A BRIEF ON CENTRAL THEMES OF BIOLOGY

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Abstract:

From amoebas to baboons, all living things have a few things in common. Five central themes of biology set the living apart from the inanimate. Take viruses: They seem to be alive, but many biologists don't consider them so since they lack one or more of these unifying characteristics. Here are the factors that help distinguish the living from the not-so-living.

Introduction

Although biology is, literally, the "study of life," what is meant by "life" varies significantly. Eukaryotes, such as most plants, animals and fungi, are multi-cellular, and those cells contain nuclei that hold genetic information. Prokaryotes are small -- often single-celled -- organisms like bacteria. Their cells do not have nuclei. Regardless of their size and structure, all living things share connections. These links make up the 10 themes of biology.

Through science, humans learn about the natural world. Technology applies this knowledge in new ways. For instance, in 2013, Australian developers created a prototype for a bionic eye. It sends an image to a microchip in the brain, allowing the user to "see" the image. The core theme of biology is evolution. This theme looks at the way organisms adapt to the environment to improve survival odds. All life on the planet exists because it evolves to best fit the environmental conditions, and those who adapt best, pass on those characteristics to their offspring. If a species does not adapt or evolve, it dies.

Biology is the science that studies life, but what exactly is life? This may sound like a silly question with an obvious response, but it is not always easy to define life. For example, a branch of biology called virology studies viruses, which exhibit some of the characteristics of living entities but lack others. It turns out that although viruses can attack living organisms, cause diseases, and even reproduce, they do not meet the criteria that biologists use to define life. Consequently, virologists are not biologists, strictly speaking. Similarly, some biologists study the early molecular evolution that gave rise to life; since the events that preceded life are not biological events, these scientists are also excluded from biology in the strict sense of the term.

From its earliest beginnings, biology has wrestled with three questions: What are the shared properties that make something "alive"? And once we know something is alive, how do we find meaningful levels of organization in its structure? And, finally, when faced with the remarkable diversity of life, how do we organize the different kinds of organisms so that we can better understand them? As new organisms are discovered every day, biologists continue to seek answers to these and other questions.

Structure and Function of Cells

All life-forms consist of at least one cell. In the 17th century, scientists Robert Hooke and Anton von Leeuwenhoek observed cells and noted their characteristics under microscopes. These and subsequent observations led to the formation of the cell theory, stating that cells make up all life, carry out all biological processes and can only come from other cells. All cells contain genetic material and other structures floating in a jelly-like matrix, acquire energy from their surroundings, and are enveloped in protection from the external environment.

Interactions Between Organisms

Organisms don't exist in vacuums. Each living thing has uniquely adapted to a particular habitat and developed specific relationships with other organisms in the same area.

In ecosystems, plants use light energy from the sun to make their own food, which becomes a source of energy for other organisms that consume the plants. Other creatures eat these plant-eating organisms and receive the energy. When plants and animals die, their energy flow doesn't stop; instead, the energy transfers to the soil and back into the environment, thanks to scavengers and decomposers that break down dead organisms.

There are various connections between life-forms. Predators eat prey, parasites find nutrients and shelter at the expense of others, and some organisms form mutually beneficial relationships with one another. As a result, changes affecting one species influence the survival of others within the ecosystem.

Homeostasis Keeps Living Things Alive

In multicellular creatures, all organ systems work together to balance substances such as:

- fluids
    - ions
    - acidity
    - gases
    - wastes

Each species can tolerate only specific environmental conditions within its range of tolerance. Outside of this range lies the zone of intolerance where all members of a species die. When the external environment changes, individuals have to maintain a constant internal environment through constant adaptation. Otherwise, they perish.

Reproduction and Genetics

All organisms reproduce and pass on characteristics

to their offspring. In asexual reproduction, offspring are exact replicas of their parents. More complex life-forms lean toward sexual reproduction, which involves two individuals producing offspring together. In this case, the offspring show characteristics of each parent.

In the mid 1800s, an Austrian monk named Gregor Mendel conducted a series of famous experiments exploring the relationship between sexual reproduction and heredity. Mendel realized that units called genes determined heredity and could be passed from parent to offspring.

Evolution and Natural Selection

In the early 1800s, French biologist Jean Baptiste de Lamarck hypothesized that the use of certain features would strengthen their existence, and nonuse would cause them to eventually disappear in subsequent generations. This would explain how snakes evolved from lizards when their legs weren't being used, and how giraffe necks grew longer with stretching, according to Lamarck.

Charles Darwin constructed his own theory of evolution called natural selection. Following his stint as a naturalist on the ship HMS Beagle, Darwin formulated a theory that claimed all individuals possess differences that allow them to survive in a particular environment, reproduce, and pass on their genes to their descendants. Individuals that adapt poorly to their environments would have fewer opportunities to mate and pass on their genes. Eventually, the genes of the stronger individuals would become more prominent in subsequent populations. Darwin's theory has become the most accepted theory for evolution.

About 1.5 billion years ago, primitive bacteria took residence inside larger cells, resulting in an intimate relationship that would mold the evolution of more complex, multicellular beings. The bigger cell was eukaryotic, meaning it contained organelles -- structures surrounded by membranes, but the prokaryotic bacterial cell had no such arrangement. The bigger cells feared oxygen, a poison to their existence, but the smaller cells used the oxygen to make energy in the form of the molecule adenosine triphosphate, or ATP. The eukaryotic cell enveloped the bacteria in predatory fashion, but somehow, the predator did not digest the prey. Predator and prey became mutually dependent. Former Boston University biologist Lynn Margulis cited this endosymbiotic scenario in her theory of the origin of mitochondria, the energy factories of cells, and the reason for their numerous similarities to bacterial cells.

Size and Shape

Based on appearance alone, scientists can draw a relationship between mitochondria and bacteria. Mitochondria have plump, jellybean-like shapes, similar to the rod-shaped bacilli bacteria. The average bacillus ranges between 1 and 10 microns in length, and the mitochondria of both plant and animal cells measure in the same range. These superficial observations constitute one line of evidence supporting the theory that primitive eukaryotic cells had engulfed bacterial cells, forming mutually beneficial relationships.

Method of Division

Bacteria reproduce in a process called fission; when a bacterium reaches a pre-determined size, it pinches itself in the middle, creating two organisms. In eukaryotic cells, mitochondria replicate themselves in a similar process. The cell's command center, or nucleus, signals the cell to produce organelles, usually in advance of a cell-dividing event; however, only mitochondria -- and the chloroplasts of plants -- replicate themselves. While other organelles can be made from substances within the cell, mitochondria and chloroplasts must divide to increase their numbers. When the energy supply in the form of ATP becomes depleted, mitochondria divide to make more mitochondria for energy production.

Membrane

Mitochondria possess inner and outer membranes, with the inner membrane consisting of folds called cristae. Bacterial cell membranes have folds called mesosomes that resemble the cristae. Energy production takes place at these folds. The inner mitochondrial membrane contains the same types of proteins and fatty substances as the bacterial plasma membrane. The outer mitochondrial membrane and the cell wall of bacteria also contain similar structures. Substances flow rather freely in and out of the outer membranes of mitochondria and the outer cell walls of bacteria; however, both the mitochondrial inner membranes and plasma membranes of bacteria restrict the passage of many substances.

Type of DNA

Both prokaryotic and eukaryotic cells use DNA to carry the code to make proteins. While eukaryotic cells carry double-stranded DNA in the form of a twisted ladder called a helix, bacterial cells have their DNA in circular loops called plasmids. Mitochondria also carry their own DNA to make their own proteins, independent of the rest of the cell; like bacteria, mitochondria also incorporate their DNA into loops. An average mitochondrion contains between two and 10 of these plasmids. These structures contain the necessary information to run all processes, including replication, within the mitochondria or bacteria.

Ribosomes and Protein Synthesis

Proteins perform all functions within cells, and the manufacture of proteins, or protein synthesis, constitutes one of the major functions of the cell. All protein synthesis occurs solely within spherical structures called ribosomes, which are scattered throughout the cell. Mitochondria carry their own ribosomes to make the proteins they need. Microscopic and chemical analyses reveal that the structure of mitochondrial ribosomes appears more similar to bacterial ribosomes than to ribosomes of eukaryotic cells. Additionally, certain antibiotics, while innocuous to eukaryotic cells, affect protein synthesis in both mitochondria and bacteria, indicating that the mechanism of protein synthesis in mitochondria is similar to that of bacteria rather than eukaryotic cells.

Some cells contain aggregates of macromolecules surrounded by membranes; these are called organelles. Organelles are small structures that exist within cells. Examples of organelles include mitochondria and chloroplasts, which carry out indispensable functions: mitochondria produce energy to power the cell, while chloroplasts enable green plants to utilize the energy in sunlight to make sugars. All living things are made of cells; the cell itself is the smallest fundamental unit of structure and function in living organisms. (This requirement is why viruses are not considered living: they are not made of cells. To make new viruses, they have to invade and hijack the reproductive mechanism of a living cell; only then can they obtain the materials they need to reproduce.) Some organisms consist of a single cell and others are multicellular. Cells are classified as prokaryotic or eukaryotic. Prokaryotes are single-celled or colonial organisms that do not have membrane-bound nuclei; in contrast, the cells of eukaryotes do have membrane-bound organelles and a membrane-bound nucleus.

In larger organisms, cells combine to make tissues, which are groups of similar cells carrying out similar or related functions. Organs are collections of tissues grouped together performing a common function. Organs are present not only in animals but also in plants. An organ system is a higher level of organization that consists of functionally related organs. Mammals have many organ systems. For instance, the circulatory system transports blood through the body and to and from the lungs; it includes organs such as the heart and blood vessels. Organisms are individual living entities. For example, each tree in a forest is an organism. Single-celled prokaryotes and single-celled eukaryotes are also considered organisms and are typically referred to as microorganisms.

All the individuals of a species living within a specific area are collectively called a population. For example, a forest may include many pine trees. All of these pine trees represent the population of pine trees in this forest. Different populations may live in the same specific area. For example, the forest with the pine trees includes populations of flowering plants and also insects and microbial populations. A community is the sum of populations inhabiting a particular area. For instance, all of the trees, flowers, insects, and other populations in a forest form the forest's community. The forest itself is an ecosystem. An ecosystem consists of all the living things in a particular area together with the abiotic, non-living parts of that environment such as nitrogen in the soil or rain water. At the highest level of organization the biosphere is the collection of all ecosystems, and it represents the zones of life on earth. It includes land, water, and even the atmosphere to a certain extent.

Conclusion

Biology is the science of life. All living organisms share several key properties such as order, sensitivity or response to stimuli, reproduction, growth and development, regulation, homeostasis, and energy processing. Living things are highly organized parts of a hierarchy that includes atoms, molecules, organelles, cells, tissues, organs, and organ systems. Organisms, in turn, are grouped as populations, communities, ecosystems, and the biosphere. The great diversity of life today evolved from less-diverse ancestral organisms over billions of years. A diagram called a phylogenetic tree can be used to show evolutionary relationships among organisms.

Biology is very broad and includes many branches and subdisciplines. Examples include molecular biology, microbiology, neurobiology, zoology, and botany, among others.

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