Chapter 1 - The Science of Biology

1.1. Introduction to Biology

Biology is the scientific study of life, which encompasses the structure, function, growth, origin, evolution, and distribution of living organisms. It is a broad field that includes the study of everything from single-celled microorganisms to complex organisms like humans. Bio means life, and logos means study. Hence, it is the study of life.

Quranic Instructions to Reveal the Study of Life

Biology, the study of living organisms and their vital processes, is viewed in Islam as a means to understand the greatness of Allah (God) through the study of His signs (*āyāt*) in nature. Islamic theology encourages scientific inquiry and empirical observation of the natural world as a way to reflect on the Creator's artistry and guidance.

- **Origin of Life in Water:** The Quran states that all living things were made from water: "We made from water every living thing" (Quran 21:30). This aligns with the modern biological understanding that life began in Earth's ancient oceans and that cells are composed primarily of water.
- **Embryology (Development):** The Quran provides detailed descriptions of human embryonic development in stages within the womb. These stages, described using terms like *nutfah* (spermatic fluid/drop), *alaqah* (clinging form/leech-like), and *mudghah* (chewed substance), are remarkably consistent with modern embryology, which developed much later with the invention of the microscope.
- **Reproduction (Creation of Man):** The Quran mentions the creation of both male and female sexes in plants, animals, and humans, a fact confirmed by botany and genetics. The determination of sex by the male sperm is also alluded to.

1.2. Major Fields of Biology

Main divisions of Biology are: Botany, Zoology, and Microbiology.

Sub-fields of Biology:

- **Morphology** - study of size, shape and structure of organisms (animals, plants and microorganisms)
- **Anatomy** - study of internal structures of organisms
- **Physiology** - study of the functions of various organs of living organisms
- **Histology** - the microscopic study of tissues of organisms
- **Cytology** - the study of the structure and function of the cell
- **Genetics** - the study of genes and heredity
- **Molecular Biology** - the study of life at a molecular level
- **Embryology** - the study of an embryo and its development
- **Paleontology** - the study of history of life based on fossils

- **Taxonomy** - the classification and naming of organisms based on species (e.g., *homo sapiens*)
- **Ecology** - the study of relationships between organisms and their environment
- **Marine Biology** - the study of organisms living in the sea
- **Pathology** - the study of diseases and their diagnoses
- **Immunology** - the ability of body to protect itself from pathogens and infectious substances/ the study of immunity of organisms
- **Pharmacology** - the study of drugs

1.3. Relationship of Biology with Other Sciences

Biology is related to many other fields of science in various ways. This integration with other sciences can be studied further:

- Biophysics
- Biochemistry
- Biostatistics
- Computational biology
- Biogeography
- Biotechnology
- Bio-economics

1.4. Careers that Require a Background in Biology:

Careers that require a background in biology include a wide range of fields like medicine and healthcare (physicians, nurses, genetic counselors), research and science (biologist, biochemist, research scientist), environmental and agricultural science (ecologist, conservation biologist, crop scientist), forensics, and biotechnology. These roles involve applying biological knowledge to areas such as health, the environment, and scientific development.

- **Physician, Dentist, or Pharmacist:** Requires additional professional degrees, but a biology background is foundational.
- **Nurse or Community Health Nurse:** Focuses on patient care and public health education.
- **Genetic Counselor:** Helps individuals understand genetic risks and diseases.
- **Clinical Laboratory Technician:** Performs medical tests and analyses.
- **Research Scientist:** Conducts experiments to study living organisms.
- **Microbiologist:** Studies microorganisms like bacteria and viruses.
- **Biochemist:** Studies the chemical processes within living organisms.

- **Biomedical Engineer:** Applies engineering principles to biology and medicine.
- **Professor or Teacher:** Educates students at the university or high school.
- **Ecologist:** Studies the relationships between living organisms and their environment.
- **Conservation Biologist:** Focuses on the protection of species and habitats.
- **Environmental Scientist:** Analyzes environmental problems and develops solutions.
- **Nature Conservation Officer:** Works to protect natural areas and wildlife.

1.5. Science is a Collaborative Field

Science is a collaborative field because it involves interdisciplinary teams sharing knowledge, data, and resources to solve complex problems and accelerate discovery.

How collaboration benefits science

- **Interdisciplinary problem-solving:** Experts from different fields work together, pooling their unique strengths and knowledge to address complicated challenges more effectively than they could alone.
- **Accelerated discovery:** Sharing ideas, data, and findings across teams and even continents speeds up the pace of discovery and leads to more comprehensive understanding.
- **Increased accuracy and reliability:** Collaboration allows for peer review and checking of work, which helps ensure accuracy and reliability in scientific findings.
- **Broader perspectives:** Working with people from different backgrounds and disciplines exposes researchers to new ideas and approaches, enriching their understanding and fostering innovation.
- **Resource sharing:** Research projects often require expensive equipment, labs, and funding. Collaboration allows these resources to be shared, making complex projects more feasible.

1.6. Biological Method/The Scientific Method

- **Recognition of a problem** A question or problem related to any living organism
- **Observation and identification**
  - Observation- made by the 5 senses (sight, smell, touch, taste, hearing)
  - Types of observations: quantitative and qualitative
    - **Quantitative observation:** (quantity) based on measurable or factual value
    - **Qualitative observation:** based on some quality
- **Hypothesis generation (Hypothesis- an educated guess/ 'tukka')** A statement which you can test or is a tentative explanation of something
- **Drawing deductions (specific)** Logical conclusions of the hypothesis For example, 'If you drink cold water, you will fall sick'

- **Conducting an experiment** To prove if the hypothesis is right or wrong Deductions are tested to see how valid they are
- **Results** Gather the actual data from experiments which, when analysed/interpreted, gives you the results

1.7. Hypothesis, Theory and Law

Hypothesis:

A **hypothesis** is a temporary or tentative answer to a question or a problem. It is based on **past experiences** and **available data**. A scientific hypothesis **predicts outcomes** that can be tested through further experiments and observations. **Deductions** are logical outcomes of the hypothesis. They usually follow **"if... then..."** logic. **Example: If** a hypothesis is true, **then** a specific result should be observed in experiments. Experiments are performed to test if deductions (based on the hypothesis) are correct. If results match predictions, the hypothesis is supported.

Theory:

A **theory** is a well-tested explanation supported by a lot of evidence and data. Theories are **broader** than hypotheses and explain a larger range of phenomena. A theory is more **general and reliable** than a hypothesis. Even well-supported theories can be **changed or rejected** if new evidence appears.

Law:

A theory with **wide application** and verification may become a **biological law**. **Example:** The sun rises in the east and sets in the west.

Data Analysis

Data is the collection of facts and observations. Data is first collected and then organized using graphs and tables. **Analysis** involves making sense of data using **ratios and proportions** to make predictions.

1.8. Malaria as an Example of Biological Method of Study

- **Symptoms:** feeling cold, nausea, temperature rises, headaches, body feels better, then gets symptoms after every 24, 48 and 72 hours.
- **Recognition of problem:** malaria exists, but the cause is unknown.
- **Observation:** In the 19th century, many different causes of malaria were being suggested. By that time, there were four major observations about malaria.
    a. Malaria and marshy areas have some relation.
    b. Quinine is an effective drug for treating malaria.
    c. Drinking the water of marshes does not cause malaria.
    d. *Plasmodium* is seen in the blood of a malarial patient.

- **Hypothesis:** '*Plasmodium* is the cause of malaria'.
- **Deduction:** "If *Plasmodium* is the cause of malaria, then all persons ill with malaria should have *Plasmodium* in their blood".
- **Experiment:** the blood of 100 malaria patients (*experimental condition*) was examined under the microscope.
  - **Control group:** a group in an experiment used to compare results of the tested/experimental condition. (healthy people).
- **Results:** all malarial patients had *Plasmodium* in their blood. 7 healthy people had *Plasmodium* in their blood as it was in the *incubation period*.
- **Conclusion:** Hence, the hypothesis is proven right- *Plasmodium* is indeed the cause of malaria.