BIOLOGY

Biology, or the study of life, offers an organized and scientific framework for posing and answering questions about the natural world. Biologists study questions about how living things work, how they interact with the environment and how they change over time. Biologists study many different kinds of living things ranging from tiny organisms, such as bacteria, to very large organisms such as elephants.

The common procedures that biologists use to gather information in order to answer questions is called the scientific method. The scientific method can be looked at as an organized way of solving a problem.

Steps of the Scientific Method

1. Recognizing a problem or something that needs to be solved.
2. Researching anything that may be known about the problem.
3. Proposing a possible answer, sometimes called a hypothesis that could be a solution to the problem. A hypothesis must be testable by experimentation to be valid.
4. Conducting an experiment to test the proposed hypothesis to the problem.
5. Collecting and analyzing data from the experiment that will help to determine if the hypothesis is correct or incorrect.
6. Verifying if the hypothesis you stated is supported or refuted by the data from the experiment.
7. Making sure the experiment you conducted can be done again with the same results.
8. Sharing the results of the experiment with others.

A scientific theory is an explanation for something that has occurred in nature that has been substantiated by a large amount of data that has been collected from many different experiments from many different experimenters. A scientific theory is not an absolute truth but is considered to be the best possible explanation to a certain question available at that time based on the experiments and data collected. As new data is collected and new experiments conducted, a current theory can be altered, revised, completely abandoned, or left alone.

Origin of life

It seems clear the earth itself was formed about 4.6 billion years ago. The oldest clear evidence of life—microfossils in ancient rock—are 3.5 billion years old.

The earth formed as a hot mass of molten rock about 4.6 billion years ago. As the earth cooled, much of the water vapor present in its atmosphere condensed into liquid water, which accumulated on the surface in chemically rich oceans.

Theories about the Origin of Life

1. Special creation. Life-forms may have been put on earth by supernatural or divine forces.

2. Extraterrestrial origin. Life may not have originated on earth at all; instead, life may have infected earth from some other planet.

3. Spontaneous origin. Life may have evolved from inanimate matter, as associations among molecules became more and more complex.

Composition of the early atmosphere

Very few geochemists agree on the exact composition of the early atmosphere. One popular view is that it contained principally carbon dioxide (CO_2) and nitrogen gas (N_2), along with significant amounts of water vapor (H_2O). It is possible that the early atmosphere also contained hydrogen gas (H_2) and compounds in which hydrogen atoms were bonded to the other light elements (sulfur, nitrogen, and carbon), producing hydrogen sulfide (H_2S), ammonia (NH_3), and methane (CH_4).

Such an atmosphere is referred to as a reducing atmosphere because of the ample availability of hydrogen atoms and their electrons. The key to this reducing atmosphere hypothesis is the assumption that there was very little oxygen around. In an atmosphere with oxygen, amino acids and sugars react spontaneously with the oxygen to form carbon dioxide and water. Therefore, the building blocks of life, the amino acids, would not last long and the spontaneous formation of complex carbon molecules could not occur.

Critics of the reducing atmosphere hypothesis point out that no carbonates have been found in rocks dating back to the early earth. This suggests that at that time carbon dioxide was locked up in the atmosphere, and if that was the case, then the prebiotic atmosphere would not have been reducing.

Another problem for the reducing atmosphere hypothesis is that because a prebiotic reducing atmosphere would have been oxygen free, there would have been no ozone. Without the protective ozone layer, any organic compounds that might have formed would have been broken down quickly by ultraviolet radiation.

The Earliest Cells

Microfossils

The earliest evidence of life appears in microfossils, fossilized forms of microscopic life. Microfossils were small (1 to 2 micrometers in diameter) and single-celled, lacked external appendages, and had little evidence of internal structure. Thus, they physically resemble present day bacteria, although some ancient forms cannot be matched exactly. Organisms with this simple body plan are called **prokaryotes.** Judging from the fossil record, eukaryotes did not appear until about 1.5 billion years ago. Therefore, for at least 2 billion years—nearly a half of the age of the earth—bacteria were the only organisms that existed**.**

Ancient Bacteria: Archaebacteria

Most organisms living today are adapted to the relatively mild conditions of present-day earth. However, in unusual environments, organisms that are quite remarkable, differing in form and metabolism from other living things exist. Sheltered from evolutionary alteration in unchanging habitats that resemble earth's early environment, these living relics are the surviving representatives of the first ages of life on earth.

In places such as the oxygen-free depths of the Black Sea or the boiling waters of hot springs and deep-sea vents, bacteria living at very high temperatures without oxygen are found. These unusual bacteria are called archaebacteria. Among the first to be studied in detail have been the methanogens, or methane-producing bacteria. These organisms are typically simple in form and are able to grow only in an oxygen-free environment.

The methane-producing bacteria convert CO_2 and H into methane gas (CH_4). Although primitive, they resemble all other bacteria in having DNA, a lipid cell membrane, an exterior cell wall, and a metabolism based on an energy carrying molecule called ATP. They are however characterized by a conspicuous lack of a protein cross-linked carbohydrate material called **peptidoglycan** in their cell walls, a key compound in the cell walls of most modern bacteria. Archaebacteria also have unusual lipids in their cell membranes that are not found in any other group of organisms.

Other archaebacteria that fall into this classification are some of those that live in very salty environments like the Dead Sea (**extreme halophiles**—"salt lovers") or very hot environments like hydrothermal volcanic vents under the ocean (**extreme thermophiles**—"heat lovers").

Eubacteria

The second major group of bacteria, the eubacteria, have very strong cell walls and a simpler gene architecture. Most bacteria living today are eubacteria. Included in this group are bacteria that have evolved the ability to capture the energy of light and transform it into the energy of chemical bonds within cells. These organisms are *photosynthetic,* as are plants and algae.

One type of photosynthetic eubacteria that has been important in the history of life on earth is the cyanobacteria, sometimes called "blue-green algae". They have the same kind of chlorophyll pigment that is most abundant in plants and algae, as well as other pigments that are blue or red. Cyanobacteria produce oxygen as a result of their photosynthetic activities, and when they appeared at least 3 billion years ago, they played a decisive role in increasing the concentration of free oxygen in the earth's atmosphere from below 1% to the current level of 21%.

As the concentration of oxygen increased, so did the amount of ozone in the upper layers of the atmosphere. The thickening ozone layer afforded protection from most of the ultraviolet radiation from the sun, radiation that is highly destructive to proteins and nucleic acids.
Certain cyanobacteria are also responsible for the accumulation of massive limestone deposits.

The three domains of life.

The kingdoms Archaebacteria and Eubacteria are as different from each other as from eukaryotes, so biologists have assigned them a higher category, a "domain."

A three-domain tree of life based on ribosomal RNA consists of the Eukarya, Bacteria, and Archaea.

The Kingdoms of Life

Confronted with the great diversity of life on earth today, biologists have attempted to categorize similar organisms in order to better understand them, giving rise to the science of taxonomy. All living things are assume to fall into one of three domains which include six kingdoms.

Kingdom Archaebacteria: Prokaryotes that lack a peptidoglycan cell wall, including the methanogens and extreme halophiles and thermophiles.

Kingdom Eubacteria: Prokaryotic organisms with a peptidoglycan cell wall, including cyanobacteria, soil bacteria, nitrogen-fixing bacteria, and pathogenic (disease-causing) bacteria.

Kingdom Protista: Eukaryotic, primarily unicellular (although algae are multicellular), photosynthetic or heterotrophic organisms, such as amoebas and paramecia.

Kingdom Fungi: Eukaryotic, mostly multicellular (although yeasts are unicellular), heterotrophic, usually non-motile organisms, with cell walls of chitin, such as mushrooms.

Kingdom Plantae: Eukaryotic, multicellular, non-motile, usually terrestrial, photosynthetic organisms, such as trees, grasses, and mosses.

Kingdom Animalia: Eukaryotic, multicellular, motile, heterotrophic organisms, such as sponges, spiders, newts, penguins, and humans.

Characteristics of living things

The phenomenon of life is generally defined in terms of the attributes of life itself i.e. the characteristics of living things. The criteria of movement, sensitivity, death and complexity are earlier used to detect life. While movement is neither *necessary* (possessed by all life) nor *sufficient* (possessed only by life) criterion, unless one can detect life, death is a meaningless concept, hence a very inadequate criterion for defining life. Complexity is a *necessary* criterion of life, but it is not *sufficient* in itself to identify living things because many complex things are not alive.

Biologists have established that living things share seven characteristics of life. These characteristics are

1. Organization and the presence of one or more cells
2. Response to a stimulus
3. Growth and development
4. Change through time
5. Reproduction
6. Metabolism
7. Homeostasis

1. Organization and cells

Organization is the high degree of order within an organism's internal and external parts and its interactions with the living world (compare a bird and bed).

All living organisms, whether made up of one cell or many cells, have some degree of organization. A cell is the smallest unit that can perform all life's processes. Some organisms e.g. bacteria are made up of one cell and are called unicellular organisms. Other organisms such as humans or trees are made up of multiple cells and are called multicellular. Complex multicellular organisms have the following level of organization

Organism – organ system – Tissues – cells – organelles – biological molecules - atoms

2. **Sensitivity/** Response to a stimulus

All organisms respond to stimuli (a physical or chemical change in the internal or external environment of an organism). Plants grow toward a source of light, and your pupils dilate when you walk into a dark room.

3. **Homeostasis –**

All living things have mechanisms that allow them to maintain stable internal conditions. Homeostasis is the maintenance of a stable level of internal conditions even though environmental conditions are constantly changing.

4. Metabolism

Living organisms use energy to power all the life processes such as movement and growth. This energy use depends on metabolism. Metabolism is the chemical processes of breaking down or building up organic compounds in organisms. For example, plants use the sun's energy to generate sugar molecules during a process called photosynthesis.

5. Growth and development

All living things grow and increase in size. Their growth result from the division and enlargement of their cells. Development is the process by which an organism becomes a mature adult. Development involves cell division and cell differentiation or specialization.

6. Reproduction

All organisms produce new organisms like themselves in a process called reproduction which is essential for the continuation of a species. During reproduction, organisms transmit hereditary information to their offspring. Hereditary information is encoded in large molecule called deoxyribonucleic acid (DNA). Reproduction can either be sexual or asexual.

Therefore, the criteria just listed although necessary for life, are not sufficient to define life. One ingredient is missing—a mechanism for the preservation of improvement. **Heredity.** All organisms on earth possess a *genetic system* that is based on the replication of a long, complex molecule called DNA. This mechanism allows for adaptation and evolution over time, also distinguishing characteristics of living things. Heredity, therefore, provides the basis for the great division between the living and the nonliving.

Change does not become evolution unless it is passed on to a new generation. A genetic system is the sufficient condition of life. Some changes are preserved because they increase the chances of survival in a hostile world, while others are lost. Not only did life evolve—evolution is the very essence of life.

What is a plant?

The science of plant biology is primarily the study of **flowering plants** or **angiosperms**. Flowering plants are by far the most important group of plants in the world, providing the overwhelming majority of plant species (over 250 000 in all) and most of the biomass on land, and they are the basis for nearly all our food.

Historically, the science of **plant biology**, or **botany**, has included all living organisms except animals, but it is clear that there is a major division of life between cells with a simple level of organization, the **prokaryotes**, and those with much more complex cells, the **eukaryotes**.

The prokaryotes include bacteria and bacteria-like organisms.

Among eukaryotes three main multicellular kingdoms are recognized: **animals**, **plants** and **fungi**. There is a fourth heterogeneous group of eukaryotes that are mainly unicellular but with a few multicellular groups such as **slime molds** and large **algae**. Some of these have affinity with animals, some with plants, some with fungi and some have no obvious affinity. They are grouped together, for convenience, as a kingdom, the **protists**, **Protista** (or Protoctista).

There is no clear boundary between protists and plants, and authors differ in which organisms they consider in which kingdom. Multicellular **green algae** and, to a lesser extent **brown** and **red algae**, have many features in common with land plants and are the dominant photosynthetic organisms in shallow seas.

Unicellular planktonic groups form the basis of the food chain in the deep sea. All these algae are photosynthetic, like plants, and share some characters.