The relationship between genetic variation and evolution

Learning objective

- explain the relationship between genetic variation and evolution

Success criteria

1. Name at least three ways due to which the initial population can change and use natural selection to explain results of a certain change in natural environment.

2. Explain interrelation between hereditary variation and evolution.

Terminology

- Natural selection, genetic variation, gene/allele variability, genetype, phenotype, mutation, formation of new allele, rapid reproduction, sexual reproduction, the struggle for survival, speciation, gene pool.
- **Stabilising selection**
- **Directional selection**
- **Disruptive selection**

Common Forms of Natural Selection

- 1. Stabilizing Selection
- 2. Directional Selection
- 3. Disruptive Selection
- 4. Sexual Selection

Darwin's theory of natural selection

depends on:

- Overproduction
- A struggle for existence
- Variation within a species and
- Survival of the fittest

Lamarck has an alternative proposal!
Darwin believed:

Lamarck: Environmental causes variation

This is called inheritance of acquired characteristics.

Natural selection

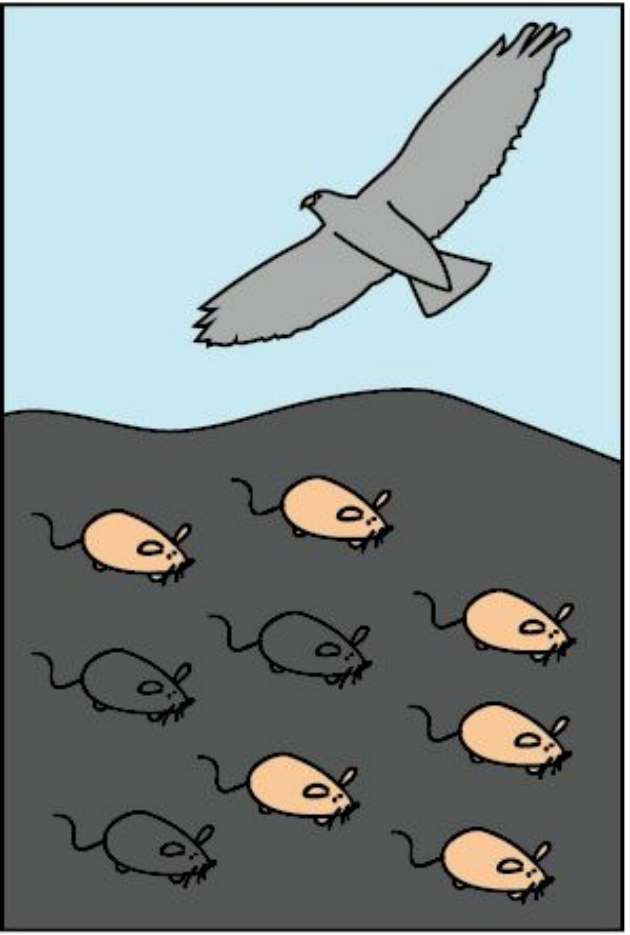
- Natural selection operates on individuals, or rather on their phenotypes.
- The concept of natural selection is based on differential success is **survival** and **reproduction**.
- In genetic terms, selection results in alleles being passed to the next generation in proportions that differ from those in the present generation.
- Natural selection causes **change to gene pools**.

Natural selection

- Natural selection causes the **frequency of certain alleles** to **increase or decrease** in a **population**.

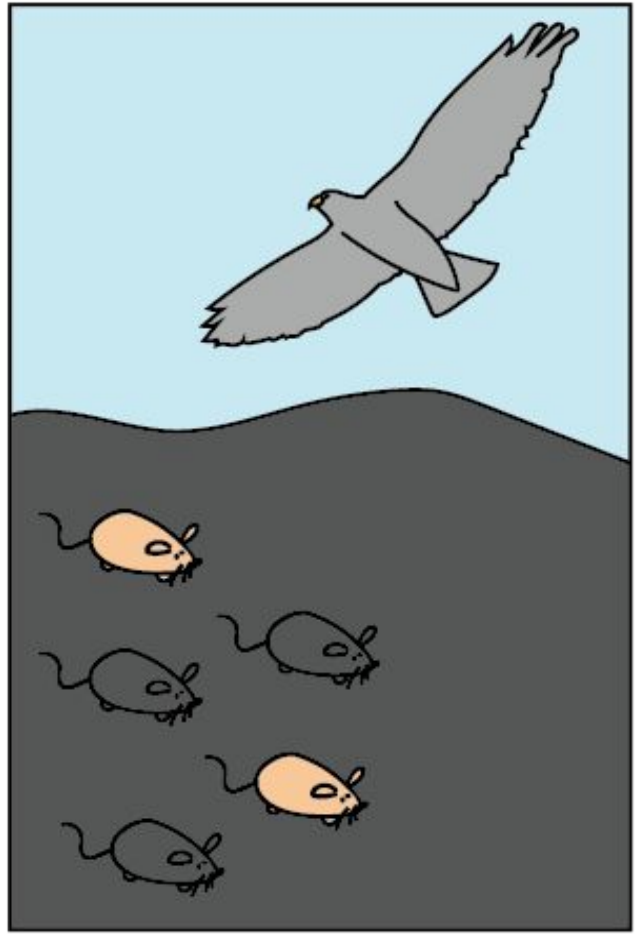
Selection pressure

- Predation by foxes is an example of a selection pressure. Selection pressures increase the chances of some alleles being passed on to the next generation, and decrease the chances of others.



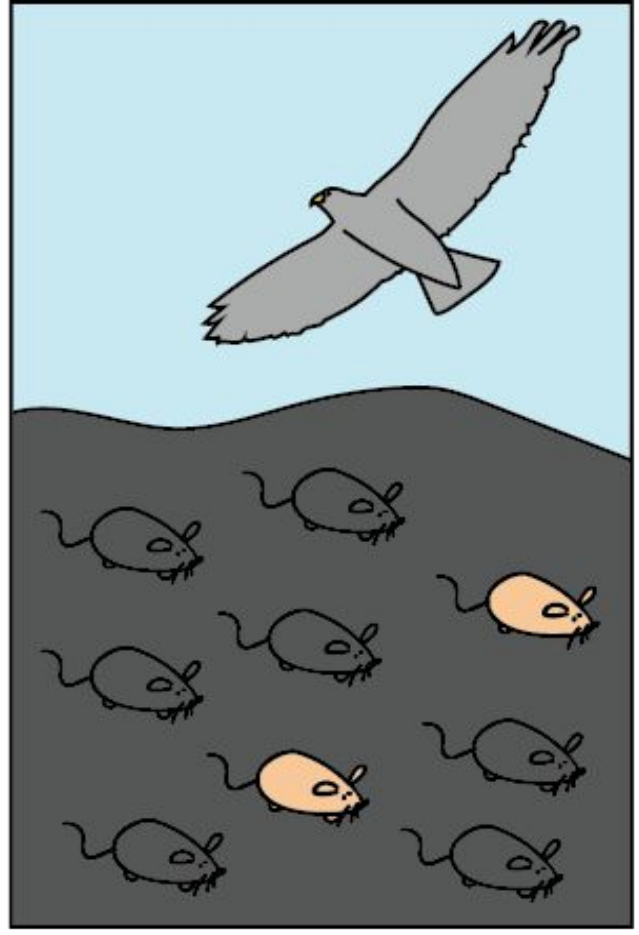
A population of mice has moved into a new area where the rocks are very dark. Due to natural genetic variation, some mice are black, while others are tan.

Some mice are eaten by birds

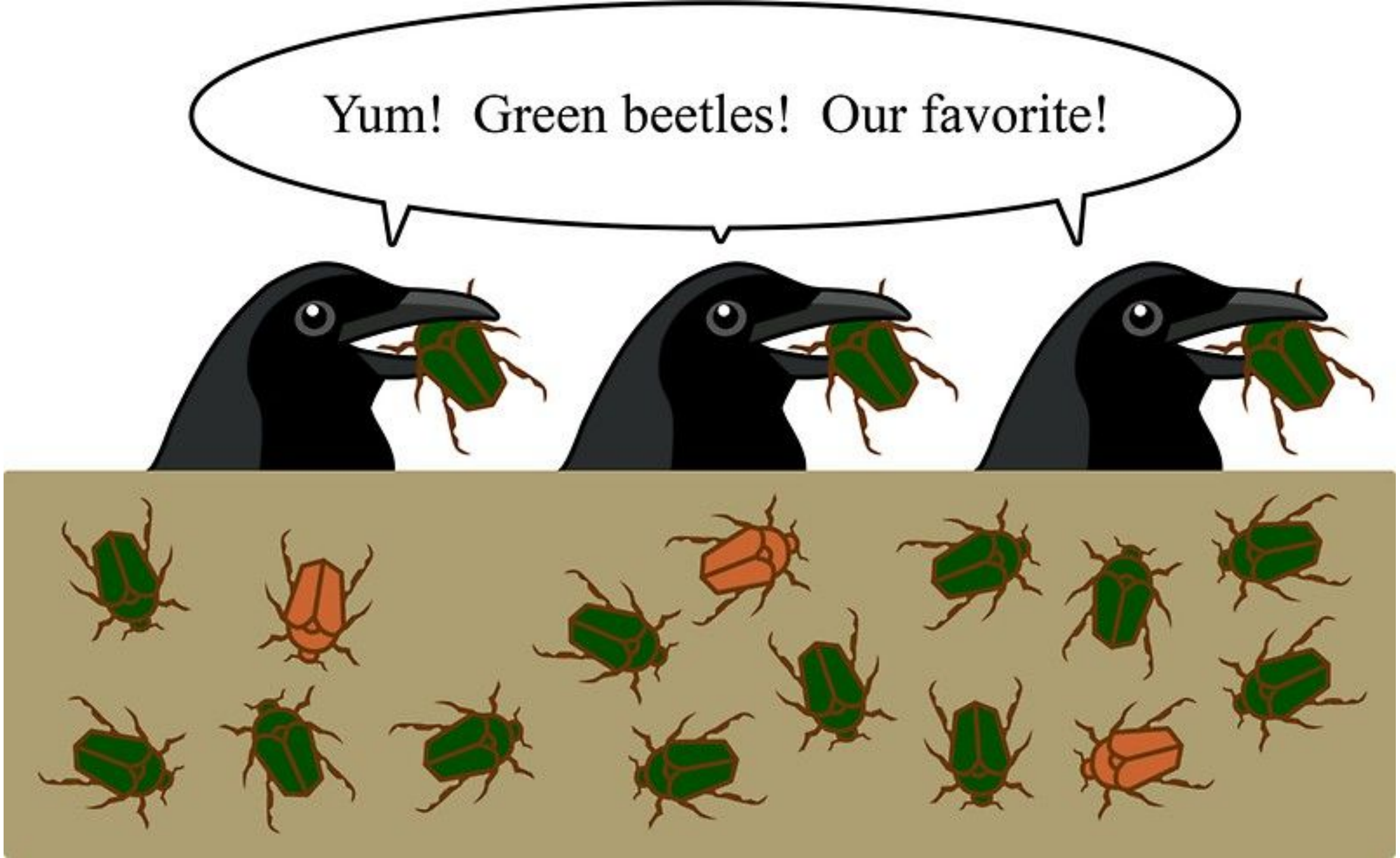


Tan mice are more visible to predatory birds than black mice. Thus, tan mice are eaten at higher frequency than black mice. Only the surviving mice reach reproductive age and leave offspring.

Mice reproduce, giving next generation



Because black mice had a higher chance of leaving offspring than tan mice, the next generation contains a higher fraction of black mice than the previous generation.

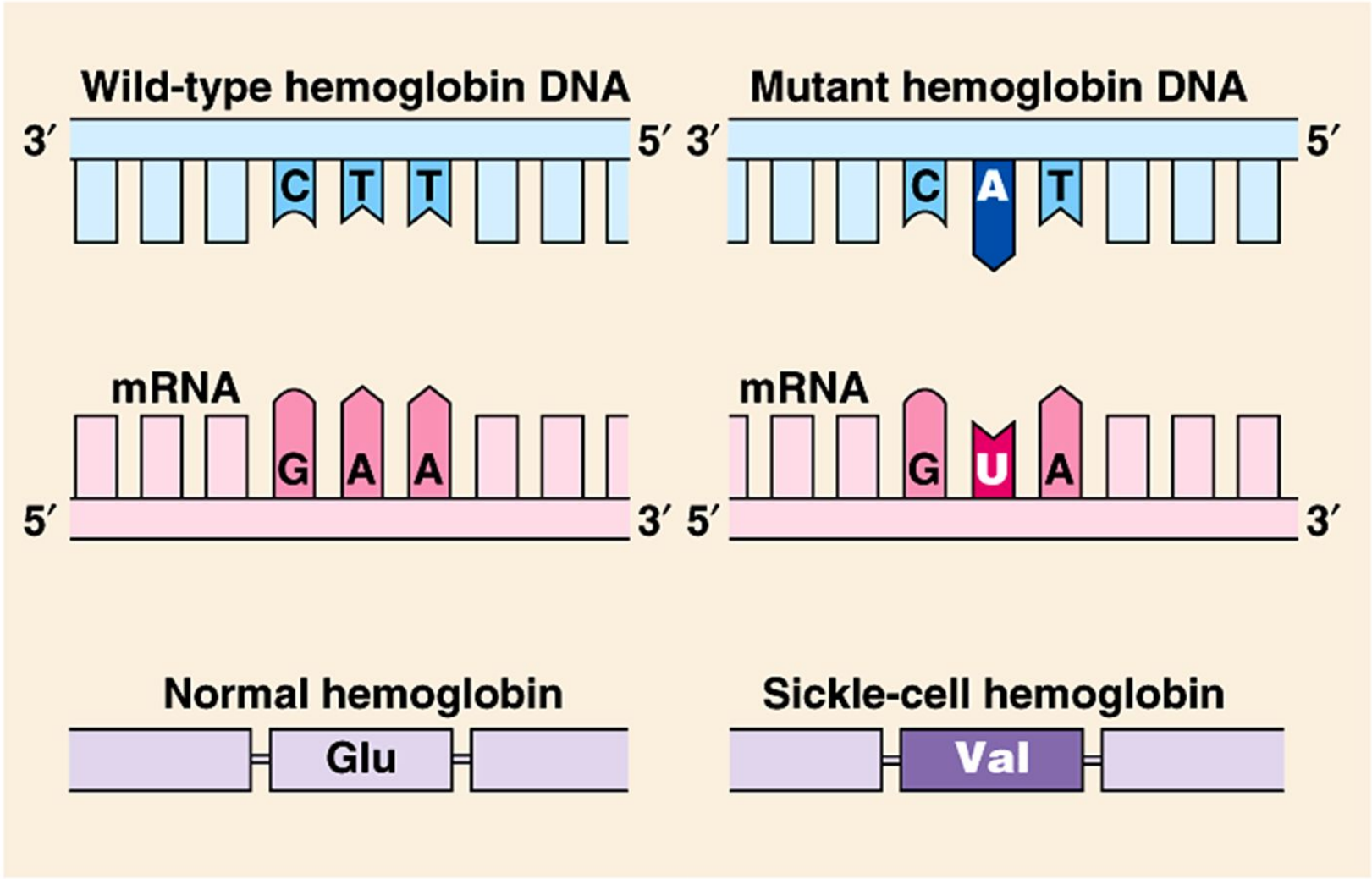

Yum! Green beetles! Our favorite!

Evolution causes:

- Genetic variation
  - Mutation
  - Sexual reproduction

Mutation

- Mutation: a new mutation will be transmitted in the gametes changing the gene pool of a population by substituting one allele for another.



Sexual reproduction

- Random fusion
- Crossing over
- Free assortment

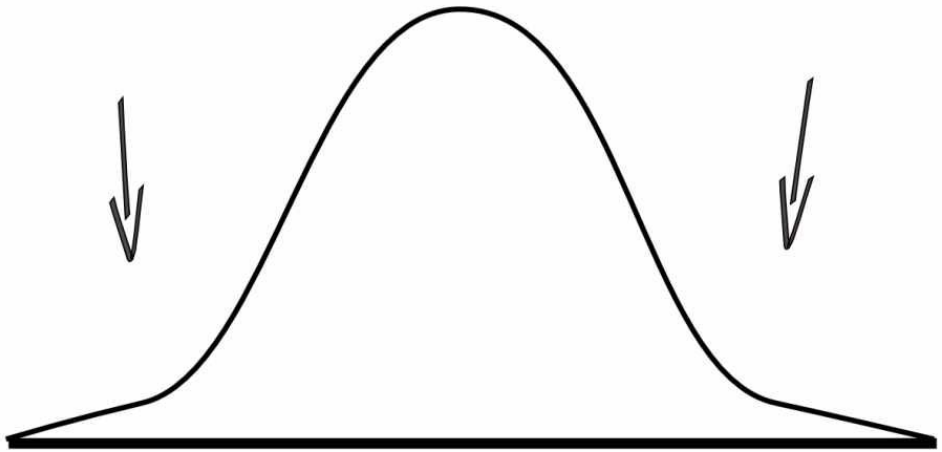
A. Variation and Gene Pools

- 1. A Gene Pool is made up of all the genes (including alleles) that are in a population.

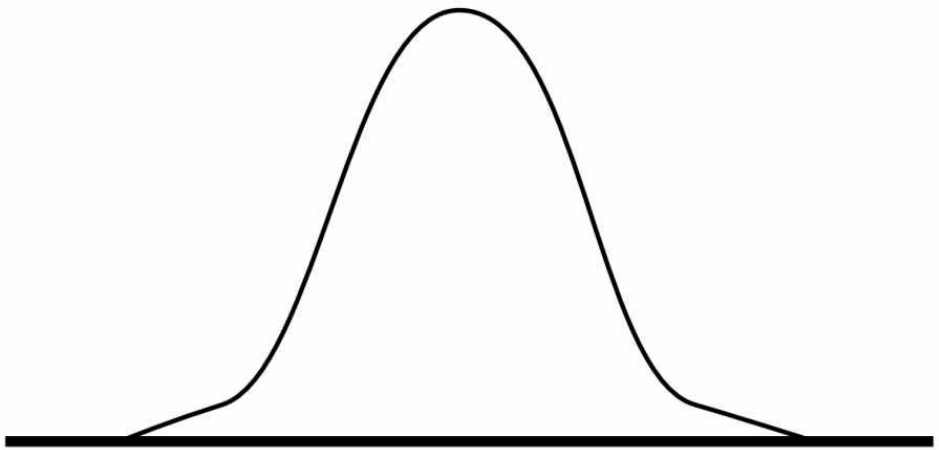
Stabilizing Selection

- Occurs when environmental conductions are largely unchanging.
- **Eliminates variants and abnormalities** that are useless or harmful.
- **Eliminates the numbers of extremes and favors the more common intermediate forms.**
- **Many mutant forms are weeded out in this way.**
- For examples: birth weights in humans between 6 and 9 pounds. For babies smaller or large than this, mortality is greater. (London 1935-1945)

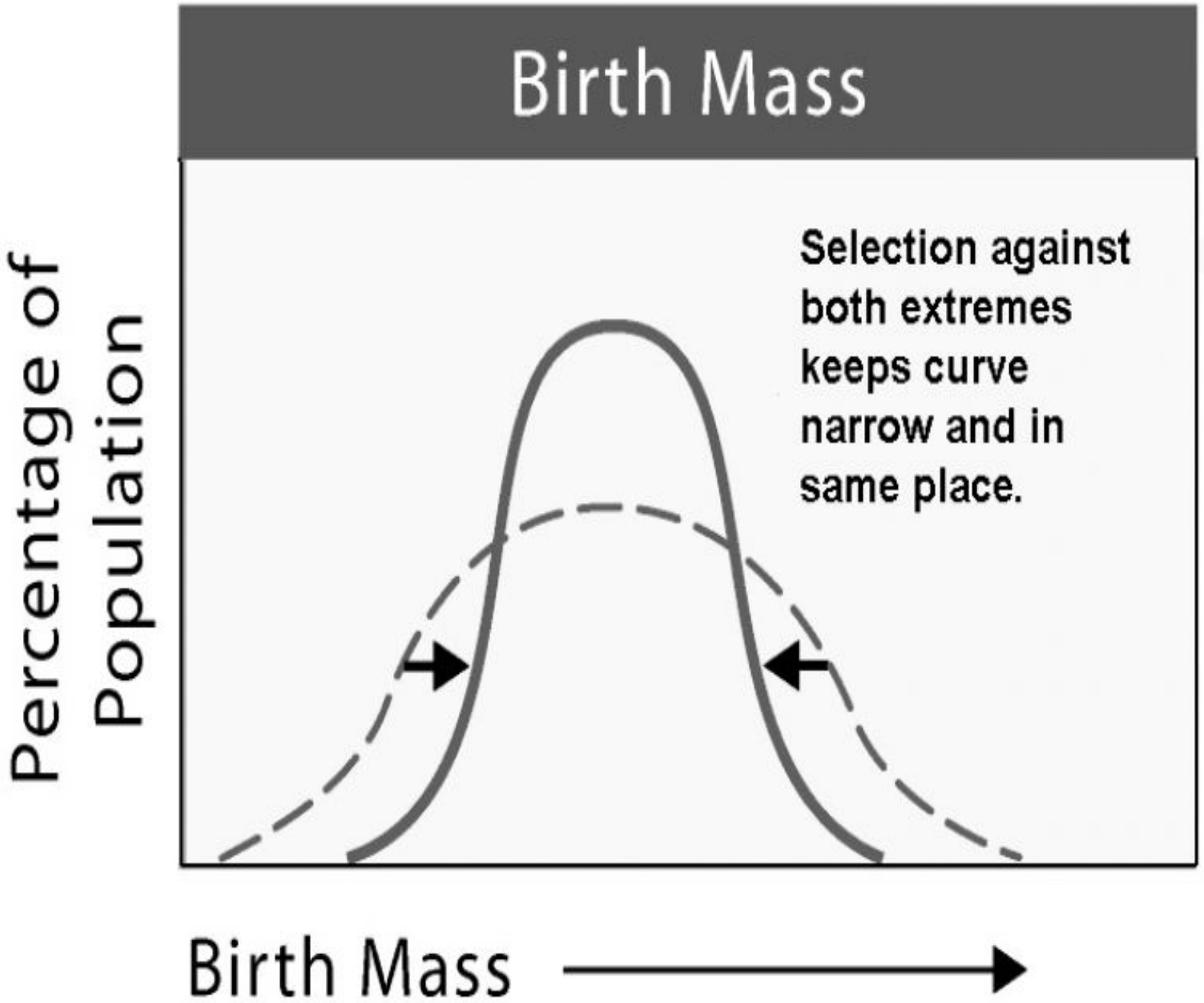
Stabilizing Selection



Before Selection

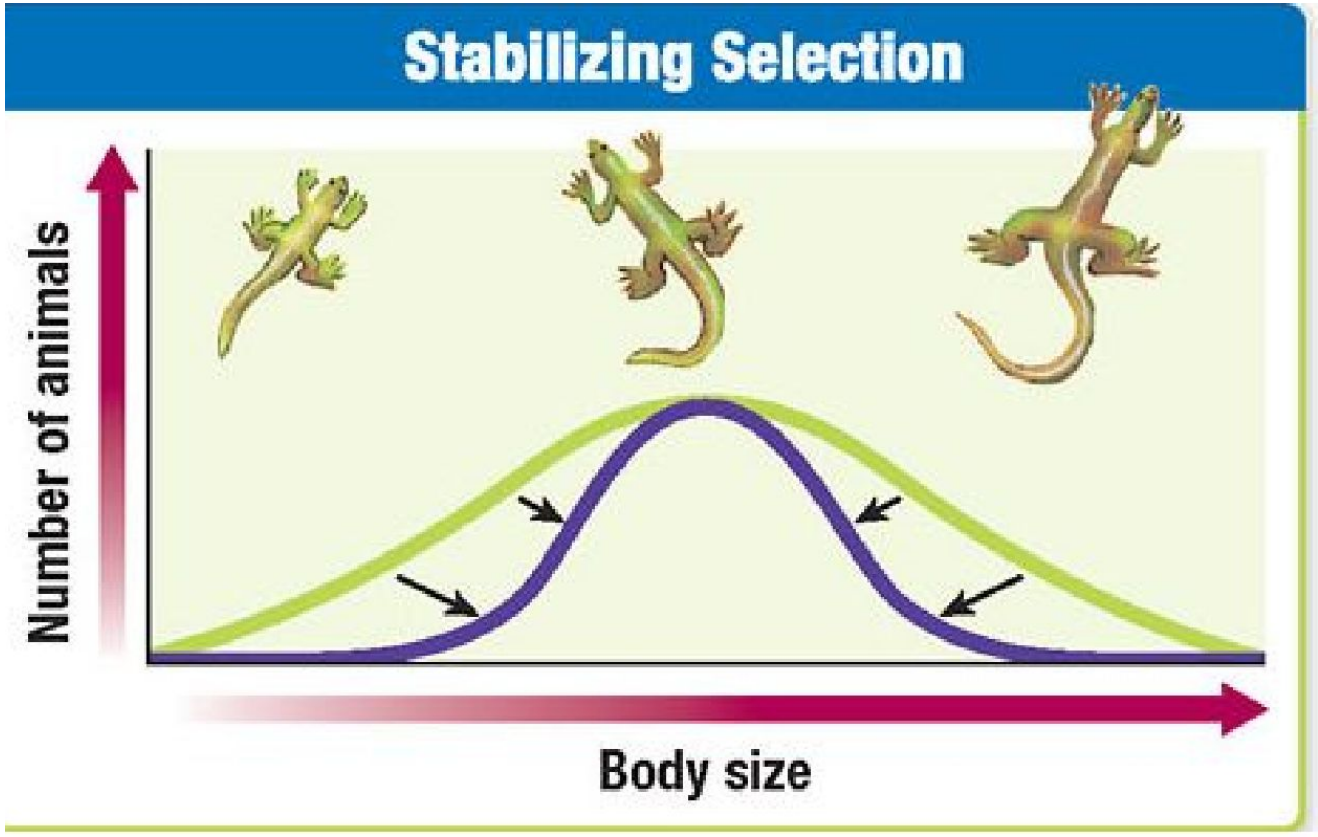


After Selection



Stabilizing Selection

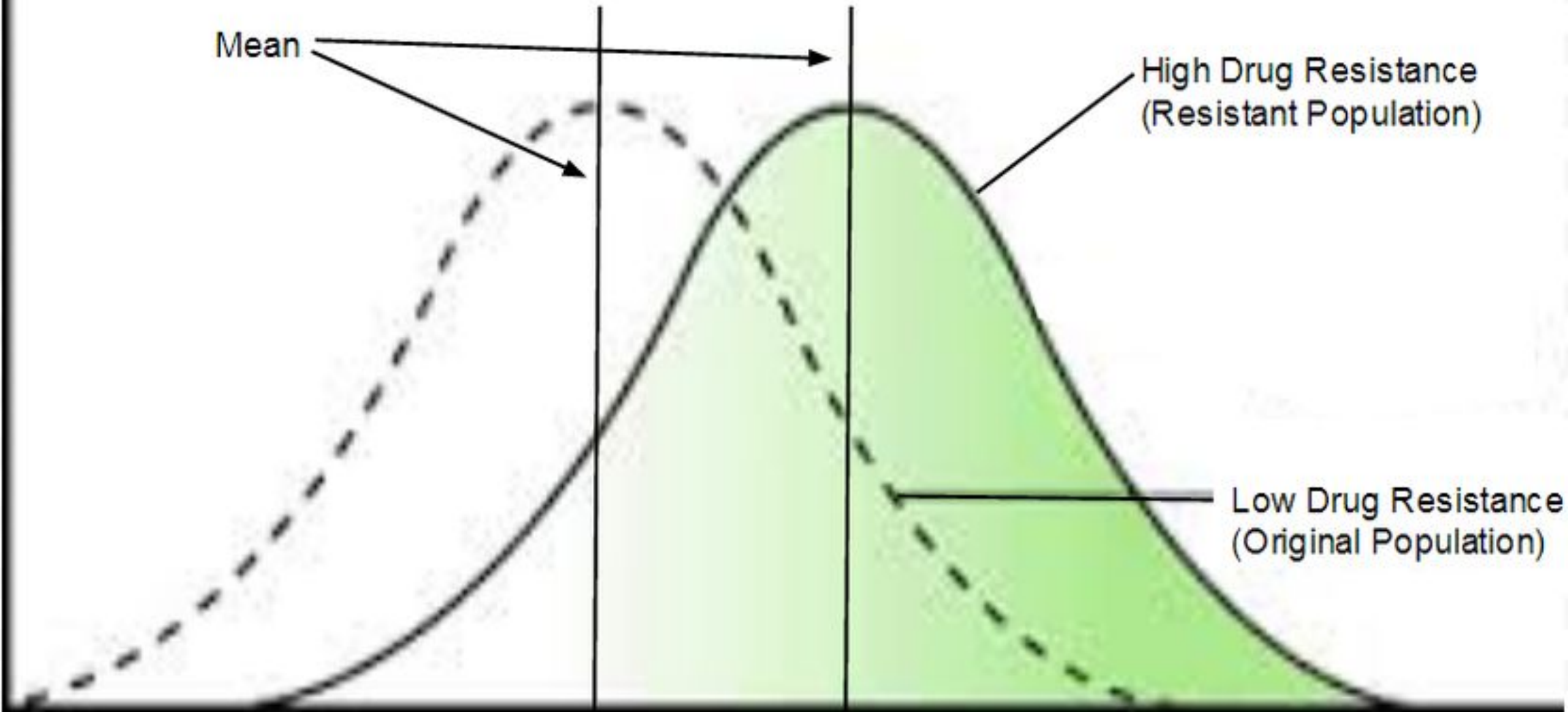
Body size varies among individuals in a species of lizard in the genus *Aristelliger*. Small lizards have a hard time defending a territory, and thus mating, but large lizards are more likely to be preyed on by owls. Therefore, natural selection favors individuals with an average body size.



Directional Selection

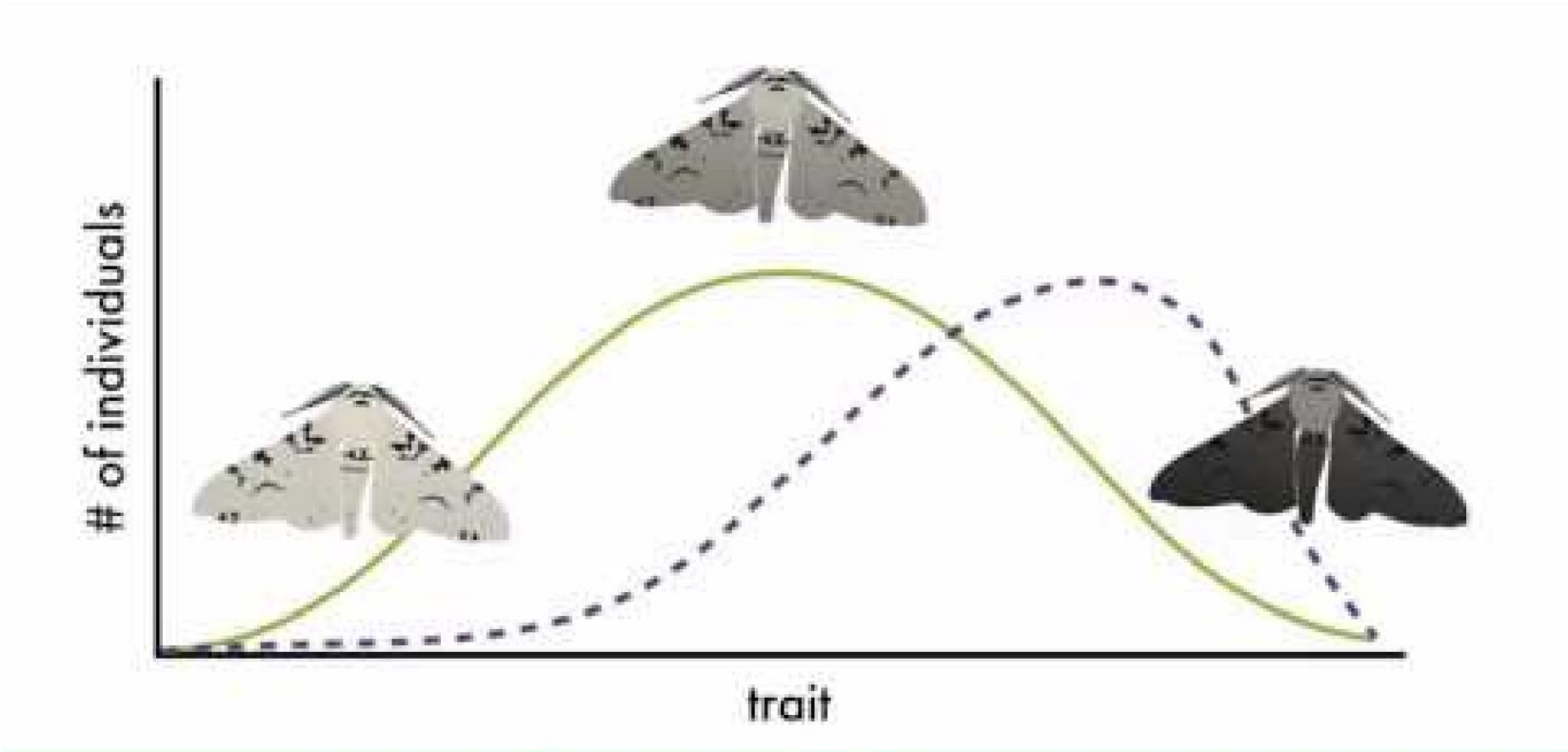
- May result from changing environmental conditions.
- In these situations the **majority of an existing form of an organism may be no longer best suited to the environmental**.
- Give rise to directional selection, where one phenotype replaces another in the gene pool.

Bacterial Directional Selection



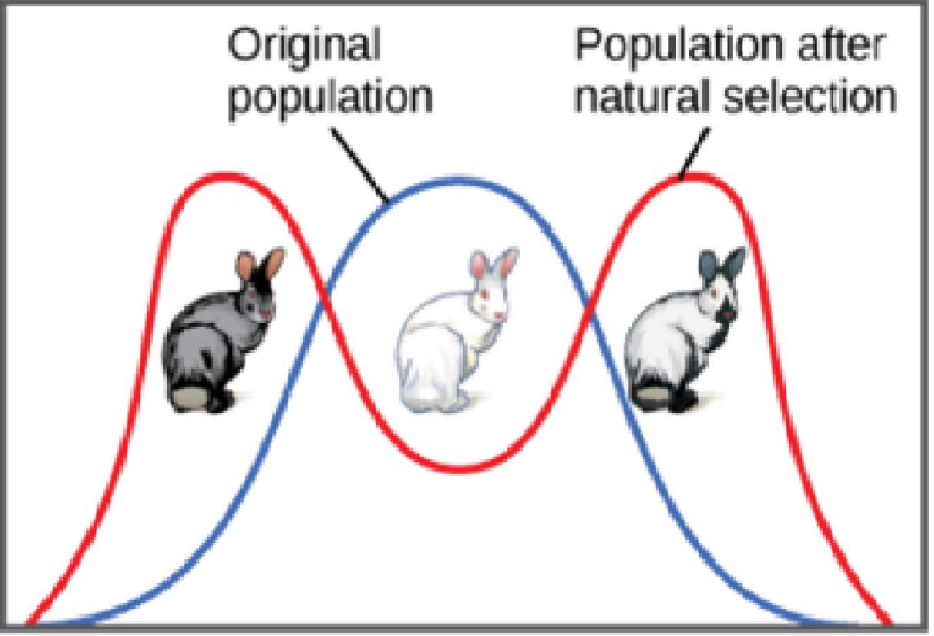
Directional Selection

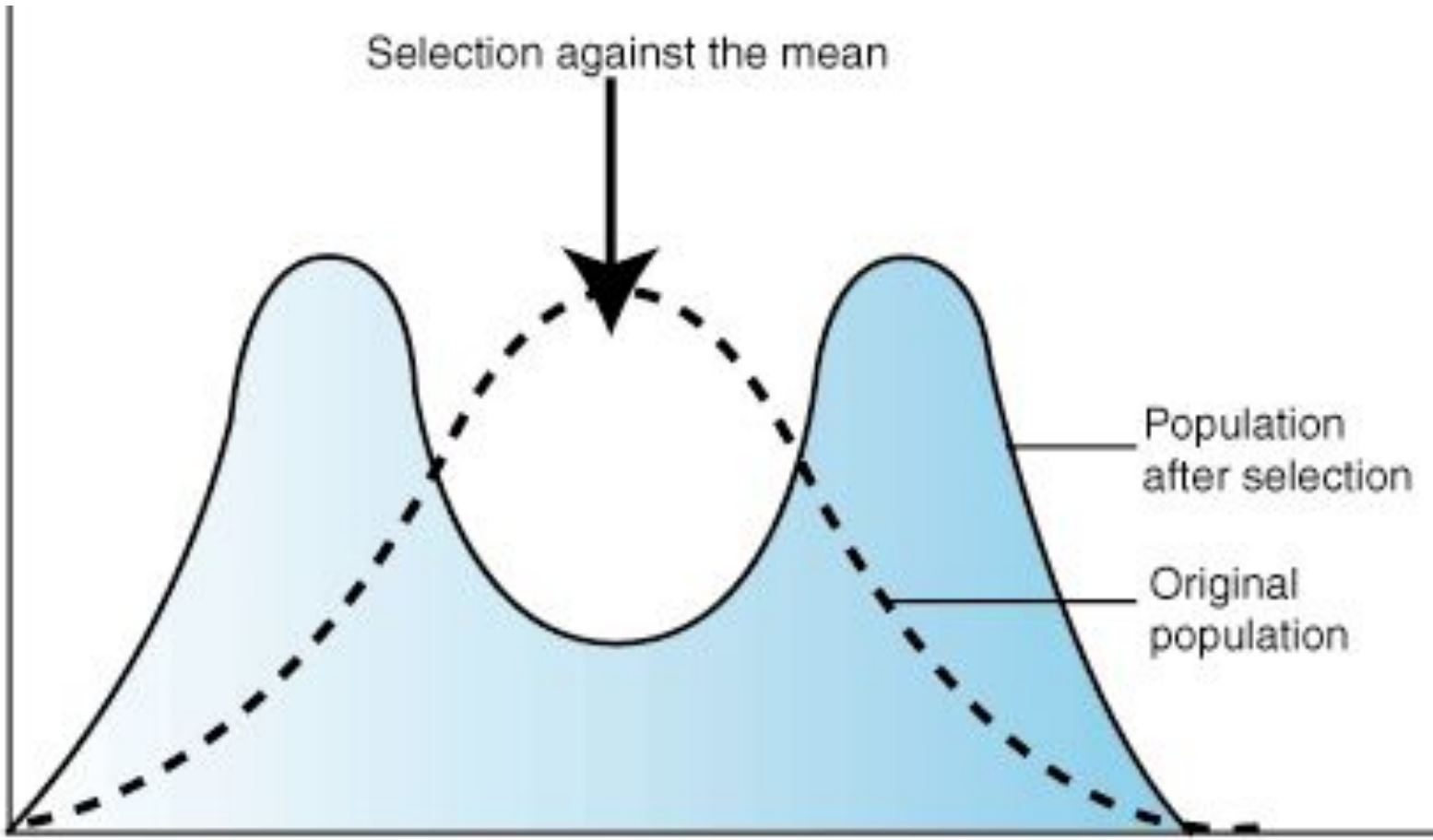
- If an extreme version of a characteristic is increased in expression due to it making the organism more fit



Disruptive Selection

- Occurs when particular environmental conditions favour the extremes of a phenotypic range over intermediate phenotypes.
- As a result, it is likely that the gene pool will become split into **two distinct gene pool**.
- **Increases the numbers of extreme types** in a population at the expanse of intermediate forms.

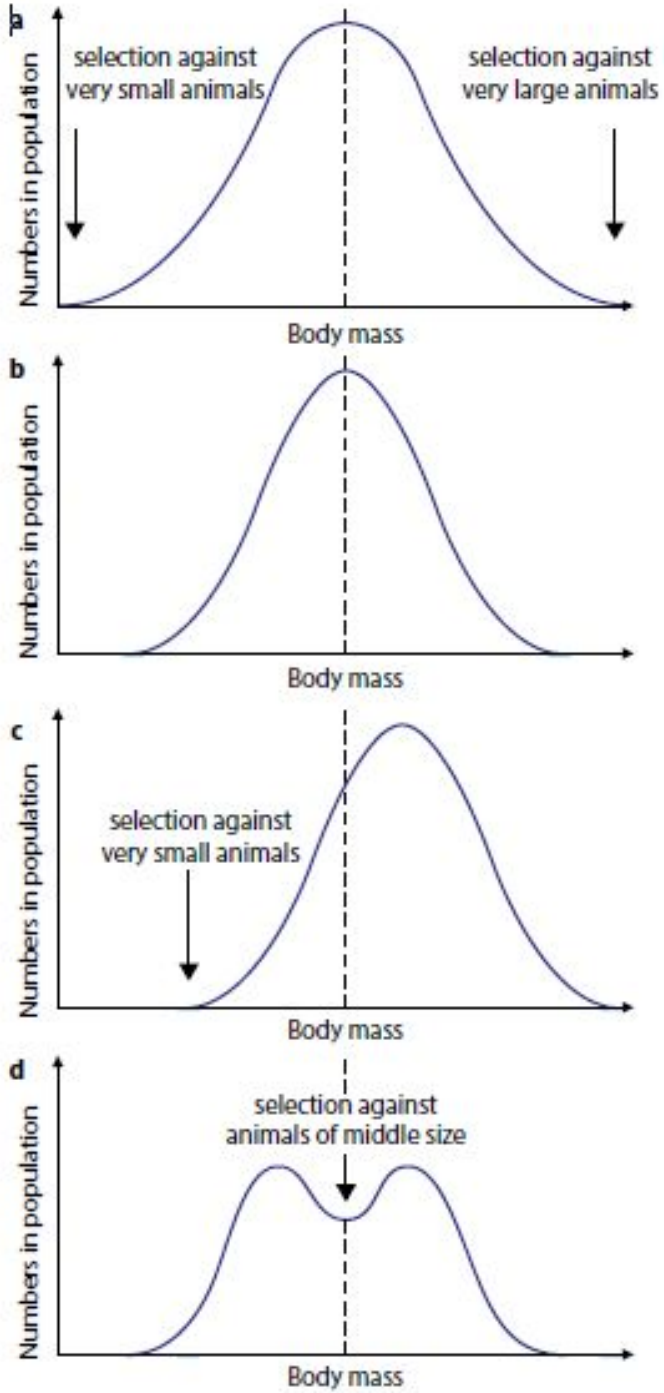

Original population
Population after natural selection

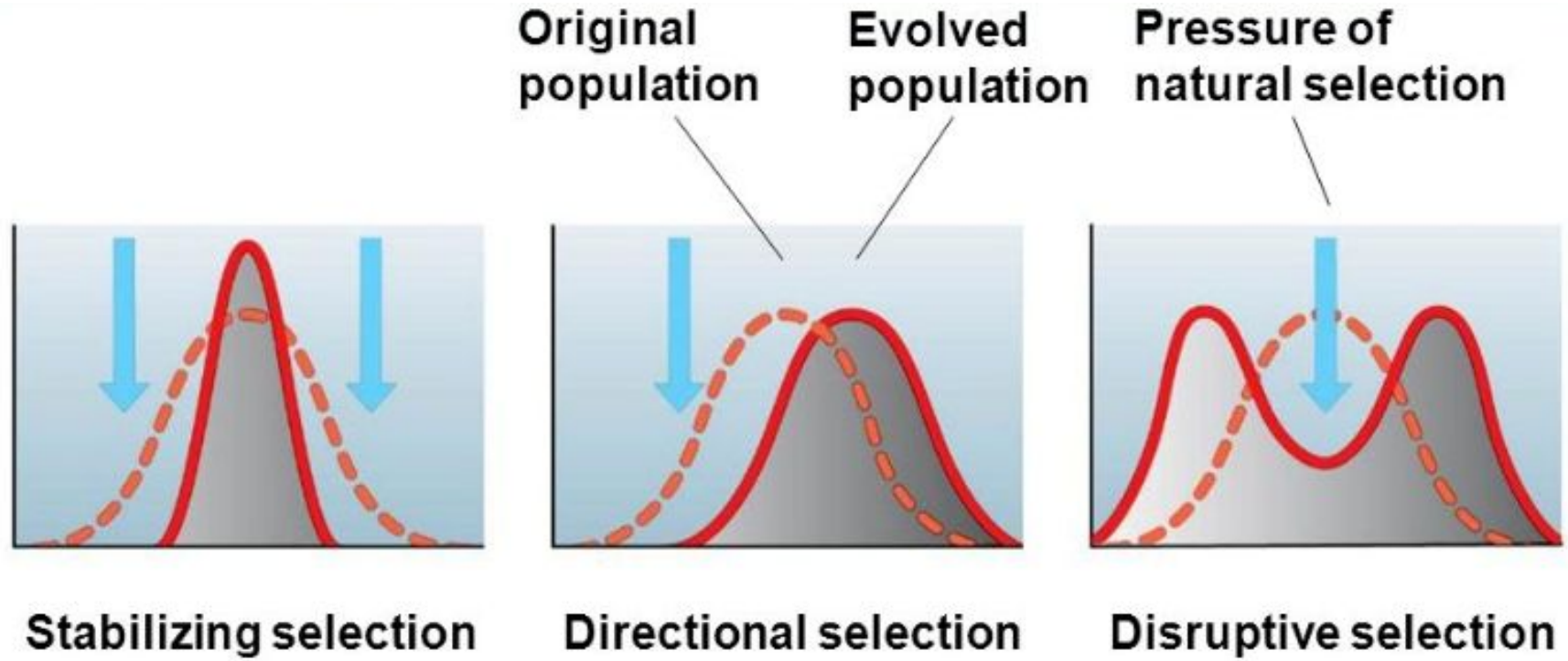

Selection against the mean
Population after selection
Original population

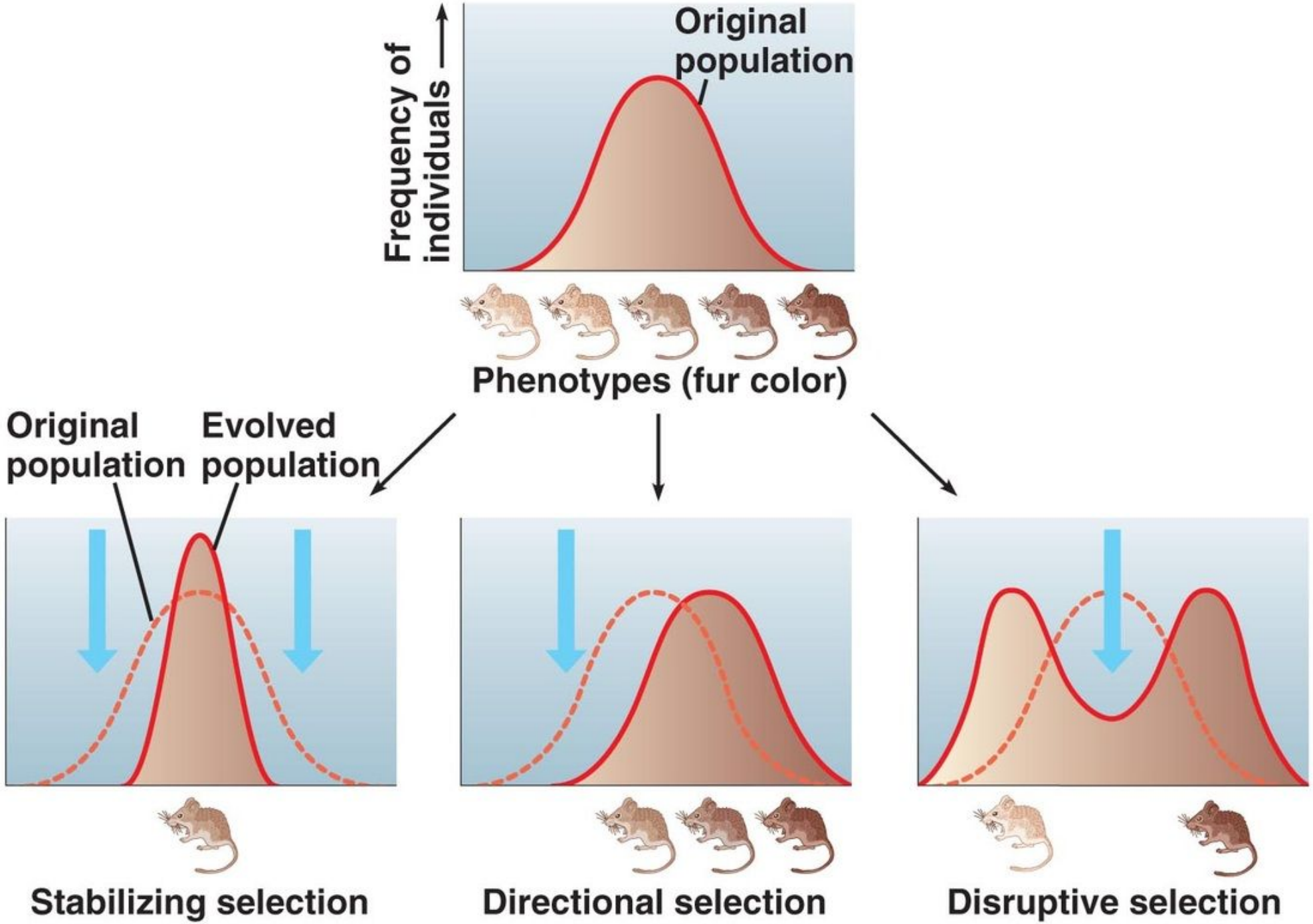
Disruptive Selection

A population of insects, newly introduced to a forest, is adapting to different breeding sites: females can lay their eggs either on mushrooms on the forest floor or on the fruits of trees. In time, one group has adapted to the mushrooms, and another to the fruit. Disruptive selection drove these adaptations.

Spotted Wing Drosophila (SWD) is a “vinegar fly” but unlike other vinegar flies, which attack rotting fruit, this fly damages ripening and decaying fruit. Infestation of fruit reveals small scars and indented soft spots and bruises on the fruit surface. Eggs hatch and larvae develop and feed inside the fruit, causing the flesh to collapse around the feeding site within as few as two days. Fungal and bacterial infections and secondary pest may contribute to further fruit deterioration

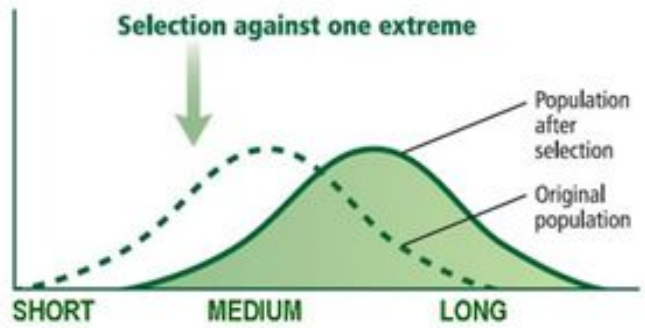

a
selection against very small animals
selection against very large animals
Numbers in population
Body mass
b
Numbers in population
Body mass
c
selection against very small animals
Numbers in population
Body mass
d
selection against animals of middle size
Numbers in population
Body mass


Original population
Evolved population
Pressure of natural selection
Stabilizing selection
Directional selection
Disruptive selection

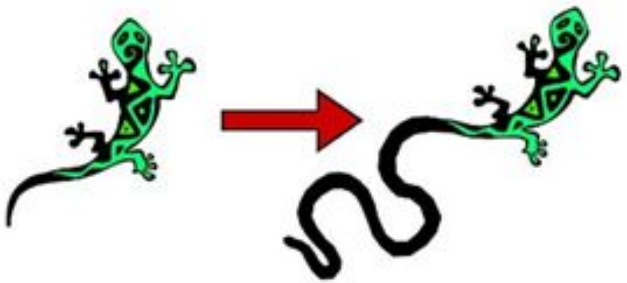


HOW does the trait change?

Directional Selection

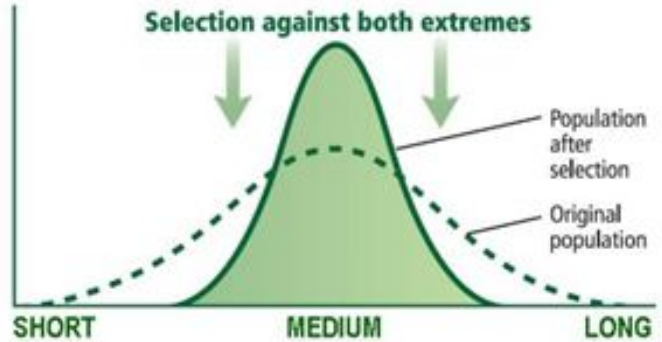


FOR: one extreme trait
AGAINST: the other extreme



EX. Long wiggly tails look like a snake and scare predators. The longer the tail, the more it looks like a snake.

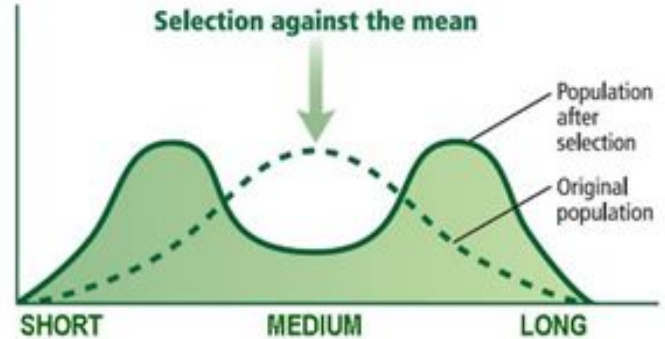
Stabilizing Selection



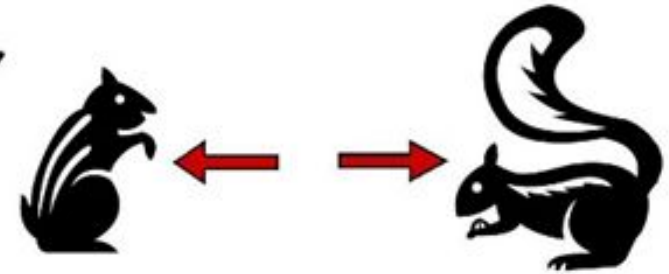
FOR: moderate traits
AGAINST: both extremes

EX. Short tails mess up the cat's balance. Long tails drag on the ground. Medium tails are best.

Disruptive Selection



FOR: both extremes
AGAINST: moderate traits



EX. Short tails help keep predators from catching you on the ground. Long tails are good for balance in the trees. Medium tails don't help.

Sexual selection

- A form of natural selection in which individuals with certain **inherited characteristics are more likely than other individuals to obtain mater.**
- Sexual selection can result in **sexual dimorphism**, a **difference** in secondary characteristics **between males and females** of the same species.

Possible evolving of exaggerated traits or ornaments

Speciation

- A species is a population whose **members have the potential to interbreed in nature and produce viable, fertile offspring**.

- a species must be able to reproduce and the offspring MUST be able to reproduce.

Speciation causes: **isolation**

- Geographic
- Polyploidy
- Habitat
- Behavioral
- Temporal
- Reproductive

Reproductive isolation

- **Closely related species may be unable to mate because of anatomical incompatibility**.
- The **inability of members of a population to successfully interbreed with members of another population of the same or a related species.**
- **Pre – zygotic: different mating ritual, differences times or seasons, sex organs that are incompatible.**
- **Post – zygotic: formed in fertile hybrid.**

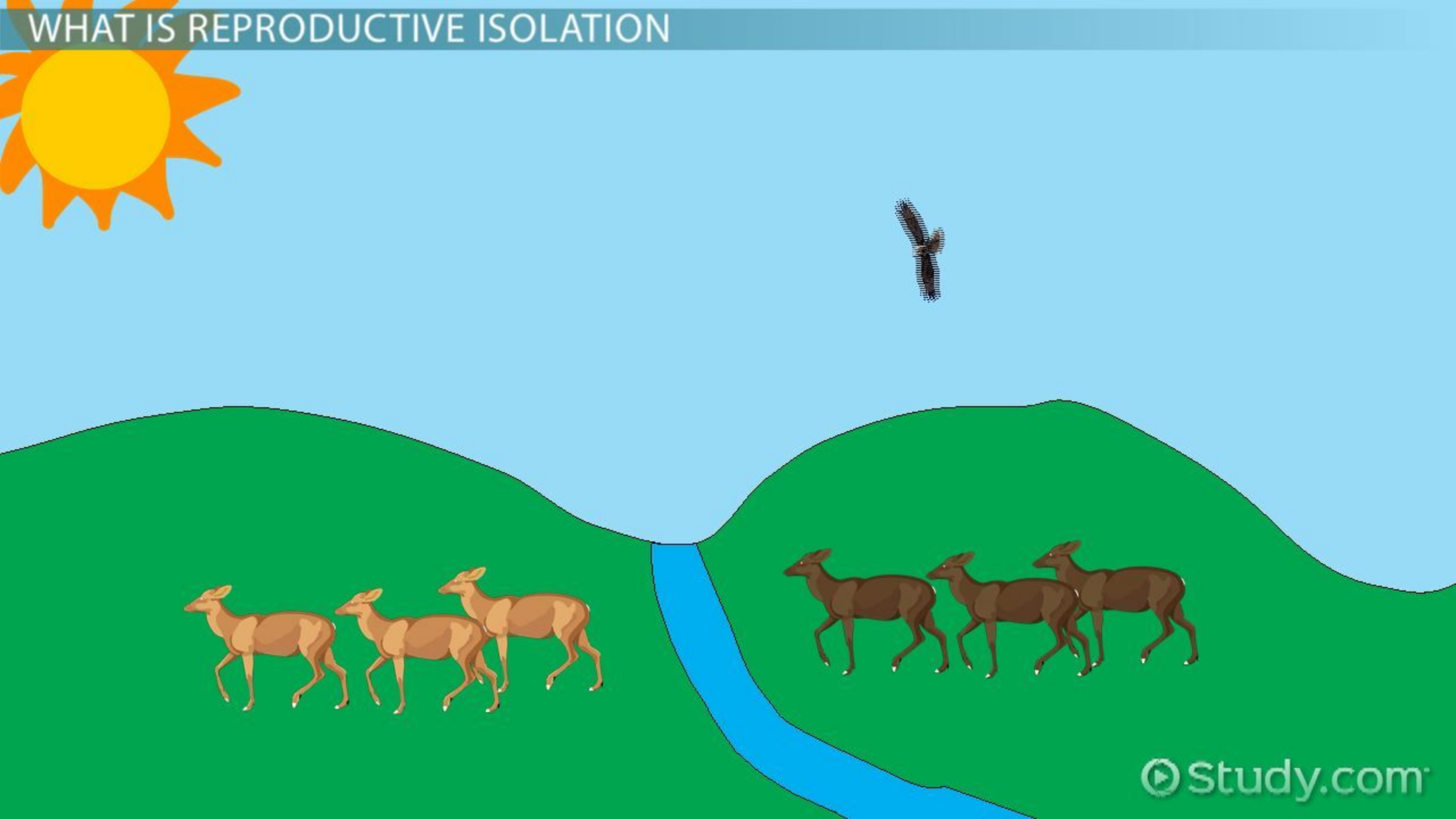
SPECIATION

REPRODUCTIVE ISOLATION

Geographic isolation

- **Occurs when species are separated:** river, mountain range and etc.
- Two population that are **isolated from each other**.
- After isolation, '**disturbing processes**' like natural selection, mutation and random genetic drift may occur independently in both population, causing them to diverge in their features and characteristics.

WHAT IS REPRODUCTIVE ISOLATION



Habitat isolation

- Occurs when two organisms **live in the same area but encounter each other rarely.**

Two different species of garter snake that belong to the same genus Thamnophis occur in the same areas, but one lives in a mainly water habitat and the other in a terrestrial habitat.

Habitat Isolation

Water-dwelling *Thamnophis*

Terrestrial *Thamnophis*

Behavioral isolation

- Occurs when **two animals become isolated from each other because of some change in behavior by one member or group**.

Male fireflies have certain light signal pattern that only the females of their species recognize and respond to-attracting the males.

Temporal isolation

- Temporal **refers to times**.
- Two **species cannot breed if their species breeding patterns are during different times of the day, seasons** of the **year**, or **different yearly patterns**.

The Western Spotted Skunk and the Eastern Spotted Skunk are similar species that do not interbreed due to one species mating during the summer and the other during the winter.

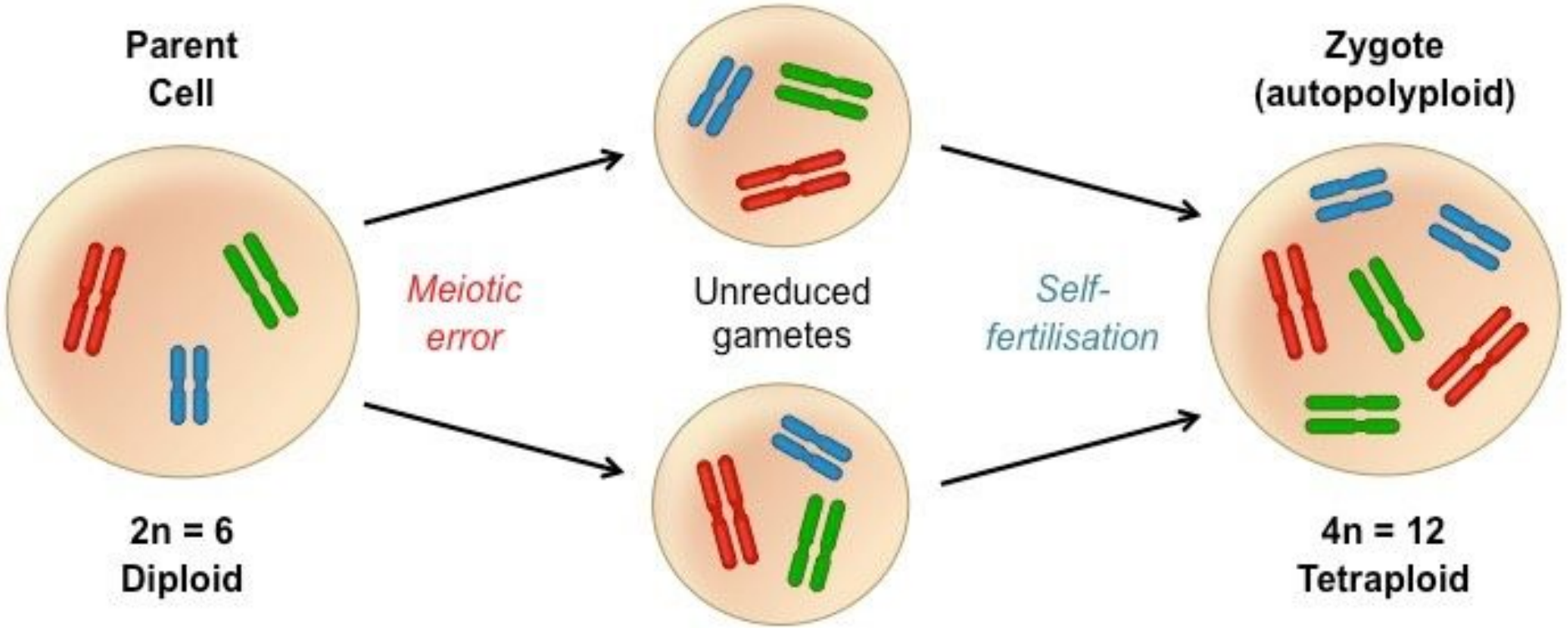
Eastern spotted skunk
(Spilogale putorius)

Western spotted skunk
(Spilogale gracilis)

These skunks have different breeding times.

Polyploidy isolation

- Type of mutation that from error during meiosis (n), (3n), (4n and etc.).



Theory about Evolution

- **Gradualism**
- **Punctuated Equilibrium**