Unifying Principles of Biology - Advanced

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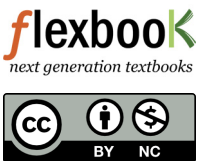

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CHAPTER 1

Unifying Principles of Biology - Advanced

- Identify and explain the four unifying principles of modern biology.
- Briefly explain the cell theory and the gene theory.
- Explain homeostasis.
- Define evolution and natural selection.

What is a biological principle?

The word *principle* can be defined as "a fundamental truth or proposition that serves as the foundation for a system of belief or behavior or for a chain of reasoning." A principle of biology is a fundamental concept that is just as true for a bee or a sunflower as it is for us. All life, including that sunflower and bee, is made of at least one cell. The traits of a particular organism are embedded within its genes, that organism must maintain homeostasis to survive, and that organism has evolved from previously existing species.

Unifying Principles of Biology

There are four unifying principles of biology that are important to all life and form the foundation of modern biology. These are:

1. the cell theory,
2. the gene theory,
3. homeostasis,
4. evolutionary theory.

The Cell Theory

The **cell** is the basic unit of structure and function of all organisms. The **Cell Theory** states that all living things are made of one or more cells, or the secretions of those cells, such as the organisms shown in **Figure** 1.1. For example,

shell and bone are built by cells from substances that they secrete into their surroundings. Cells come from cells that already exist, that is, they do not suddenly appear from nowhere. In organisms that are made of many cells (called multicellular organisms), every cell in the organism's body derives from the single cell that results from a fertilized egg. You will learn more about cells and the Cell Theory in *Cells: The Cell Theory (Advanced)* concept.

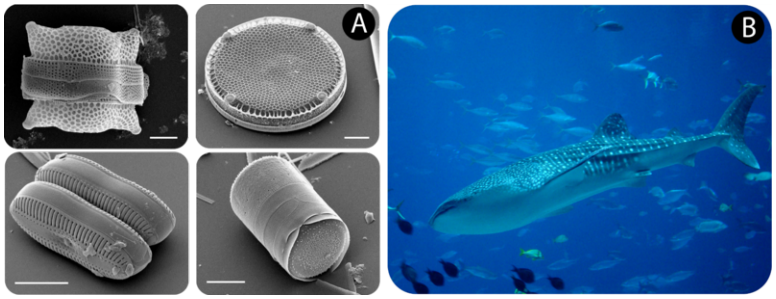


FIGURE 1.1

Tiny diatoms and whale sharks are all made of cells. Diatoms are about 20 μm in diameter and are made up of one cell, whereas whale sharks can measure up to 12 meters in length, and are made up of billions of cells.

Gene Theory

An organism's traits are encoded in their **DNA**, the large molecule, or macromolecule, that holds the instructions needed to build cells and organisms. DNA makes up the **genes** of an organism. Traits are passed on from one generation to the next by way of these genes. Information for how the organism appears and how its cells work come from the organism's genes. Although the appearance and cell function of the organism may change due to the organism's environment, the environment does not change its genes. The only way that genes can change in response to a particular environment is through the process of evolution in populations of organisms. You will learn more about DNA and genes in *Concept Molecular Biology (Advanced)*.

Homeostasis

Homeostasis is the ability of an organism to control its body functions in order to uphold a stable internal environment even when its external environment changes. All living organisms perform homeostasis. For example, cells maintain a stable internal acidity (pH); and warm-blooded animals maintain a constant body temperature. You will learn more about homeostasis in the *The Human Body: Homeostasis (Advanced)* concept.

Homeostasis is a term that is also used when talking about the environment. For example, the atmospheric concentration of carbon dioxide on Earth has been regulated by the concentration of plant life on Earth, because plants remove more carbon dioxide from the atmosphere during the daylight hours than they emit to the atmosphere at night.

Evolution

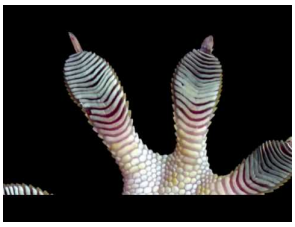
Evolution by **natural selection**, is the theory that maintains that a population's inherited traits change over time, and that all known organisms have a common origin. This theory, initially described by Charles Darwin, describes why organisms must adapt to their environments. Evolutionary theory can explain how specialized features, such as the geckos sticky foot pads shown in **Figure** 1.2, develop in different species. More about evolution is discussed in *Concept Evolution (Advanced)*.

FIGURE 1.2

A Tokay Gecko. The pads at the tip of the Tokay gecko's foot are covered in microscopic hairs, each split into hundreds of tips that measure about 200 nanometers in diameter. By using these tiny hairs that can cling to smooth surfaces, the geckos are able to support their entire body weight while climbing walls This is evidence of a product of evolution.

KQED: Bio-Inspiration: Nature as Muse

For hundreds of years, scientists have been using design ideas from structures in nature. Now, biologists and engineers at the University of California, Berkeley are working together to design a broad range of new products, such as life-saving milli-robots modeled on the way cockroaches run and adhesives based on the amazing design of a geckos foot. This process starts with making observations of nature, which lead to asking questions and to the additional aspects of the scientific process. *Bio-Inspiration: Nature as Muse* can be observed at http://www.kqed.org/quest/television/bioinspiration-nature-as-muse (11:01).



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Vocabulary

- **cell**: The basic unit of structure and function of all living organisms.
- **DNA (deoxyribonucleic acid)**: Double-stranded nucleic acid that composes genes and chromosomes; the hereditary material.
- **evolution**: The change in the characteristics of living organisms over time; the change in species over time.
- **gene**: A segment of DNA that contains information to encode an RNA molecule or a single polypeptide.
- **homeostasis**: The process of maintaining a stable environment inside a cell or an entire organism.
- **natural selection**: Evolutionary process by which certain beneficial traits becomes more common within a population, changing the characteristics (traits) of a species over time.

Summary

- Four unifying principles form the foundation of modern biology: cell theory, evolutionary theory, the gene theory and the principle of homeostasis. These four principles are important to each and every field of biology.

Explore More

Use this resource to answer the questions that follow.

- http://www.hippocampus.org/Biology . → Non-Majors Biology → Search: **Cell Theory**

1. What is the Cell Theory?
2. What are the three basic tenets of the Cell Theory?
3. Describe the findings of Schwann, Schleiden, and Virchow.
4. What has led to the "modernization" of the Cell Theory?
5. What are the main differences between the classic cell theory and the modern cell theory?

Review

1. Identify and describe the four unifying principles of modern biology.
2. Why do you believe the four unifying principles of modern biology form the foundation of modern biology.

References

1. (a) Mary Ann Tiffany, San Diego State University; (b) Flickr: istolethetv. (a) http://commons.wikimedia.org/wiki/File:Diatoms.png; (b) http://commons.wikimedia.org/wiki/File:Whale_Shark_diagonal.jpg . (a) CC BY 2.5; (b) CC BY 2.0
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