

Unit 1: Sub-fields of Biology

Sub-fields of Biology

Introduction

Biology, the study of life and living organisms, is a vast and diverse field. It covers everything from the smallest microbes to the largest mammals, encompassing various sub-disciplines that focus on different aspects of life. In this unit, we will explore the primary sub-fields of biology, namely Zoology, Botany, and Microbiology, and briefly discuss some additional sub-disciplines.

Major Discoveries That Revolutionized Biology

Biology has been shaped by many groundbreaking discoveries over the centuries. Here are twelve major discoveries that have significantly advanced our understanding of life:

Aristotle (384-322 BC):

Aristotle, an ancient Greek philosopher, made the first significant attempt to classify living organisms. His system, called the 'Ladder of Life,' grouped organisms based on their ability to move and their characteristics, such as herbs, shrubs, and trees. This classification system laid the foundation for future biological categorization.

Galen (129-161 AD):

Galen, a prominent Greek physician, made substantial contributions to medicine, particularly in Anatomy, Pathology, Physiology, and Neurology. He differentiated between veins and arteries and recognized that the larynx produces the voice. Despite some inaccuracies, Galen's work was crucial in advancing medical science.

Antonie van Leeuwenhoek (1632-1723):

Leeuwenhoek, known as the father of microbiology, revolutionized the study of biology by developing powerful lenses that could magnify up to 500 times. He was the first to observe bacteria and the vacuole of a cell, significantly expanding our understanding of the microscopic world.

Carl Linnaeus (1707-1775):

Linnaeus developed the system of naming, ordering, and classifying organisms that is still in use today. His system categorizes living things into three kingdoms: animals, plants, and minerals, and further classifies them

into classes, orders, genera, and species. For example, in *Homo sapiens*, 'Homo' is the genus, and 'sapiens' is the species.

Charles Darwin (1809-1882):

Darwin's theory of evolution by natural selection is one of the most influential ideas in biology. He proposed that all species descended from common ancestors and that natural selection drives the evolution of species. His book, *On the Origin of Species* (1859), challenged the belief that species were unchanging and created by divine intervention.

Gregor Mendel (1822-1884):

Mendel, often called the father of genetics, discovered the fundamental laws of inheritance by experimenting with pea plants. He introduced the concepts of dominant and recessive genes, which form the basis of genetic inheritance. Mendel's work provided the mechanism for Darwin's theory of natural selection.

Louis Pasteur (1822-1893):

Pasteur made groundbreaking contributions to microbiology and medicine. He demonstrated that bacteria cause fermentation and disease, developed the process of pasteurization, and created vaccines for anthrax and rabies. Pasteur's work laid the foundation for modern microbiology and immunology.

Robert Koch (1843-1910):

Koch, a German physician, is known as the father of modern bacteriology. He identified the specific bacteria that cause tuberculosis, cholera, and anthrax, and his work established the germ theory of disease, which revolutionized the understanding of infectious diseases.

Jane Goodall (1934-Present):

Goodall is a renowned ethologist who transformed our understanding of primates, particularly chimpanzees. She discovered that chimpanzees are omnivores and use tools, challenging previous notions of animal behavior. Goodall is also a leading advocate for animal rights and conservation.

Barbara McClintock (1902-1992):

McClintock was an American geneticist who discovered transposition, the ability of genes to change positions on chromosomes, which can turn physical characteristics on and off. Her work on maize led to advancements in genetic mapping and earned her a Nobel Prize in 1983.

James Watson (1928-) and Francis Crick (1916-2004):

Watson and Crick discovered the double helix structure of DNA in 1953.

This discovery explained how DNA replicates and how hereditary information is passed on, revolutionizing genetics, medicine, and many other fields.

Ian Wilmut (1944-) and Keith Campbell (1934-2012):

Wilmut and Campbell achieved the first successful cloning of a mammal, Dolly the Sheep, in 1996. Using a single adult sheep cell, they demonstrated that cloning is possible, opening up new possibilities in genetics and biotechnology, although ethical concerns remain.

These discoveries have not only revolutionized biology but have also had profound impacts on medicine, genetics, conservation, and our understanding of life itself.

Zoology

Definition:

Zoology is the branch of biology that studies animals. It encompasses a wide range of topics related to animals, including their behavior, genetics, embryonic development, and interaction with their environment.

Sub-disciplines:

- **Herpetology:** The study of reptiles.
- **Ichthyology:** The study of fish.
- **Mammalogy:** The study of mammals.
- **Ornithology:** The study of birds.
- **Entomology:** The study of insects.

Importance:

Zoology helps us understand animal life, which is essential for conservation, wildlife management, and understanding human impacts on ecosystems. Figure 1.1 shows an example of an endemic wild animal in Ethiopia, the Waliya ibex.

Botany

Definition:

Botany is the scientific study of plants, including their structure, properties, biochemical processes, classification, diseases, and interactions with the environment.

Key Concepts:

- **Photosynthesis:** The process by which plants convert sunlight into energy, producing oxygen as a by-product.
- **Plant Classification:** Understanding the classification of plants is vital for agriculture, horticulture, and forestry.

Importance:

Botany is crucial for understanding the role of plants in ecosystems, food production, and medicine. Green plants are essential for life on Earth as they provide oxygen and food. An example of a plant studied in botany is *Ruta chalepensis* L., known as 'Tena Adam' in Amharic, a traditional herbal medicine in Ethiopia (Figure 1.2).

Microbiology

Definition:

Microbiology is the study of microscopic organisms, or microbes, that cannot be seen with the naked eye. This includes bacteria, archaea, protists, viruses, and microscopic algae and fungi.

Sub-disciplines:

- **Bacteriology:** The study of bacteria.
- **Mycology:** The study of fungi.

Importance:

Microbiology is essential for understanding the roles of microbes in disease, environmental processes, and biotechnology. Despite the challenges in studying microbes due to their small size, advancements in technology continue to expand our knowledge in this rapidly growing field. Figure 1.3 illustrates various types of microorganisms.

Additional Sub-fields of Biology

Morphology:

The study of the external form and structure of organisms. For example, examining the shape and texture of leaves or stems.

Anatomy:

The study of the internal structure of organisms, often through dissection. For example, analyzing organs such as the stomach, liver, or heart.

Histology:

The study of tissues at the microscopic level, focusing on the details of tissue structure.

Cytology:

The study of cells, including their structure and function.

Molecular Biology:

The study of biological processes at the molecular level, focusing on molecules like DNA and RNA.

Pure and Applied Biology**Pure Biology:**

Pure biology involves studying the fundamental processes of life, such as behavior, reproduction, and structure, to understand how living organisms function in nature.

Applied Biology:

Applied biology uses the knowledge gained from pure biology to address practical problems, such as improving agriculture, managing forests, and treating diseases.

Examples of Applied Biology:

- **Biotechnology:** Utilizing living organisms to develop products that benefit humanity, such as genetically modified crops.
- **Biomedical Engineering:** Applying engineering principles to biology and medicine to improve healthcare.
- **Forensic Science:** Using biological knowledge, such as DNA analysis, to solve crimes.

Major Discoveries in Biology

Biology has a rich history of discoveries that have revolutionized our understanding of life. Some of the most notable figures include:

- **Aristotle (384-322 BC):** Developed an early classification system for living organisms.
- **Antonie van Leeuwenhoek (1632-1723):** Pioneered microscopy and discovered bacteria.
- **Charles Darwin (1809-1882):** Proposed the theory of evolution by natural selection.

- **Gregor Mendel (1822-1884):** Discovered the basic principles of genetics through his work with pea plants.
- **Louis Pasteur (1822-1893):** Established the germ theory of disease and developed vaccines.
- **James Watson and Francis Crick (1953):** Discovered the structure of DNA, revolutionizing genetics.

Ethiopian Biologists and Their Contributions

Ethiopia has produced several prominent biologists whose work has made significant contributions to both the scientific community and society at large. Below are three renowned Ethiopian biologists and their notable contributions:

1. Professor Yalemtehay Mekonnen

Prof. Yalemtehay Mekonnen is a distinguished biologist and a faculty member in the Department of Biology at Addis Ababa University. She has served in academia for over 30 years and obtained her Ph.D. in human physiology from the University of Heidelberg in Germany. Her research primarily focuses on two areas:

- **Chemical Pesticide Hazards:** Prof. Yalemtehay has conducted extensive research on the impact of chemical pesticides on human health. Her studies encompass various government farms, including the Upper Awash agricultural farms, and private horticultural farms in the Rift Valley region of Ethiopia.
- **Medicinal Plants:** She has also explored the use of plants as medicinal remedies for both human and animal diseases. One of her notable contributions is her research on *Moringa Stenopetala* (locally known as Shiferaw or Alekko Shekatta), which is recognized for its medicinal properties.

Prof. Yalemtehay has published over 100 scientific papers, contributing significantly to the fields of medicinal plants, human health, and environmental safety.

2. Dr. Aklilu Lemma

Dr. Aklilu Lemma was a pioneering Ethiopian biologist best known for his groundbreaking work on controlling schistosomiasis, a parasitic disease caused by flatworms. This disease affects millions of people, particularly in Africa, including Ethiopia.

- **Discovery of Endod:** In 1964, while studying freshwater snails in Adwa, northern Ethiopia, Dr. Aklilu observed that snails died when exposed to the soapberry plant, *Phytolacca dodecandra* (locally known as Endod). This observation led him to discover that Endod could effectively kill the snails that host the schistosomiasis parasite.
- **Impact:** Dr. Aklilu's discovery offered a low-cost, environmentally friendly solution to controlling schistosomiasis. The World Health Organization eventually recognized the efficacy of Endod as a molluscicide, and its use has expanded throughout Africa and beyond.

Dr. Aklilu's work has been published in numerous international journals, and he has been widely honored for his contributions to public health.

3. Professor Gebissa Ejeta

Prof. Gebissa Ejeta is an internationally recognized Ethiopian plant breeder and geneticist who has made significant contributions to improving food security in Africa.

- **Sorghum Research:** Prof. Gebissa is best known for developing Africa's first commercial hybrid sorghum. His research focused on creating drought-resistant sorghum varieties that also yield more grain compared to traditional varieties.
- **Striga-Resistant Sorghum:** He also developed sorghum varieties resistant to the parasitic weed Striga, which is known to devastate crops. His innovations have substantially increased sorghum yields, improving food availability in Ethiopia and other African countries.
- **Awards:** In recognition of his contributions to agricultural science, Prof. Gebissa Ejeta was awarded the World Food Prize in 2009, the highest honor in the field of agriculture. He has also received Ethiopia's National Hero award for his work.

These biologists are just a few examples of the many Ethiopian scientists whose research and discoveries have had a profound impact on both Ethiopia and the world. Their work continues to inspire future generations of scientists.