Lecture1-2: Biology, Scopes of Biology and Characteristics of Life

Aspects of Science

Science has two aspects. It is both (1) a body of knowledge and (2) a method used for discovering new knowledge.

What is biology?

The word biology comes from the Greek words bios, which means life, and logos, which means thought. Thus, biology is the science that deals with the study of life.

Importance of Biology

Biology is a natural science which studies living organisms and how they interact with each other and their environment.

It examines the structure, function, growth, origin, evolution, and distribution of living things. Also, it classifies and describes organisms, their functions, and how species come into existence.

Four unifying principles form the foundation of modern biology: cell theory, evolution, genetics and homeostasis.

Biology as a separate science was developed in the nineteenth century as scientists discovered that organisms shared fundamental characteristics. Biology is now a standard subject of instruction at schools and universities around the world, and over a million papers are published annually in a wide array of biology and medicine journals.

Most biological sciences are specialized disciplines. Traditionally, they are grouped by the type of organism being studied: botany, the study of plants; zoology, the study of animals; and microbiology, the study of microorganisms. The fields within biology are further divided based on the scale at which organisms are studied and the methods used to study them:

1. biochemistry examines the fundamental chemistry of life;
2. molecular biology studies the complex interactions of systems of biological molecules;
3. cellular biology examines the basic building block of all life, the cell;
4. physiology examines the physical and chemical functions of the tissues and organ systems of an organism; and

5. ecology examines how various organisms and their environment interrelate.

Biology is important because it is used in every field. Without understanding biology you cannot understand the environment in which you, me and everyone is living. Biology contains so many secrets of nature. Biology is a vast and complex subject. It tells you about Human Body and its functions and physical makeup of our bodies, which enables us to produce cures and treatment for diseases. Biology tells you about different plants and their mechanism of converting carbon dioxide in to oxygen which is very important for everybody.

Biology tells us about the most difficult and dire challenges faced by humans.

Scopes of Biology for non major science

Biology revels to us the secrets of life uncovered by the biologists through centuries of researches. Biology is of great importance in a practical sense. There are many scopes for biology –

1. Anthropology: The science of man and mankind including the study of the physical and mental constitution of man. It also deals cultural development, social condition, as exhibited both in present and past.
2. Biotechnology: It deals with the living organism or the substances obtained from them and its use in industrial process.
3. Food technology: Science of processing and preserving food.
4. Biomedical Engineering: Biomedical engineering (BME) is the application of engineering principles and design concepts to medicine and biology for healthcare purposes (e.g. diagnostic or therapeutic).
5. Veterinary medicine: Veterinary medicine is the branch of medicine that deals with the prevention, diagnosis and treatment of disease, disorder and injury in animals. The scope of veterinary medicine is wide, covering all animal species, both domesticated and wild, with a wide range of conditions which can affect different species.
6. Medicine: Science of treating disease with drug and curative agents.
7. Forensic Science: The field of Forensic science involves investigating of a crime with the help of applying scientific principles.
8. Geology: Geology is the study of earth and everything related to its structure, processes including study of organisms inhabited on earth. Geology also comprises study of oceanography, hydrogeology, geostatistics.
9. Bioinformatics: an interdisciplinary field that develops methods and software tools for understanding biological data. As an interdisciplinary field of science, bioinformatics combines computer science, statistics, mathematics and engineering to study and process biological data.

Unifying Themes of Biology

- ❑ Hierarchical organization of life

-- structural make up, from the smallest, simple to largest,complex

- ❑ Cell theory

-- all organisms are made of cells, central idea in all studies of biology

- ❑ Heredity

-- Biological information is inherited from parents in one generation by the offspring in the next.

- ❑ Evolution

-- the modification of populations over time

- ❑ Regulation

-- To survive and reproduce, all forms of life must regulate their internal, and sometimes external, environment.

- ❑ Structure and function

-- Correlations between the structure of a biological object, and its function.

- ❑ Environmental interactions

-- Individuals interact with other organisms of their own species and those of the greater community.

- ❑ Energy flow

-- Energy flows through a food chain, cycles through an ecosystem, or is converted to different forms within the cells of an organism.

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What is Life?

What is life? What is the difference between a living and a nonliving thing? You would have no trouble deciding that a dog running down the street was alive; nor would you have any trouble deciding that a stone was nonliving. However, if you ask yourself whether a bean seed, an apple, or a potato is living or nonliving, you may have problems deciding on the answer. All these appear just as nonliving as a stone. Yet we know that all three can produce a living plant. Since it seems unlikely that a nonliving thing can produce a living plant, we can assume that the bean seed, apple, and potato are living. *What, then, are the characteristics of living things?*

Characteristics of Living Things

There are nine characteristics of living things.

1. The need for energy
2. Movement
3. Cellular structure and organization
4. Growth and development
5. Maintaining Homeostasis and Repair
6. Reproduction
7. Response to stimuli
8. Variation and adaptation
9. Metabolism

1. The Need for Energy

All living things require a continuous supply of energy to support their more obvious characteristics such as movement, growth, and reproduction.

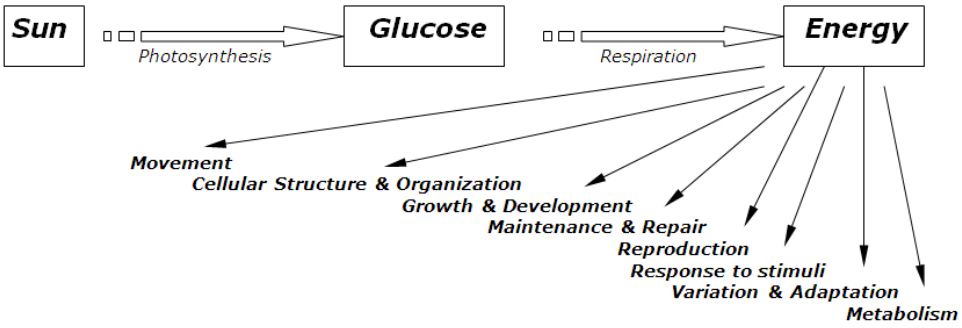


Figure: All living things have common characteristics. These characteristics are functions that require energy.

Almost all the energy used by living things comes originally from the sun (Figure). Green plants, through **photosynthesis**, store some of the sun's energy in compounds such as **glucose**. These plants, through **respiration**, then '*burn*' or breakdown the glucose, releasing the energy needed to support their life processes. Animals get their supply of energy by eating the plants or by eating other animals that have eaten plants. By doing this, they obtain glucose and other compounds which they too, break down through **respiration** to release energy to support their life processes.

2. Movement

Movement

One of the most obvious characteristics of living things is movement. Most **animals** show obvious signs of movement when they are alive.

Although movement in **plants** is not as obvious, it does occur. This movement can be very slow, such as (1) the opening of buds on a tree or (2) the turning of leaves of a plant toward the sun. In contrast, (3) the tiny sundew of northern bogs and (4) the Venus flytrap of Carolinian bogs show much more rapid motion. One of the most interesting examples of motion in plants is shown by (5) the *Mimosa pudica*, commonly called the Sensitive Plant. If this plant is touched, its leaves quickly fold up.

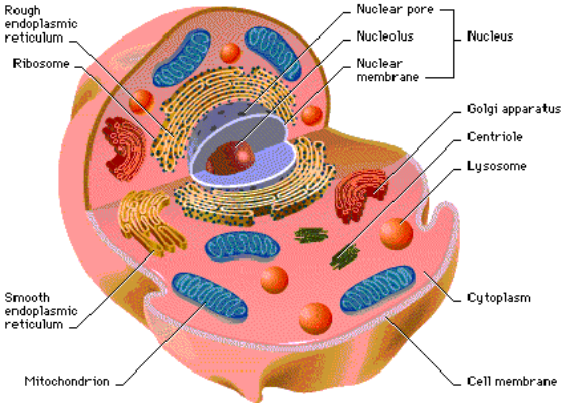
Many animals, plants, and microscopic organisms show few or no outward signs of movement. Yet under the microscope, you can see that the cell contents of these organisms are in continuous motion. This proves that in one way or another, all living things show movement.

Locomotion

Some organisms show a special type of movement called ***locomotion***. *Locomotion is the movement of an organism from one place to another*. Most animals can carry out locomotion but very few plants can. Remember that both movement and locomotion, in a biological sense, must be initiated or caused by the organism itself. Locomotion does not occur when the wind blows a plant from one place to another, nor does movement occur when the wind moves the branches of a tree.

3. Cellular Structure and Organization

All living things are made up of **cells**. Some have only one cell; others have millions of cells. Some cells are very simple and others are very complex. However, from bacteria and amoebas to trees and humans, the cell is the basic unit in which substance are organized to produce a living thing.



Protoplasm

Living cells contain a complex mixture of substances that is called ***protoplasm***. This mixture is found only in living cells. The protoplasm itself, however, is not alive. None of the materials of which protoplasm is made — carbohydrates, fats, proteins, waters, and other compounds — are alive. Yet, living cells have the ability to organize all these materials into what biologists call a ***living condition***. Protoplasm differs from one kind of organism to another and even from one individual to another of the same kind. It even differs from one part of an individual to another part of the same individual. In fact, the composition, or makeup, of any particular sample of protoplasm is always changing.

Organism

Living things have the ability to organize materials into protoplasm and to organize protoplasm and other substances into cells. Living things are therefore called ***organisms*** *because of this ability to organize substances.*

4. Growth and Development

Growth

All living things **grow** at some time during their lives. The total growth may be very small, as in the case of a bacterium or an amoeba. Total growth can be quite extensive, as in the case of a whale or a large tree. Yet, whether great or small, growth is a characteristic of all living things.

However, many **nonliving things** can also grow. For example, crystals of sugar, salt, and bluestone can be made to grow larger. You probably have seen an icicle grow. *How, then, can we say that growth is a characteristic of living thing? What kind of growth are we referring to?*

The crystals and the icicle grow larger by adding more material of the same kind to their surfaces. The **growth of living things** is quite different from this. A dog does not grow by the collection of more dogs on its surface; nor does a mango plant grow by the collection of more mango plants on its surface. Yet, neither of these organisms grows simply by taking in food. They must organize the food, along with water, minerals, and other chemicals, into the complex materials that make up protoplasm and the other parts of living cells.

Living things grow, not by adding more of their own material to their surfaces, but by organizing materials that they take in to form their own special kind of protoplasm.

Development

If you plant a bean seed, it will become a bean plant. It never becomes a potato plant or a tree. It becomes a unique living thing with specialized parts that make it different from other living things. *The series of changes that take place as an organism grows toward its final form is called* ***development***. All living things undergo development.

5. Maintaining Homeostasis and Repair

Organisms maintain a stable internal environment, even when the external environment changes are Homeostasis.

Most living things live long after growth appears to have stopped. Yet, in one sense, they continue to grow as long as they are alive. They may not grow any larger but they must continually **maintain and repair** the materials of which they are made.

For example:

1) Skin cells on your body wear away and must be replaced by new ones. A cut on your finger heals because new tissues are produced to cover the cut.

2) Some organisms, such as the salamander, house lizard and crayfish, can even grow new limbs or tail to replace lost ones by recognizing old, and adding new, material.

3) Drinking water when thirsty, Sweating to release water during summer all are examples of homeostasis.

Living things use great deal of energy in the maintenance and repair of worn-out and damaged parts. This is a characteristic of all living things.

6. Reproduction

Only living things can produce offspring similar to themselves. Shrimps lay eggs that hatch and develop into shrimps; bluebirds lay eggs that eventually produce bluebirds; horse give birth to horses; apple seeds grow into apple plants; and mango seeds become mango trees.

*It is a basic law of biology that only **life can produce life** and **like produces like**. Reproduction is the process whereby all living organisms produce offspring*.

Organisms must be able to reproduce themselves because they have a limited life span. After most organisms are formed, they go through a period of rapid growth. They eventually reach a stage called maturity at which growth in size usually ceases but maintenance and repair may continue. They then enter a period of decline in which maintenance and repair of worn-out and damage materials are no longer fast enough to keep the organisms in a stable state. Finally death occurs.

Life span

Life spans vary considerably from one type of organism to another. Some **insects** live only a few weeks. **A person** in Western world can expect to live, on the average, about seventy years. A **horse** lives about thirty years. **Some trees** live for a few decades and *others* for hundreds of years. Some **redwood trees** in California have lived for several thousand years. Some simple organisms such as **bacteria and amoebas** appear to have an indefinite life span. In a sense, they live forever, because they reproduce by splitting in two. The offspring repeat this process. Clearly such organisms never die of old age!

Organisms use a great deal of energy in the reproduction of offspring. This also is a characteristic of all living things.

7. Response to Stimuli

Irritability

All living things are able to respond to certain ***stimuli*** or change in their environment (surroundings). A **dog** comes when you whistle. A **fly** moves when you try to swat it. A ***Mimosa*** (Sensitive) plant folds its leaves in response to darkness, touch, and heat. A **plant** in a window turns its leaves toward the light. **Earthworms** seek out moist soil containing decaying vegetation. In all these examples a ***stimulus***—*sound, touch, heat, light, moisture*—causes a response by a living thing.

A living thing's response to a stimulus is called ***irritability***.

Irritability is valuable to **animals** in many ways. It helps them obtain food and avoid predators. It is most highly developed in those animals that have **nervous systems** and keen **sense organs** such as eyes, nose, and ears.

Plants usually respond slowly to *stimuli* because they lack sense organs, muscles, and other parts needed for a quick response. However, they usually respond to **light** by turning their leaves towards it. They also respond to **gravity** by sending roots downward into the soil. Many homeowners have discovered, to their dismay that Poplar and Willow trees often respond to the presence of **water** around a home by clogging the water trains with roots.

Even **single-celled organisms** such as amoebas show *irritability*. Such organisms respond to *touch*, *light*, *heat*, and *other environmental stimuli*.

Coordination

Response to stimuli must be **coordinated** if they are to be effective. Even simple organisms have many parts and each part must do the right thing at the right time if the proper response is to be carried out. For example, when you call a **dog** to supper, stimuli will be received by one or more of the *eyes*, *ears*, and *nose*. The responses to these stimuli must be coordinated within the dog before it can respond properly. Some muscles must contract; others must relax; digestive juices must be secreted. A system of nerves and a system of chemical regulators called **hormones** coordinates these responses in a dog and many other animals. In **plants**, only hormones are involved in the coordination of responses.

Behaviour

Organisms respond to stimuli by changing their relationship to it. For example, a **dog** usually comes when you whistle. It changes its location in response to the stimulus. *Such responses, which often occur in definite pattern, are called* ***behaviour***. Remember that behaviour must begin with the organism. A **ball rolling** down a hill is not showing behaviour. It is simply being pulled along by the force of gravity. However, a **dog** that responds to a whistle creates a change in its relationship to its environment. Your whistle does not pull the dog to you. Organisms use a considerable amount of energy as they respond to stimuli within their environments.

8. Variation and Adaptation

Variation

Change occurs as a result of a characteristic called ***variation***.

Offspring always differ in some ways from one another and from their parents. These differences are called *variations*.

Most variations do not affect an organism's chances of survival. For example, the fact that your hair is a different colour from your parents will not likely affect your chances of survival.

However, now and then a variation occurs that does give an organism a better chance of surviving in a changing environment. Suppose that the climate of an area is changing and deeper snow is produced each winter. Clearly a variation that produced longer legs in a deer would increase that deer's chances of surviving in that area. If this variation is passed on to the offspring of that deer, they, also, would have an increased chance of survival. Gradually the only deer of that type to be found in the deep snow area may be the long-legged types. The others would have moved away or died.

Adaptation

The process by which a certain type of organisms becomes better suited to survive in its environment is called ***adaptation***.

Keep in mind that organisms do not change in order to survive in a changing environment. The deer in our example did not grow long legs because they needed them to survive in the deep snow. *Organisms do not change to survive; they survive because they change.*

9. Metabolism

Metabolism *is the exchange of matter and energy between an organism and its environment, and the changes that occur in this matter and energy when they are within the organism*.

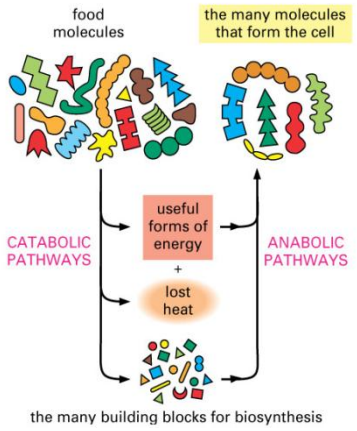
In effect, metabolism is the sum of all the processes occurring in an organism.

- It includes taking in food, or **ingestion**, as well as taking in water and air.
- It also includes all the changes in food materials that occur within organisms during **digestion**.
- It includes all changes that occur as the products of digestion are **assimilated**, or put together, during growth, maintenance, and repair.
- Finally, metabolism includes the release of energy through **respiration**.
- Finally, it includes the elimination of by-products through **excretion**.

Metabolism has two distinct phases, anabolism and catabolism.

Anabolism *is a constructive or building-up phase; it includes assimilation, or building of protoplasm from simple compounds and elements that were obtained as a result of ingestion and digestion*. It also includes the process of photosynthesis.

Catabolism *is a destructive or breaking-down phase; it involves the release of energy by the breakdown of food materials through respiration*.



A New Definition of Biology

Biology was first defined as the science that deals with the study of life. However, as we learn more, we see that biology involves many other things. It is also a study of all those things that affect life. Thus the following is a more accurate definition of biology:

Biology is the study of living things and the things that were once alive, together with the matter and energy that surround them.