UNIT SEVEN
EVOLUTION OF LIVING THINGS

LEARNING OUTCOMES: Upon completion of the study of this unit, you should be able to:

• Define organic evolution.
• Recognize the problems involved in determining the age of the earth and its fossils.
• Recognize the problems involved in formulating theories for the origin of life.
• Identify observations that support evolution.
• Contrast the theories of evolution of Charles Darwin and Jean Lamarck.
• Explain modern theories of evolution that have grown out of new research.
• Recognize the scientific theories that humans may have evolved from ancestral organisms.

Chapter 26: Evidence for Organic Evolution

A. WHAT IS EVOLUTION? Scientists are like detectives because they search and search for information to solve science problems. They then propose (suggest) theories based on their observations. Scientists have observed that the earth and its organisms have gradually changed over a long period of time. The process of gradual (slow) change through time is called evolution. Geologic evolution is the study of the changes that have occurred to the earth itself. The study of the changes in living things is called organic evolution. Included in organic evolution are the changes in characteristics in populations through generations. The theory of evolution helps to explain the differences in structure, function, and behavior among living things. In this unit you will investigate such problems as:

Evolution Problems:
• How life began on earth.
• How complex organisms developed from simpler forms of life.
• How organisms may have changed over long periods of time.
There are other commonly accepted solutions to the problems discussed in this unit. The theory of evolution presented in this book, is currently accepted by most scientists. Studies supporting the current theory of organic evolution include evidences of fossil records, similarities in the skeletons, embryos, cell structures and functions, and chemical makeup of organisms. The presence of vestigial structures is also evidence that living things have changed over time. You will study these theories and evidences in this unit. Remember, theories change as new evidence is discovered.

**REVIEW QUESTIONS**

1. What is the meaning of the term "evolution"?

2. State the difference between geologic evolution and organic evolution.

**B. GEOLOGIC TIME.** Most people are used to thinking of time in terms of years. You probably think that 50 years is a long time and 100 years is forever! To understand evolution, you will have to think in very large numbers—in millions and billions of years! For example, scientists estimate the earth to be more than 4.5 billion years old. The oldest living thing, a bacteria-like organism, is estimated to be 3.4 billion years old.

To make the study of evolution easier, scientists developed a time chart that divides the large numbers of years into smaller time units called eras. The major eras are the Cenozoic, Mesozoic, Paleozoic, and Precambrian (Figure 26-1). The Cenozoic era is the youngest era and the Precambrian is the oldest era.

Eras are further divided into units called periods and periods are divided into epochs. These time divisions are approximate and are based on noticeable differences in the earth's rock layers. These differences were thought to be caused by major climate changes. Proof of such a climate change was discovered in Pennsylvania, where remains of tropical plants were found in coal deposits. This evidence proves that the climate of Pennsylvania was once very hot. Today, Pennsylvania's climate is temperate, with cold winters and warm summers. Tropical plants do not grow successfully in a temperate climate. Because of this, tropical plants are no longer common in Pennsylvania.

Each time period is identified by its dominant (common) animal and plant life. The Cenozoic era, the most recent era, began approximately 60 million years ago. It is called the Age of Mammals because it was during this era that mammals became the dominant form of animal life. Flowering plants were the dominant form of plant life. Man appeared late in the Cenozoic era.

The Mesozoic era, which began over 200 million years ago, is known as the Age of Reptiles. During the Mesozoic era, reptiles, such as dinosaurs, were the dominant animal life. The first birds were thought to appear during the Mesozoic era, when fern forests were the dominant plants.
The **Paleozoic era** was the longest era. It lasted over 400 million years and is divided into the Age of Amphibians, the Age of Fishes and the Age of Invertebrates. The first land plants developed during this time and fern trees were widespread along with swampy forests. Modern insects also appeared at this time, and amphibians, giant insects, trilobites, crustaceans, and fishes were common.

The oldest time period, over 4.6 billion years ago, was the **Precambrian era**. During this time simple multicellular organisms, such as sponges and worms, were numerous. The first protists (one-celled organisms) appeared during this time and probably bacteria and algae were dominant.

![Geologic Time Diagram]

**Figure 26-1. Geologic Time.**

**Review Questions**

1. Name the four major eras into which geologic time is divided.

2. Which era is the most recent era?

3. Which era is the oldest era?

4. During which era did man first appear?
C. FOSSIL EVIDENCE. Fossils are the remains or traces of organisms that once lived. Scientists who study fossils are called paleontologists. The study of fossils in the earth provides evidence to support the idea that life changed over time from simple to complex. Fossil distribution shows that life began in the sea and then moved to land. It also provides evidence for the time of origin (beginning) of various forms of life. In addition, fossils help scientists understand how climates and land surfaces have changed. It is through fossil evidence that we know that organisms existed over three billion years ago. By the process of radioactive dating, scientists determine the age of the earth's rocks and its fossils.

Many fossils are found in sedimentary rock. Where the crust of the earth is undisturbed, the oldest rock layers lie under the younger layers. Sedimentary rock is formed from layers of slowly deposited sediments. Sediments, such as rock particles, silt, and mud, are usually deposited by water. After a long period of time and great amounts of heat and pressure, sediments harden into rock forming visible layers. In undisturbed layers, the oldest layer is at the bottom and the youngest layer is at the top. Skeletons, imprints, shells, bones and other animal and plant remains become trapped in the sediment layers. When the sediment hardens, the remains of plants and animals become fossils. Fossils found in lower rock layers are assumed to be older than fossils found in upper layers. Generally, fossils found in upper layers look like those in the lower layers, but are more complex in form. This suggests a relationship between modern and older forms (Figure 26-2).

![Diagram of fossils in undisturbed rock layers]

FIGURE 26-2. FOSSILS IN UNDISTURBED ROCK LAYERS.

Organisms can become fossils (fossilization) in a number of different ways. Whole organisms have been discovered preserved in amber (a yellowish-brown sap secreted by pine trees), tar, or ice. By this method the entire body of an organism is preserved after death. Ancient insects have been found perfectly preserved in amber. The soft parts of organisms usually decay but the hard parts, such as bones and teeth, may form molds or casts. A mold is an indentation in rock shaped like an organism. A cast is formed when the decayed organism forms a mold, and the mold becomes filled with a different substance. Organisms may also be preserved by petrification. In petrification, the tissues of the organism are
slowly replaced by minerals, which preserve the original form of the organism. **Imprints**, such as dinosaur footprints, occur when a print is made in a soft sediment, such as mud, that later turns to rock. Imprints of ancient ferns have been found in coal.

**REVIEW QUESTIONS**

1. What is a fossil?

2. Describe the formation of sedimentary rock.

3. In undisturbed layers of rock, the oldest rock is found at the ________________.

4. Name three ways that fossils are formed.

**D. SKELETAL EVIDENCE.** **Comparative anatomy** is the science that studies the structures (anatomy) of plants and animals. When scientists compare skeletal structures of different vertebrates, they see a similar basic structure. This observation shows that organisms with similar bone structures may have evolved from a common ancestor population. Organs or structural parts that seem to have a common evolutionary origin are referred to as **homologous structures**. For example, the wing of a bat, the flipper of a whale, and a human arm are homologous structures (Figure 26-3). Although homologous structures are similar in structure, they do not always have the same function.

**FIGURE 26-3. HOMOLOGOUS STRUCTURES.**
E. VESTIGIAL STRUCTURES. Vestigial structures are parts of an animal's body that are not used. These structures look like structures that are fully developed and used by other animals. The human appendix is an example of a vestigial structure. Scientists think that perhaps some ancestor of humans used their appendix and, as evolution continued, humans stopped using this organ. Other vestigial structures are human ear muscles, and the leg bones of the python and porpoise. These structures provide further evidence of changing structure and function.

F. COMPARING CELL STRUCTURE. Cells and cell organelles are basically alike from one group of organisms to another. For example, all cells have a nucleus, cell membrane, cytoplasm, ribosomes, mitochondria, chromosomes, and various other organelles. In terms of evolution, this is evidence that different kinds of living things may share a common origin.

G. COMPARING EMBRYOS. Another evidence for evolution is the study of the embryonic development of different organisms. Comparisons of early stages of embryonic development show the possibility of common ancestry and evolutionary relationships. At early stages, vertebrate embryos, for example, show gill slits, tails, and two-chambered hearts. Look closely at Figure 26-4. Do you see many differences among the embryos during their early embryo stages? Observe that as development continues, the distinct traits of each species become more noticeable. The science that studies the structural similarities among vertebrate embryos is called comparative embryology.
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**FIGURE 26-3. HOMOLOGOUS STRUCTURES.**
H. SIMILARITIES IN BIOCHEMISTRY. Similarities in the biochemistry (body chemicals) of living things, such as DNA, hormones, and enzymes, show a close relationship between various forms of life. Organisms that are closely related, like the cat and the lion, have a greater similarity in their protein structure. Greater differences in cell biochemistry are thought to show a lesser evolutionary relationship.

I. EXAMPLES OF EVOLUTION. Scientists have found several complete series of fossil records that show gradual changes in animals through the ages. Two of the best examples of vertebrate evolution are those of the horse and the elephant (Figure 26-5).

The ancient ancestor of the horse, *Eohippus*, was about the size of a fox. It had four toes on its front feet and three toes on its hind feet. The horse gradually got bigger and the length of its feet increased. As time passed, some of the toes disappeared, until today the modern horse, *Equus*, is one-toed. The middle toe is the one that remains, but the horse retains tiny splints of two other toes. The skull grew longer and the teeth became flat-topped.
The ancestor of the present elephant was the size of a pig and had no tusks. Over time, the size of the elephant's body and head increased tremendously. The two upper incisor teeth increased in size and length and gradually developed into tusks. The early trunk was much shorter than the trunk of today's elephant.

**FIGURE 26-5. EVOLUTION OF THE HORSE AND THE ELEPHANT.**

1. Fossils of the __________________ and the __________________ show that animals have gradually changed through time.