8.3A: Processes and Patterns of Evolution

Natural selection can only occur in the presence of genetic variation; environmental conditions determine which traits are selected.

Learning Objectives

• Explain why only heritable variation can be acted upon by natural selection

Key Points

• Genetic variation within a population is a result of mutations and sexual reproduction.
• A mutation may be neutral, reduce an organism’s fitness, or increase an organism’s fitness.
• An adaptation is a heritable trait that increases the survival and rate of reproduction of an organism in its present environment.
• Divergent evolution describes the process in which two species evolve in diverse directions from a common point.
• Convergent evolution is the process in which similar traits evolve independently in species that do not share a recent common ancestry.

Key Terms

• adaptation: modification of something or its parts that makes it more fit for existence under the conditions of its current environment
• divergent evolution: the process by which a species with similar traits become groups that are tremendously different from each other over many generations
• **convergent evolution**: a trait of evolution in which species not of similar recent origin acquire similar properties due to natural selection

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**Variation**

Natural selection can only take place if there is variation, or differences, among individuals in a population. Importantly, these differences must have some genetic basis; otherwise, the selection will not lead to change in the next generation. This is critical because variation among individuals can be caused by non-genetic reasons, such as an individual being taller due to better nutrition rather than different genes.

Genetic diversity within a population comes from two main mechanisms: mutation and sexual reproduction. Mutation, a change in the DNA sequence, is the ultimate source of new alleles, or new genetic variation in any population. The genetic changes caused by mutation can have one of three outcomes:

- Many mutations will have no effect on the fitness of the phenotype; these are called neutral mutations.
- A mutation may affect the phenotype of the organism in a way that gives it reduced fitness (a lower likelihood of survival or fewer offspring).
- A mutation may produce a phenotype with a beneficial effect on fitness. Different mutations will have a range of effects on the fitness of an organism that expresses them in their phenotype, from a small effect to a great effect.

Sexual reproduction also leads to genetic diversity: when two parents reproduce, unique combinations of alleles assemble to produce the unique genotypes and thus phenotypes in each of the offspring. However, sexual reproduction can not lead to new genes, but rather provides a new combination of genes in a given individual.

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**Adaptations**

A heritable trait that aids the survival and reproduction of an organism in its present environment is called an adaptation. Scientists describe groups of organisms becoming adapted to their environment when a change in the range of genetic variation occurs over time that increases or maintains the “fitness” of the population to its environment. The webbed feet of platypuses are an adaptation for swimming. The snow leopards’ thick fur is an adaptation for living in the cold. The cheetahs’ fast speed is an adaptation for catching prey.

Whether or not a trait is favorable depends on the environmental conditions at the time. The same traits are not always selected because environmental conditions can change. For example, consider a species of plant that grew in a moist climate and did not need to conserve water. Large leaves were selected because they allowed the plant to obtain more energy from the sun. Large leaves require more water to maintain than small leaves, and the moist environment provided favorable conditions to support large leaves. After thousands of years, the climate changed and the area no longer had excess water. The direction of natural selection shifted so that plants with small leaves were selected because those populations were able to conserve water to survive the new environmental conditions.

The evolution of species has resulted in enormous variation in form and function. Sometimes, evolution gives rise to groups of organisms that become tremendously different from each other. When two species evolve in diverse directions from a common point, it is called divergent evolution. Such divergent evolution can be seen in the forms of the
reproductive organs of flowering plants which share the same basic anatomies; however, they can look very different as a result of selection in different physical environments and adaptation to different kinds of pollinators.

Flowering Plants: Flowering plants evolved from a common ancestor. Notice that the (a) dense blazing star (Liatrus spicata) and the (b) purple coneflower (Echinacea purpurea) vary in appearance, yet both share a similar basic morphology.

In other cases, similar phenotypes evolve independently in distantly-related species. For example, flight has evolved in both bats and insects; they both have structures we refer to as wings, which are adaptations to flight. However, the wings of bats and insects have evolved from very different original structures. This phenomenon is called convergent evolution, where similar traits evolve independently in species that do not share a recent common ancestry. The two species came to the same function, flying, but did so separately from each other.

These physical changes occur over enormous spans of time and help explain how evolution occurs. Natural selection acts on individual organisms, which in turn can shape an entire species. Although natural selection may work in a single generation on an individual, it can take thousands or even millions of years for the genotype of an entire species to evolve. It is over these large time spans that life on earth has changed and continues to change.