

INTRODUCTION TO BIOSCIENCE

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By

Dr. J.P. Sharma

M.Sc., Ph.D., FISST

Ex. H.O.D. Deptt. of Botany

Hindu College, Sonapat

(M.D. University, Rohtak, Haryana)

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PREFACE

In recent years there have been many advances made in the field of bioscience. And so the techniques of bioscience have been included in the curriculum of Engineering sciences of Indian Universities. There has been made tremendous progress in the research methodology of biosciences. The progress has been driven by the new and minor modifications to existing techniques in turn propelling and enhancing the scientific investigation. However, the use of any procedure can only be advantageous if there is an appreciation of basic principles, requirements, benefits and pitfalls of the technique employed. This is true for both experienced and beginners in the field of biosciences.

No doubt, the newly enrolled students for this course may find struggling to understand the basics of techniques in bioscience as there is a lack of appropriate support in the literature on this topic. The book entitled 'Introduction to Bioscience' has been written keeping this in view. With this in mind, the rationale of this book is to supply the students with an easy to use reference book that will provide the students with a basis for understanding the basic bioscience techniques that the students come across in their studies. The book provides the foundation of biosciences techniques to make it a novice course book for the students as well as teachers. The content of the book follow the latest curriculum prescribed by the universities for B.Tech. courses.

All efforts have been made to make the subject matter comprehensive up to date and concise. Every care has been taken to make the language simple and the presentation of the text systematic. Well informative and self explanatory diagrams have also been included in sufficient number. While great emphasis has been laid on basic fundamentals, no effort has been spared to incorporate recent information in sufficient details. Each chapter has been appended with sufficient number of review exercises that include multiple choice type questions, objective type questions, and descriptive questions.

It is confidently hoped that the present book will go a longway in meeting the requirements of students who aspire for brighter career.

Constructive suggestions for the improvement of book shall be gratefully acknowledged.

— Author

UNIT-1

INTRODUCTION TO BIOSCIENCE

1. Introduction to Bioscience
2. Cell Structure and Function
3. Metabolic Engineering (Cellular Respiration)

1

Introduction To Bioscience

- Defining Characteristics of Living Beings
- Comparison in Structure and Organisation between Living and Non-living Things
- Levels of Organisation
- Review Exercises
- Test Questions

The living world comprises of diverse type of organisms. Millions types of living organisms exist on the Earth. *The Science which deals with the study of living things is called biology* (Gk. *bio*-life, *logos*-study or discourse). The definition of biology appears to be quite simple, but this science is very complex and informative. It covers all aspects of study of living beings like origin, occurrence, external form, organisation, life history and inheritance. All these disciplines constitute several aspects or branches of biology. Being broad based and multidisciplinary, the term biology is often replaced by the term '**life sciences**' or **biosciences** or **biological sciences**.

Biology deals with the science of living things—what they are, how they work, interact and change or evolve. The living organism interact with one another, as well as with their physical and chemical environment. Biology as a disciple of science, demands a scientific approach for analysis of its facts. It is therefore, imperative that student of biology should have a clear idea about the basic nature of science.

There are two types of objects—living and non-living. However, despite our recognition of the two, it is very difficult to distinguish living beings from non-living objects. Though biologists have vast knowledge of living things, yet it is quite difficult for them to definite life. Therefore, rather than to trying to definite life, biologists focus on how life works. All the living beings share certain unified and basic characteristics.

Life is a unique, complex organisation of molecules expressing itself through chemical reactions, which lead to growth, development, responsiveness, adaptation and reproduction. The object by itself exhibiting the growth, development, death etc., is designated as living being.

DEFINING CHARACTERISTICS OF LIVING BEINGS

Although, there exist a great diversity among organisms, still they have many things in common. The diverse form of organisms such as fungi, plants, insects and vertebrates are made up of cells, similar in internal organisation and functions. May be a single celled *Amoeba* or bacterium or giant multicellular whale or the unique human, all share some unified and basic characteristics like growth, reproduction, ability to sense environment, metabolism, ability to self replicate, self organise, interact and emergence, etc.

All these become the defining property of living organisms. Let us understand each of these.

1. Growth. Increase in mass and increase in number of individuals are the two characteristics of growth. All organisms are able to grow. A multicellular organism grows by cell division. In plants growth occurs throughout their lifespan. However, in animals this growth occurs only up to a certain age, and thereafter cell division occurs in certain tissues to replace the lost cells. Unicellular organisms also grow by cell division. The increase in body mass is considered as growth. In living organisms growth is from inside.

Certain non-living objects such as mountains, boulders and sand mounds also grow. However, the growth of non-living objects is established by the accumulation of material on the surface. Growth, therefore, cannot be taken as a defining characteristic of living systems.

2. Reproduction. Living organisms produce new individuals similar to them. Organisms reproduce by sexual and asexual means. Fungi multiply and spread easily by producing millions of asexual spores. Some organisms like yeast and *Hydra* multiply by budding. The flat worms (*e.g.*, *Planaria*) regenerate from fragmented parts of their body. The filamentous algae, fungi, protonema of mosses also multiply by fragmentation.

In unicellular organisms like bacteria, *Amoeba*, unicellular algae reproduction is synonymous with growth *i.e.*, increase in number of cells. Therefore, in unicellular organisms, there is no distinction in the usage of the terms 'growth' and 'reproduction'.

Many organisms such as mules, sterile worker bees, infertile human couples, etc., do not reproduce. Also non-living objects cannot reproduce and replicate by itself. Therefore, reproduction cannot be taken as a defining property of living organisms.

3. Metabolism. Living organisms are made of different kinds of chemicals, which are constantly being made and changed into some other biomolecules. These reactions are called **metabolic reactions**. Thousands of metabolic reactions occur simultaneously inside all living organisms. The sum total of all the chemical reactions occurring in our body is called **metabolism**.

Metabolic reactions can be performed outside the body in cell free systems. An isolated metabolic reaction outside the body of an organism is neither living nor non-living. The isolated metabolic reactions *in vitro* are not 'living things' but are 'living reactions'. Hence, metabolism can be considered a defining feature of all living organisms without exception.

4. Cellular Organisation. All types of organisms starting from simple to highly complex entities are made up of one or more cells, similar in internal structure and functions. Hence, cellular organisation of the body is the defining feature of life forms.

5. Protoplasm. Living beings possess a highly organised living matter, called **protoplasm** (Purkinji, 1837) capable of performing life processes. **Huxley** (1868) has described it as '**the physical basis of life**'. The protoplasm or living matter consists of a variety of organic and inorganic substances. Non-living things lack such living matter.

6. Consciousness. All living organisms have the ability to sense their surroundings or environment and respond to these environmental stimuli, which could be physical, chemical or biological. All organisms, from prokaryotes to most complex eukaryotes can sense and respond to environmental cues. Photoperiod (*i.e.*, duration of light) affects reproduction in seasonal breeders of both plants and animals. Plants respond to external factors like light, water, temperature, pollutants and other organisms. All organisms are able to handle chemicals that enter their bodies, and are aware of their surroundings. We sense our environment through our sense organs. Human being is the only organism that has 'self consciousness' *i.e.*, aware of himself. Hence, consciousness (chetan tatwa) is the defining property of living organisms.

It is quite difficult to define the living state of a human being at different times. For example, lying in coma in hospital, supported by machines (*i.e.*, heart and lung machines), with dead brain. The patient has no self consciousness. Are such patients who never come back to normal life, living or non-living.

All living phenomenon are due to underlying interactions. The properties of tissues are not present in constituent cells but arise as a result of interactions among the constituent cells. In the same way, the properties of tissues are not present in the molecular constituents of the organelle, but is due to the interactions among the molecular components that constitute the organelle. These interactions result in emergent properties at a higher level of organisation. Thus, *the living organisms are self-replicating, evolving and self regulating interactive systems capable of responding to external stimuli*. All living organisms—present, past and future, are linked to one another by the sharing of common genetic material, but to varying degree.

COMPARISON IN STRUCTURE AND ORGANISATION BETWEEN LIVING AND NON-LIVING THINGS

Living beings share some features with the non-living things whereas they differ in certain other respects. Some of these points of similarities and differences are listed below :

Similarities

- Living beings are made up of same elements, which constitute the non-living things.
- These elements combine and form **molecules (biomolecules** in living beings).
- The molecules of living beings or biomolecules are capable of interacting like those of non-living things.
- Both the living beings and non-living things are governed by the same physical laws such as those of gravitation, magnetism, action and reaction, etc.

Differences

- The differences between living beings and non-living things at molecular level started very early in the geographical history when organic compounds were synthesized for the first time.
- Living beings possess a number of organic molecules, whereas the non-living things do not have them.
- Living beings possess a number of complex molecules called **macromolecules** formed by the condensation and interaction of smaller molecules known as **micromolecules**. The macromolecules are absent in non-living things.
- Living beings possess DNA or RNA as genetic material. Such genetic material is not present in non-living things.
- In the living beings, the molecules and compounds coordinate with one another to form sub-cellular components such as **cell organelles**, cytoplasmic matrix etc. On the other hand in non-living things, molecules and compounds are organised into **colloids, crystals** and **mixtures** and there is no further organisation beyond these structures.
- In the living world, the sub-cellular components are organised into the protoplasmic units called **cells**. The cells are organised into **tissues**, tissues into **organs**, organs

into **organ systems** and the organ systems into an **individual**. No such type of organisation is found in non-living things.

- In living beings, organisation becomes more and more complex, beyond the individual level.

LEVELS OF ORGANISATION

The term organisation has many meanings depending on the context in which it is used. In a simple way organisation may be defined as *‘the manner in which smaller components of any structure, system or a situation are arranged in a hierarchy to co-ordinate with one another towards a goal’*.

The above definition indicates the presence of organisation at several levels. The levels of organisation of matter in the living and non-living things are different from one another (Fig. 1.1 and Fig. 1.2). The living beings present a characteristic complexity in their organisation. Various levels of organisation in the living beings and the non-living things are described below :

(i) **Atomic Level.** The basic unit or component of organisation of both living and non-living objects is the **atom**. The atoms are, of course, themselves made of still smaller particles—mainly **electrons, protons** and **neutrons**.

(ii) **Molecular Level.** Atoms are organised to form molecules and compounds. In non-living world, the molecules and compounds are aggregated to form **crystals, mixtures** and **colloids**, but beyond them the organisation is absent. In the living world, the molecules and compounds co-ordinate with one another to form sub-cellular components like cell organelles, cytoplasmic matrix, etc.

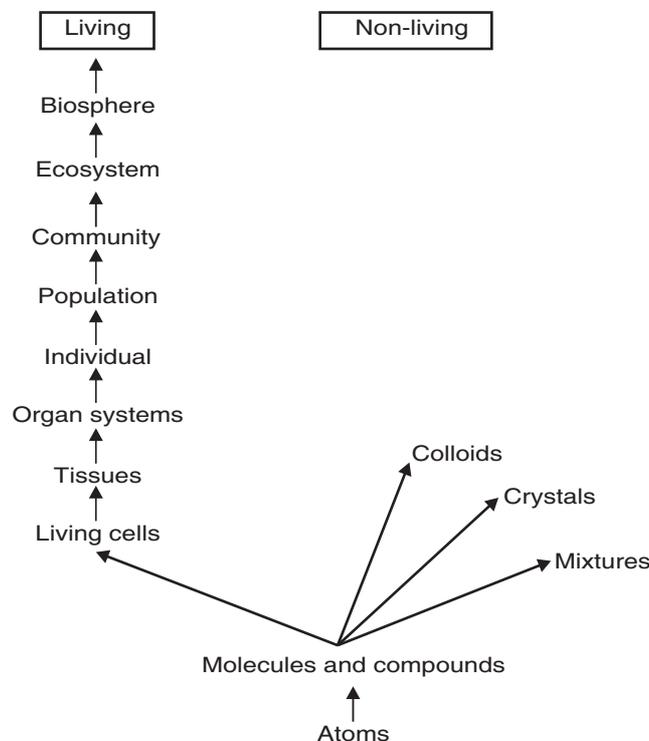


Fig. 1.1. Levels of organisation in living and non-living.

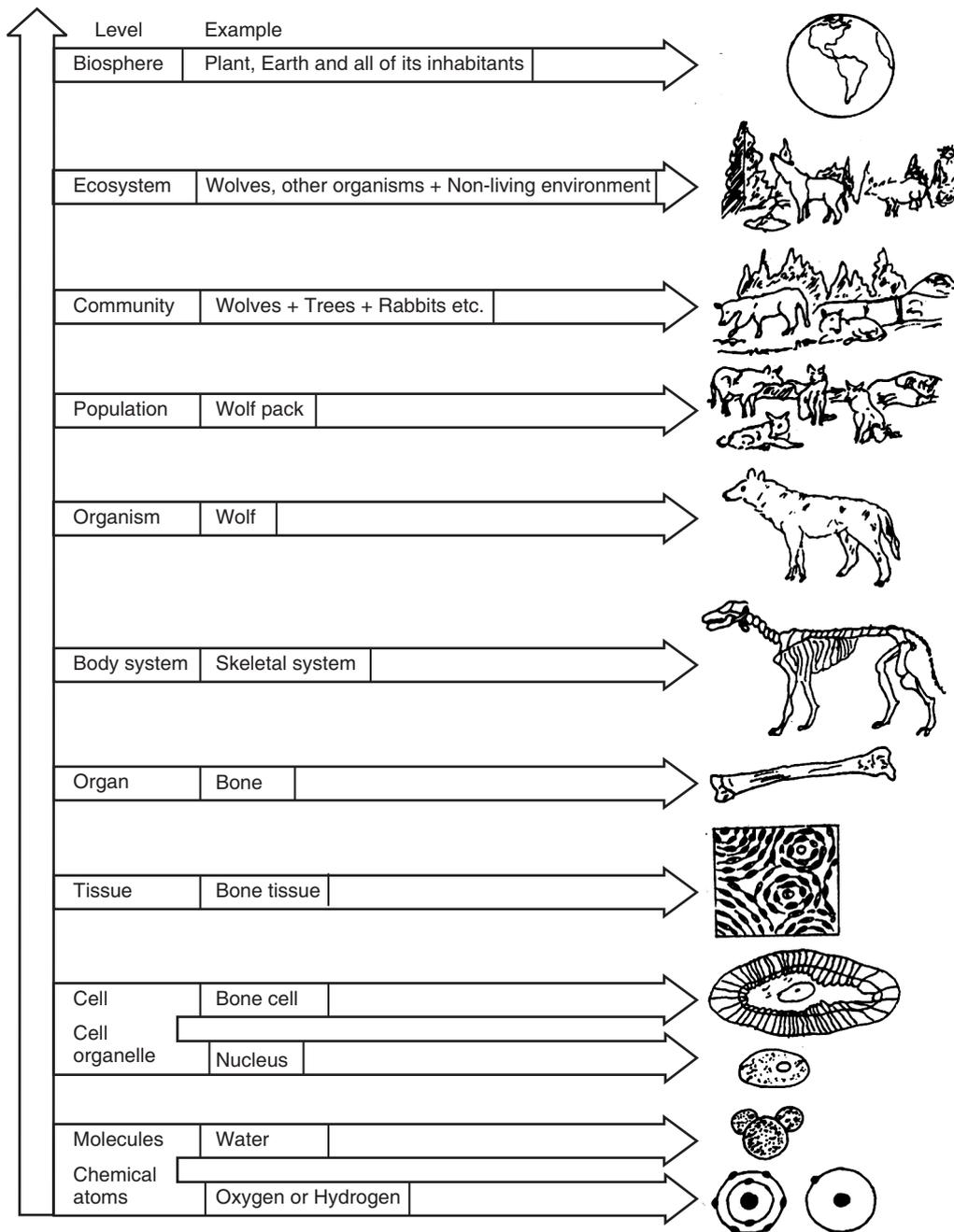
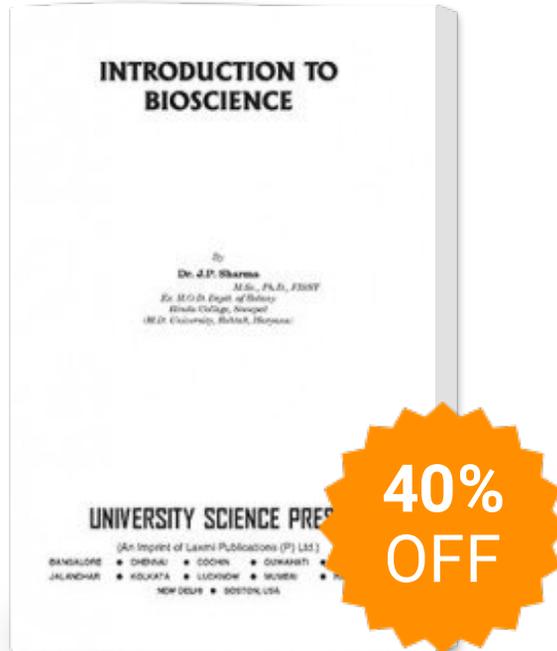


Fig. 1.2. Levels of biological organization.

(iii) **Cellular Level.** The sub-cellular components co-ordinate their activities to produce living cells. The cells are the structural and functional units of life. Living beings are made up of one cell (**unicellular organisms**) or numerous cells (**multicellular organisms**).

(iv) **Tissue Level.** In simple multicellular organisms similar cells form aggregates. This type of organisation is called **colonial**. In most multicellular organisms cells are organised in

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