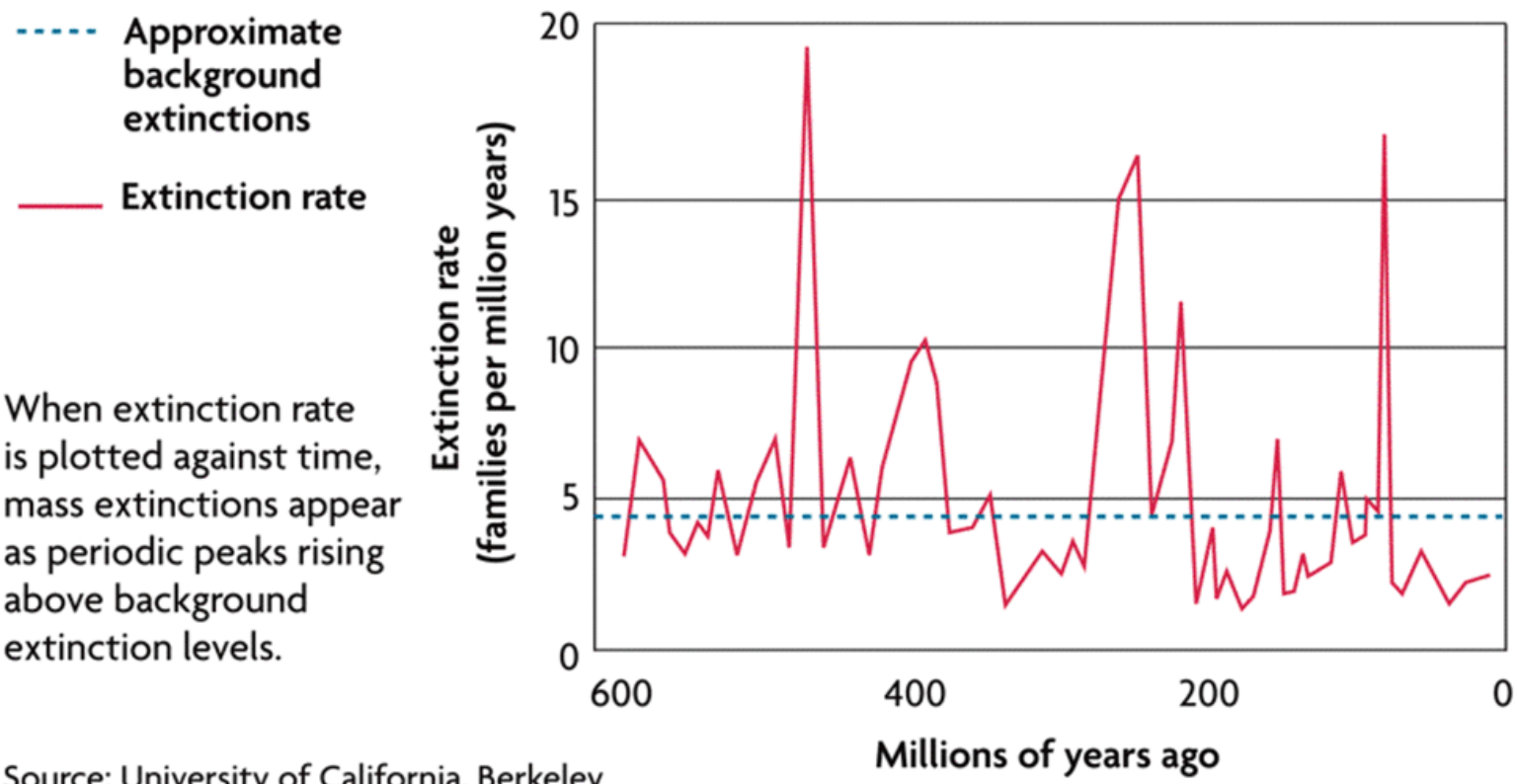


Species can become extinct.

- Extinction is the elimination of a species from Earth.
- Background extinctions occur continuously at a very low rate.
  - occur at roughly the same rate as speciation
  - usually affects a few species in a small area
  - caused by local changes in environment

- Background extinctions occur continuously at a very low rate.
  - occur at roughly the same rate as speciation
  - usually affects a few species in a small area
  - caused by local changes in environment

- Mass extinctions are rare but much more intense.
  - destroy many species at global level
  - thought to be caused by catastrophic events
  - at least five mass extinctions in last 600 million years



When extinction rate is plotted against time, mass extinctions appear as periodic peaks rising above background extinction levels.

Source: University of California, Berkeley

Speciation often occurs in patterns.

- A pattern of punctuated equilibrium exists in the fossil record.
  - theory proposed by Eldredge and Gould in 1972
  - episodes of speciation occur suddenly in geologic time
  - followed by long periods of little evolutionary change
  - revised Darwin’s idea that species arose through gradual transformations

- Many species evolve from one species during adaptive radiation.
  - ancestral species diversifies into many descendent species
  - descendent species usually adapted to wide range of environments