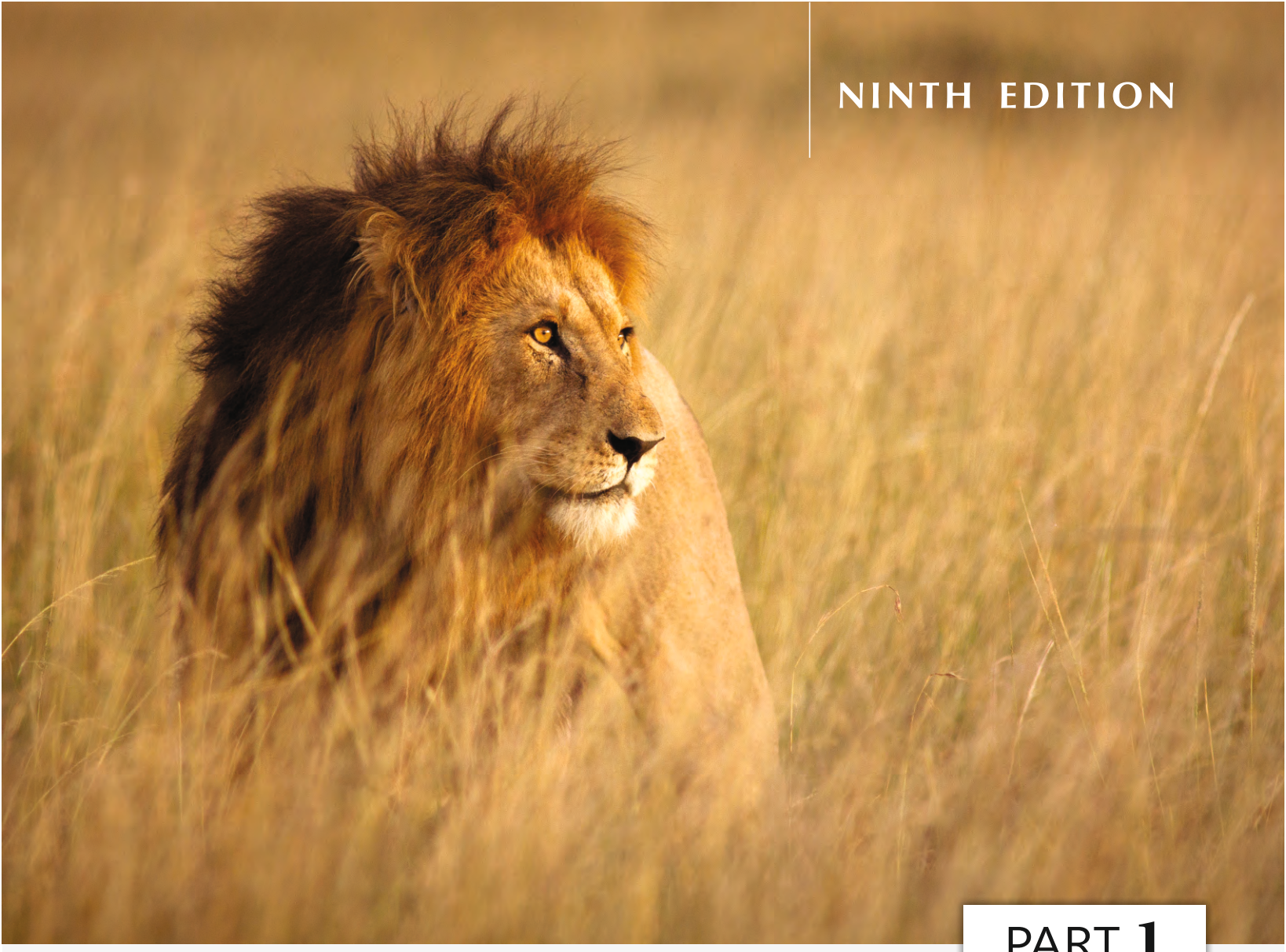

NINTH EDITION

PART 1

Life Sciences

Fundamentals and Practice

PRANAV KUMAR USHA MINA

Life Sciences

Fundamentals and Practice

Part-1

Ninth edition

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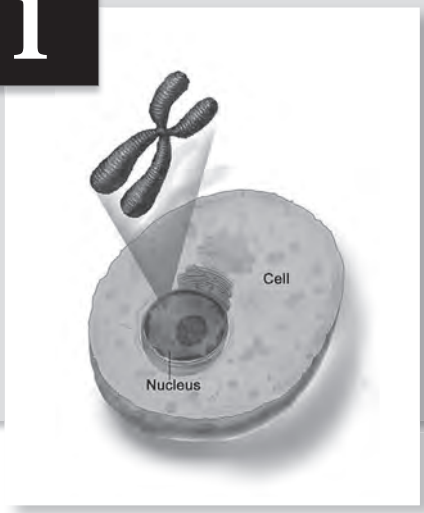

Biomolecules and Catalysis

Learning objective

Biomolecules are *carbon-based organic compounds* that are produced by living organisms. Most biomolecules can be regarded as derivatives of hydrocarbons, with hydrogen atoms replaced by a variety of functional groups that confer specific chemical properties on the molecule. These molecules consist of a relatively small number of elements. Approximately 25 naturally occurring chemical elements are found in biomolecules, and most of these elements have a relatively low atomic number. In terms of the percentage of the total number of atoms, hydrogen, oxygen, nitrogen, and carbon together makeup over 99% of the mass of most cells. Biomolecules include both small as well as large molecules. The **small biomolecules** are low molecular weight (less than 1000) compounds which include sugars, fatty acids, amino acids, nucleotides, vitamins, hormones, neurotransmitters, primary and secondary metabolites. Sugars, fatty acids, amino acids, and nucleotides constitute the four major families of small biomolecules in cells. Each of these small biomolecules is composed of a small set of atoms linked to each other in a precise configuration through covalent bonds. **Large biomolecules** which have high molecular weight are called *macromolecules* and mostly are polymers of small biomolecules. These macromolecules are proteins, carbohydrates, and nucleic acids.

Small biomolecules	Macromolecules
Sugars	Polysaccharides
Amino acids	Polypeptides (proteins)
Nucleotides	Polynucleotides (nucleic acids)

Nucleic acids and proteins are **informational macromolecules**. Proteins are polymers of amino acids and constitute the largest fraction (besides water) of cells. The nucleic acids, DNA and RNA, are polymers of nucleotides. They store, transmit, and translate genetic information. The polysaccharides, polymers of monosaccharides, have two primary functions: serving as a storage form of energy and as extracellular structural components.

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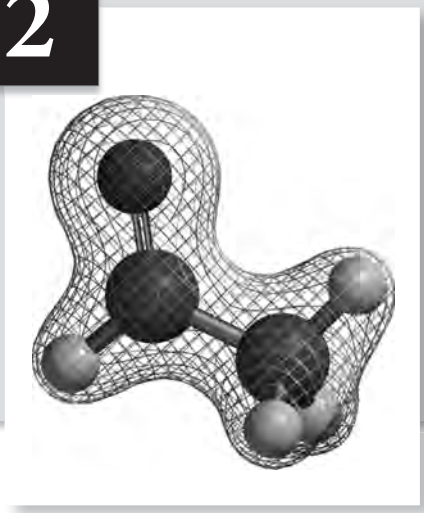
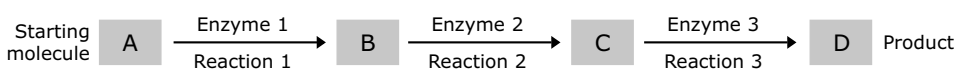


Metabolism

Learning objective

All cells function as biochemical factories. Within the living cell, biomolecules are constantly being synthesized and transformed into some other biomolecules. This synthesis and transformation constantly occur through enzyme-catalyzed chemical reactions. More than a thousand chemical reactions take place in a cell. Most of these chemical reactions do not occur in isolation but are always linked to some other reactions. All the interconnected chemical reactions occurring within a cell are called **metabolism** (derived from the Greek word for a *change*). Metabolism serves two fundamentally different purposes: 1. Generation of energy to drive vital functions and 2. Synthesis of biological molecules. The precursor is converted into a product during metabolic processes through a series of metabolic intermediates called **metabolites**. Cell metabolism is organized by enzymes. Enzyme-catalyzed reactions are connected in series so that the product of one reaction becomes the starting material, or substrate, for the next. The series of enzyme-catalyzed reactions transform substrates into end products through many specific chemical intermediates constitutes a **metabolic pathway**. Metabolism is sometimes referred to as **intermediary metabolism**. The term *intermediary metabolism* is often applied to the enzyme-catalyzed reactions that extract chemical energy from nutrient molecules and use it to synthesize and assemble cell components. The flow of metabolites through the metabolic pathway has a definite rate and direction. Metabolism is highly organized and regulated. Metabolic pathways are regulated through control of (1) the amounts of enzymes, (2) their catalytic activities, and (3) the availability of substrates. In multicellular organisms, the metabolic activities of different tissues are also regulated and integrated by growth factors and hormones that act from outside the cell.



Metabolism consists of energy-yielding and energy-requiring reactions. The oxidation of carbon compounds is an important source of cellular energy. An energy currency common to all life forms, ATP, links energy-releasing pathways with energy-requiring pathways. ATP serves as the principal immediate donor of free energy in biological systems rather than as a long-term storage form of free energy.

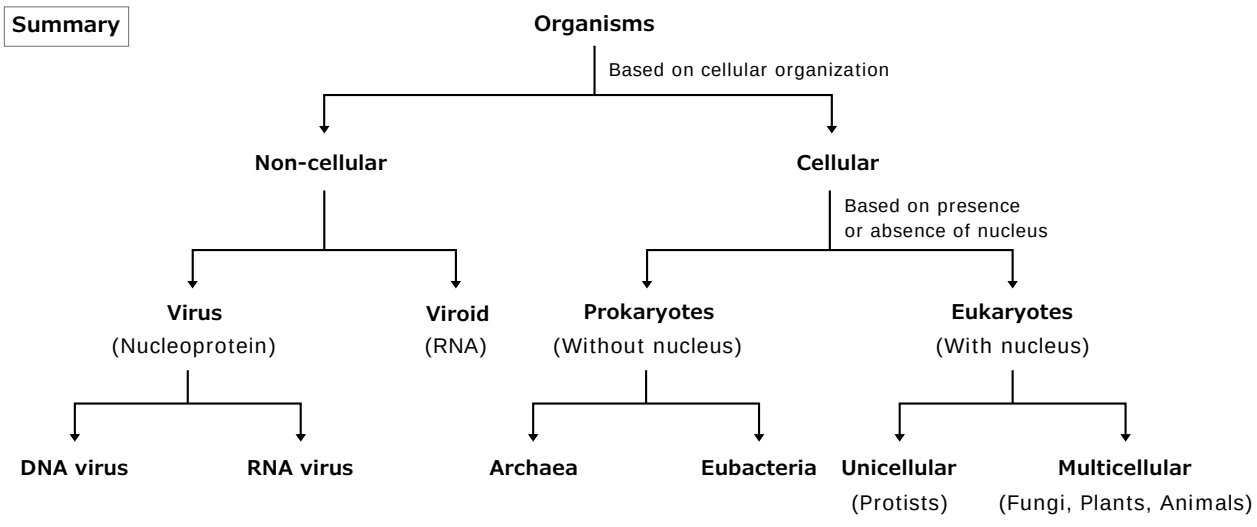
3

Cell Structure and functions

Learning objective

A great diversity of organisms are present on the Earth. These organisms can be classified into two broad categories- **cellular organisms** and **non-cellular organisms**. Cellular organisms are further subdivided into three distinct domains of life: *bacteria*, *archaea*, and *eukarya*. Bacteria and archaea are classified as **prokaryotes**, characterized by the absence of a nucleus. All **eukaryotes** belong to domain eukarya which includes *protists*, *fungi*, *plants* and *animals*. Both prokaryotes and eukaryotes are *cellular organisms*. Viruses and viroids are non-cellular organisms because they lack cell or cell-like structure.

Summary



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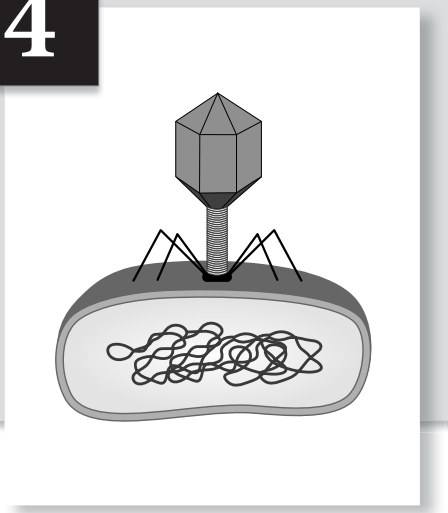

Prokaryotes and Viruses

Learning objective

Prokaryotes (*pro* means before and *karyon* means kernel or nucleus) are cellular organisms that include two domains– **Bacteria** (sometimes referred to as *true bacteria* or *eubacteria*) and **archaea** (also termed as *archaebacteria* or *archaeobacteria*). The term *bacteria* or *eubacteria* refers to those that belong to the domain Bacteria, and the term *archaea* is used to refer to those that belong to domain Archaea. *The informal name 'bacteria' is occasionally used loosely in the literature to refer to all the prokaryotes, and care should be taken to interpret its meaning in any particular context*. Prokaryotic organisms are usually microscopic, single-celled organisms that have a relatively simple structure – neither nucleus nor unit membrane-bound organelles. Prokaryotes can be distinguished from eukaryotes in terms of their cell structure and molecular make-up. Prokaryotic cells have a simpler internal structure than eukaryotic cells. Although many structures are common to both cell types, some are unique to prokaryotes. Most prokaryotic cells lack extensive, complex internal membrane systems. The major distinguishing characteristics of prokaryotic and eukaryotic cells are as follows:

Feature	Prokaryotic cells	Eukaryotic cells
Membrane-bound nucleus	Absent	Present
DNA complexed with histone	Absent	Present
Number of chromosomes	One (mostly)	More than one
Mitosis and meiosis	Absent	Present
Sterol (in plasma membrane)	Absent, except *Mycoplasma*	Present
Ribosome	70S (cytosol)	80S (cytosol)
Unit-mem. bound organelle	Absent	Present
Cell wall	Present in *most* of prokaryotic cells. In eubacteria, it is made up of peptidoglycan.	Made up of cellulose in plant and chitin in fungi. Absent in animal cells.

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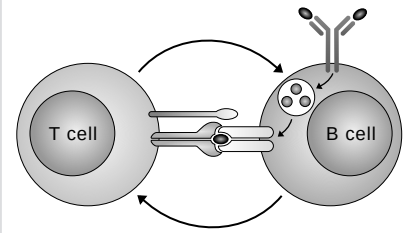

Immunology

Learning objective

Immunology is the science that is concerned with immune response to foreign challenges or simply, study of the body's defense against infection. It addresses the questions such as how does the body defend itself against infection, when an infection does occur, how does the body eliminate the pathogens and how does long-lasting immunity to many infectious diseases develop? The ability of an organism to resist infections by pathogens or state of protection against foreign organisms or substances is called **immunity** (derived from Latin term *immunis*, meaning 'exempt'). The array of cells, tissues and organs which carry out this activity constitute the **immune system**. The immune response is a complex process and is divided into two categories — **innate** (or **native**) and **adaptive** (or **acquired**) immunity. *Innate immunity* is a general, non-specific immune response which presents in all individuals at all times. In contrast to innate immunity, *adaptive immunity* is highly specific to the particular pathogen that induced it. It develops during the lifetime of an individual as a response to infection and adaptation to the infection. Thus, when a given pathogen is new to the host, it is initially recognized by the innate immune system and then the adaptive immune response is activated. Innate immunity is the most ancient form of defense, found in most multicellular organisms, while adaptive immunity is a recent evolutionary phenomenon, having arisen in vertebrates. Thus, vertebrates are protected by both innate immunity and adaptive immunity.

5.1 Innate immunity

Innate immunity is present since birth, evolutionarily primitive and is relatively nonspecific. It provides the *early defense* against pathogens, before adaptive immune responses can develop. It is not specific to any one pathogen but rather acts against all foreign molecules and pathogens. It also does not rely on previous exposure to a pathogen and response is functional since birth and has no memory.

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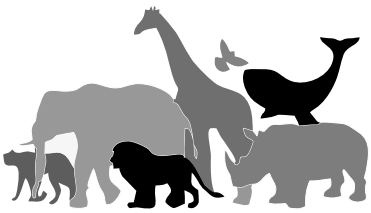

Diversity of Life

Learning objective

Diversity of life can be summarized as 'variety of life on Earth.' The living world is enormously diverse. The total number of species on the Earth described so far is about 1.2 million. There are many more species that have not yet been described. Scientists are still discovering new species. Thus, we do not know for sure how many species really exist today. Current estimates of the total number of species range from 8 million to 10 million. The known species are unevenly distributed across taxonomic groups. More than 70 percent of all the species recorded are animals, while plants (including algae and fungi) comprise no more than 22 percent of the total. The variety of life on Earth plays a critical role in regulating the Earth's physical, chemical, and geological properties, from influencing the chemical and physical composition of the environment. To understand the diversity of life, it is important to organize the different kinds of organisms. Here the role of taxonomy comes which classify organisms in a way so that we can understand them better.

6.1 Taxonomy

In order to study the diversity of organisms, biologists have evolved certain rules and principles for identifying, describing, naming, and classifying organisms. The branch of science dealing with these aspects is referred to as **taxonomy** (*arrangement by the rules*). Taxonomy is often used as a synonym for **systematics**. Taxonomy can be considered as a branch of systematics. The main difference between taxonomy and systematics is that *taxonomy* is involved in the description, identification, nomenclature, and classification of organisms. In contrast, *systematics* is, in principle, broader, covering all aspects of relationships among organisms.

Levels of taxonomy: The discipline of taxonomy traditionally covers three areas: alpha, beta and gamma taxonomy. **Alpha taxonomy** is concerned with finding, describing, and naming species. **Beta taxonomy** includes the identification of natural groups and biological classes. **Gamma taxonomy** includes the study of evolutionary processes and patterns.

Organisms were first classified more than 2,000 years ago by Greek philosopher *Aristotle*. He classified organisms as either plant or animal. Modern biological classification began with the eighteenth-century Swedish naturalist *C. Linnaeus*. He established a simple system for classifying and naming organisms. He developed a hierarchy (a ranking system) for classifying organisms that is the basis for modern taxonomy.

7

Ecology

Learning objective

Ecology is the scientific study of the relationships between organisms and their environment. These relationships are complex, varied and hierarchical. The word 'ecology' was first used by German biologist Ernst Haeckel in 1869. It is derived from the Greek words, *oikos* (meaning 'house' or 'dwelling place') and *logos* (meaning the study of). Haeckel defined ecology as '*the study of the natural environment including the relations of organisms to one another and to their surroundings*'. Ecology describes the relationships between living organisms and their environments, the interaction of organisms with each other and the pattern and cause of the abundance and distribution of organisms in nature. It is the science that attempts to answer questions about how the nature works.

7.1 The Environment

Organisms and their environments are dynamic and interdependent. The term '**environment**' etymologically means *surroundings*. It includes everything (biotic as well as abiotic) that surrounds an organism. Any factor, abiotic or biotic, that influences living organisms is called **environmental factor** (or *ecological factor* or *ecofactor*). **Abiotic factors** include factors such as temperature, sunlight levels, pH, salinity and soil composition. In contrast, **biotic factors** encompass producers, consumers and decomposers.

7.1.1 Physical environment

Soil

Soil constitutes the uppermost weathered layer of the Earth's crust. It is a mixture of weathered mineral rock particles, organic matter (i.e. both living and dead), water and air. Soil is a biologically active matrix and home of diverse organisms. The scientific discipline dedicated to the study of soil is known as **pedology**.

A letter from Bruce Alberts

(author of Molecular Biology of the Cell)

To: "Usha Mina" <ushamina@mail.jnu.ac.in>
Sent: Tuesday, January 3, 2023 11:14:02 AM
Subject: Re: Review of book

Some feedback on your two Life Sciences volumes – for authors only
Bruce Alberts

Dear Usha and Pranav,

I have finally finished reading through many sections of your large two-volume introductory biology textbook, and I write to provide some feedback that might possibly help with your next edition.

Let me start by saying how impressed I am that such a wide-ranging textbook was written by only two authors. For those sections where I am most knowledgeable – which I read closely -- I find it to be remarkably accurate. As you well know, most such textbooks that attempt to cover all of biology are written by a sizeable team of authors – each with a different expertise -- who in addition acknowledge help from a large number of other experts. And it is great to learn that you are able to provide these two volumes at a low price that Indian students can afford.

My first question concerns the way that this material has been divided up into two separate volumes. If I were a student, I would have felt a need to learn about genetic mechanisms (which you call “genetics”) in volume 1, before learning about how proteins are sorted through internal membranes, for example.

A major concern that I would have is one of level. I find that in many places you go into considerably more detail that we do in MBOC (molecular biology of the cell), even though the latter book is aimed at a more advanced student population than I believe yours is. Biology is such a huge subject that we can easily lose students in all the details, when what is most important for them learn are the concepts. Students often feel a need to memorize such details: in our interviews with sets of students who had just used our textbook, we found that many (most?) lack the judgement to ignore them when preparing for exams. For the same reason, we also leave out many of the scientific words in our book, like 2.2_7 helix, linking number, abzyme, etc.

I hope that you find these comments useful, and I write to wish you the very best in 2023, as well as to encourage you in all of your future efforts!

With my best wishes,

Bruce

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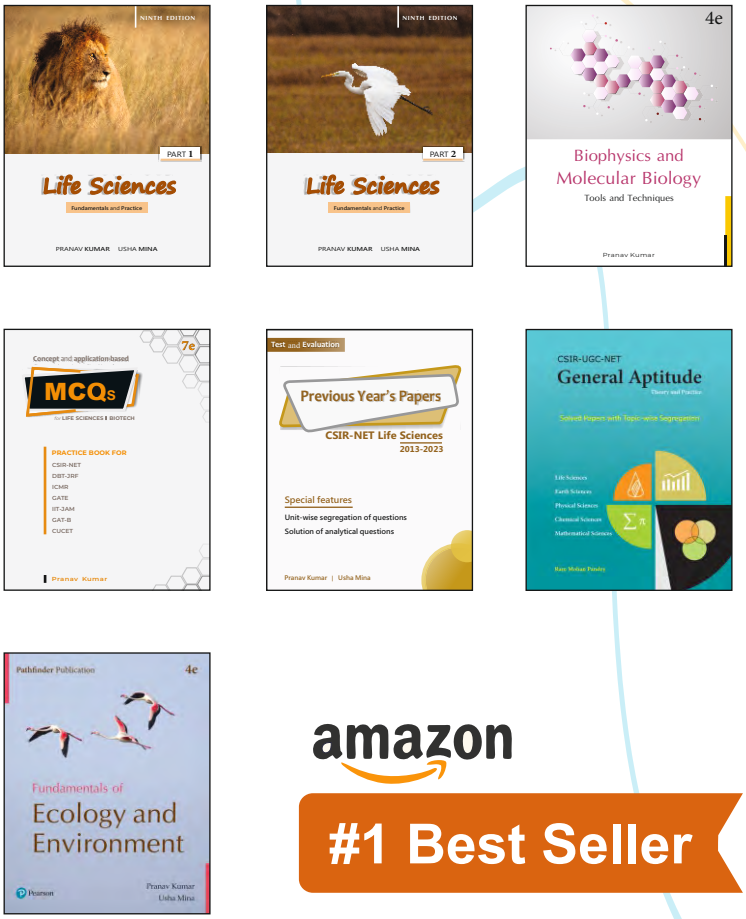
Life Sciences

Complete Study Material

by **Pranav Kumar**

9818063394



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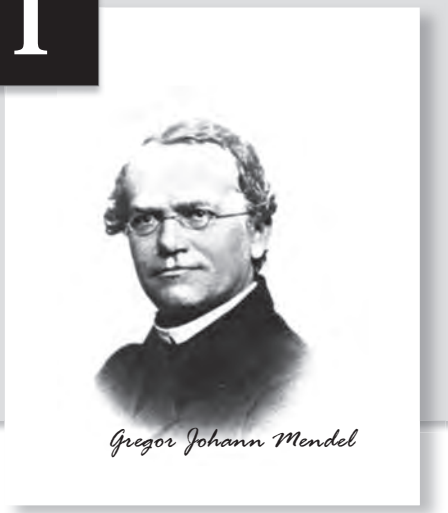
Gregor Johann Mendel

Genetics

Learning objective

1.1	**Mendel's principles**	**1.10**	**Cytogenetics**	**1.19**	**Regulation of bacterial genes**
1.2	**Chromosomal basis of inheritance**	**1.11**	**Genome**	**1.20**	**Genetic switch in phage lambda**
1.3	**Gene interaction**	**1.12**	**Eukaryotic chromatin**	**1.21**	**Regulation of eukaryotic genes**
1.4	**Linkage and gene mapping**	**1.13**	**DNA replication**	**1.22**	**RNA interference**
1.5	**Tetrad analysis**	**1.14**	**Recombination**	**1.23**	**Epigenetics**
1.6	**Sex determination**	**1.15**	**DNA repair**	**1.24**	**Genetic code**
1.7	**Pedigree analysis**	**1.16**	**Transcription**	**1.25**	**Protein synthesis**
1.8	**Quantitative inheritance**	**1.17**	**RNA processing**	**1.26**	**Mutation**
1.9	**Extranuclear inheritance**	**1.18**	**mRNA degradation**		

All living organisms reproduce. Reproduction results in the formation of offspring of the same kind. However, the resulting offsprings need not and, most often, do not completely resemble the parents. Several characteristics may differ between individuals belonging to the same species. These differences are termed **variations**. The mechanism of transmission of characters, resemblances, and differences from the parental generation to the offspring is called **heredity**. The scientific study of heredity and variations is known as **genetics** (from the Greek word genno = give birth). The word 'genetics' was first suggested by prominent British scientist William Bateson. Genetics can be divided into three areas: *classical genetics, molecular genetics*, and *evolutionary genetics*. **Classical genetics** is concerned with the basic principles of heredity and how traits are passed from one generation to the next. It also addresses the relationship between chromosomes and heredity and the arrangement of genes on chromosomes. **Molecular genetics** covers the chemical nature of the gene and how genetic information is replicated and expressed, i.e., cellular processes of replication, transcription, and translation. **Evolutionary genetics** is the study of how genetic variation leads to evolutionary change. It is concerned with the evolution of genome structure, the genetic basis of speciation and adaptation, and genetic change in response to evolutionary processes such as natural selection, genetic drift, mutation, and gene flow in populations.

Classical genetics

1.1 Mendel's principles

Gregor Johann Mendel (1822–1884), known as the *father of genetics*, was an Austrian monk. He conducted a series of experiments using pea plants and showed that traits are passed from parents to offspring in predictable ways. By quantitative data analysis of results, he concluded that each trait in the pea plant is controlled by a pair of factors

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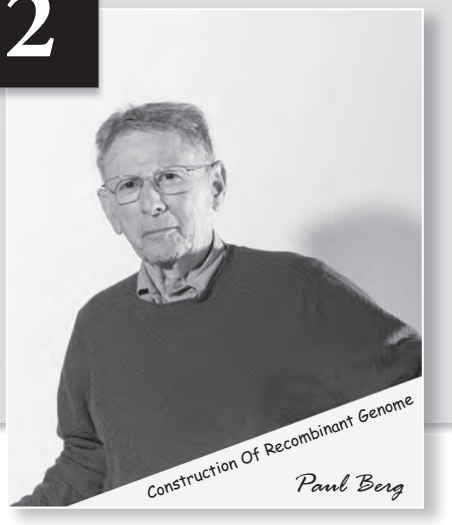


Recombinant DNA technology

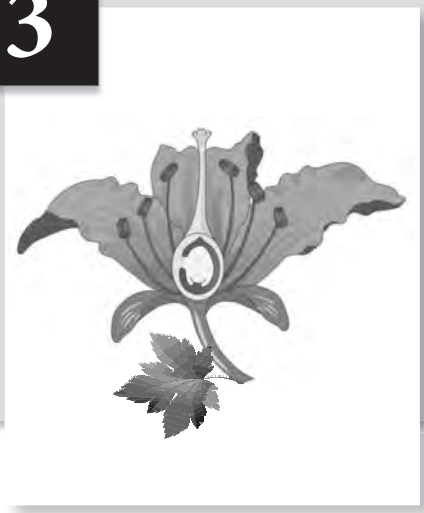
Learning objective

Recombinant DNA technology (also known as **genetic engineering**) is the set of techniques that enable the DNA from different sources to be identified, isolated and recombined so that new characteristics can be introduced into an organism. The invention of recombinant DNA technology—the way in which genetic material from one organism is artificially integrated into the genome of another organism and then replicated and expressed by that other organism—was largely the work of Paul Berg, Herbert W. Boyer and Stanley N. Cohen, although many other scientists also made important contributions to the new technology as well. Paul Berg developed the first recombinant DNA molecules that combined DNA from the SV40 virus and lambda phage. Later in 1973, Herbert Boyer and Stanley Cohen develop recombinant DNA technology, showing that genetically engineered DNA molecules may be developed and cloned in foreign cells. One important aspect of recombinant DNA technology is **DNA cloning**. It is a set of techniques that are used to design recombinant DNA molecules and to direct their replication within host organisms. The use of the word 'cloning' refers to the method used to generate identical DNA molecules.

2.1 DNA cloning

DNA cloning is the production of a large number of identical DNA molecules from a single ancestral DNA molecule. The essential characteristic of DNA cloning is that the desired DNA fragments must be *selectively amplified,* resulting in a large increase in copy number of selected DNA sequences. In practice, this involves multiple rounds of DNA replication catalyzed by a DNA polymerase acting on one or more types of the template DNA molecule. Essentially two different DNA cloning approaches are used: *Cell-based* and *cell-free DNA cloning*.

3



Plant Physiology and Development

Learning objective

Plants are multicellular, photoautotrophic eukaryotic organisms. It includes algae, bryophytes, pteridophytes, gymnosperms, and angiosperms. Bryophytes, pteridophytes, gymnosperms, and angiosperms are usually referred to as **land plants**. Angiosperms (also called **flowering plants**) are a major group of land plants. These plants are by far the most numerous, diverse, and successful terrestrial plants, representing more than 90% of all land plant species alive today. They range in size from tiny, almost microscopic *Wolfia* to tall trees of Eucalyptus (over 100 meters). Angiosperms are **vascular plants** containing two types of vascular tissue – **xylem** that conducts water and dissolved minerals upward from the roots and **phloem** that conducts food throughout the plant. Vascular tissues develop in the sporophytic body but (with a few exceptions) not in the gametophytic body. Angiosperms are also classified as **spermatophytes** (also known as **phanerogams**) because they produce seeds. A **seed** is an embryo packaged with a supply of nutrients inside a protective coat. In angiosperms, seeds develop inside ovaries, which mature into fruits. The seed is a crucial adaptation to life on land because it protects the embryo from drying out.

A typical flowering plant body can be divided into the **root** and **shoot systems**. The underground part of the flowering plant is the *root system*, while the portion above the ground forms the *shoot system*. The shoot system consists of stems, leaves, flowers and fruits.

Root is typically a non-green underground structure. The first root in a vascular plant develops from the **radicle** of the embryo. The root develops from the direct elongation of the radicle is known as the **primary root**. Any root that develops from plant organs other than radicle is called an **adventitious root**. The primary root continues to grow and develops **lateral roots** (or **branch roots**) of several orders that are referred to as *secondary roots*, *tertiary roots* and so on. The primary roots and its branches constitute the **tap root system**. Commonly, the primary root in monocots such as wheat is short-lived, and it is replaced by the roots developing from the base of the stem. These stem-borne roots and their lateral roots constitute **fibrous root system**. The main functions of the root are absorption of water and minerals from the soil, anchorage, storage of reserve food material and synthesis of plant growth regulators. But, roots in some plants become modified to perform functions (such as respiration, support) other than anchorage and absorption of water and minerals.

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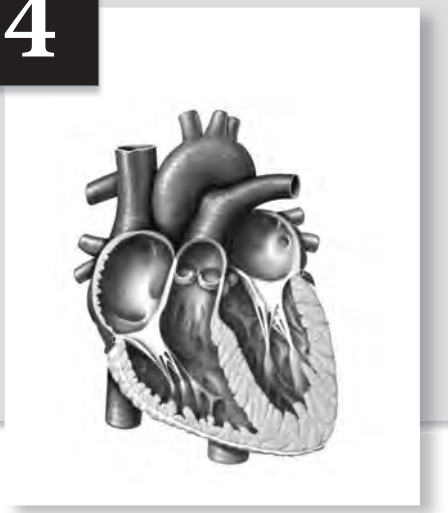


Human Physiology

Learning objective

Like all multicellular animals, human body is composed of different types of cells. Groups of cells similar in structure and function are organized into *tissues*. Different tissues grouped together into a structural and functional unit called *organs*. An *organ system* is a group of organs that function together to carry out the principal activities of the body.

4.1 Tissues

A *tissue* is a group of similar cells that usually have a common embryonic origin and functions together to carry out specialized activities. On the basis of structure and function, animal tissues can be classified into four basic types: epithelial tissue, connective tissue, nervous tissue and muscular tissue.

1. Epithelial tissue

An *epithelial tissue* or **epithelium** consists of cells that form membranes, which cover and line the body surfaces and glands, which are derived from these membranes. Epithelial cells arranged in continuous sheets, in either single or multiple layers. Because the cells are closely packed and are held tightly together by many cell junctions, there is little intercellular space between cells. Three types of cell junctions are found in the epithelium and other tissues. These cell junctions are called as *tight*, *anchoring* (adherens junction and desmosome) and *gap junctions*. Epithelial tissue has its own nerve supply, but is **avascular**; that is, it lacks its own blood supply. The blood vessels that bring in nutrients and remove wastes are located in the adjacent connective tissue. Exchange of substances between epithelium and connective tissue occurs by diffusion. Epithelial tissue plays many roles such as protection, filtration, secretion, absorption and excretion. Because epithelial tissue subjected to wear and tear and injury, it has high capacity for renewal.

5

Animal Development

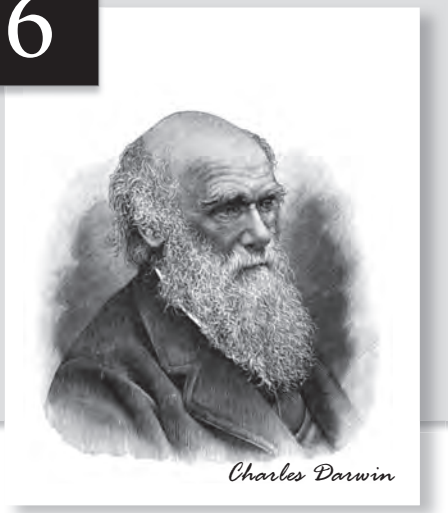
Learning objective

Animal development is a highly complex process that begins with a fertilized egg (or zygote) and leads to the birth of a complex organism with organs at precise positions and shapes. The stages of development between fertilization and birth are collectively called **embryogenesis** and its study is called **embryology**. Embryonic development begins with the fusion of the male and female gametes (**fertilization**). After fertilization, a multicellular organism's development proceeds through a process called **cleavage**, a series of mitotic divisions. Cleavage divides the zygote into numerous cells called *blastomeres*. By the end of cleavage, a solid or hollow fluid-filled ball of the blastomeres develops, known as a **blastula**. Cleavage is followed by **gastrulation**, a process that rearranges the blastomeres and forms the germ layers — *ectoderm*, *mesoderm*, and *endoderm*. Over time and space, these cells interact with one another and rearrange themselves to produce tissues and organs. This process is called **organogenesis**. Many animals have life cycles involving a larval stage specialized for feeding and dispersal. The larva undergoes **metamorphosis** to become a sexually mature adult.

5.1 Patterns and processes of animal development

Developmental biology aims to understand how an organism develops. During development, the zygote divides repeatedly to produce many different kinds of cells arranged in a specific pattern i.e., cells are organized in space and time so that a well-ordered structure develops within the embryo. Several key processes fundamentally occur during animal development. These processes include *cell proliferation*, which produces many cells from one; *cell-cell communications*, which coordinate the behavior of each cell with that of its neighbors; *cell differentiation*, which creates cells with different characteristics at different positions; and *cell movement*, which rearranges the cells to form structured tissues and organs.

6



Evolution

Learning objective

Evolution refers to the changes that occur in life forms over time, leading to the development of many different forms of life. By understanding evolution, we can gain insight into how and why life has changed and diversified. It includes the study of evolutionary processes—how they operate, what they produce, and how they are likely to proceed in the future. It deals mainly with how life changed after its origin. It does not discuss about the *origin of life*. To understand evolution, it is also very important to understand how life originated? We should understand the physical and chemical conditions prevailing on the prebiotic Earth that could drive the first steps of the origin of life. We also have to address a simple question central to our understanding of the origin of life: how complex organic molecules formed and how they have become organized into cells?

6.1 Origin of Life

Life is characterized by the three functions: 1. **compartmentalization**: the ability to keep its components together and separate itself from the environment, 2. **replication**: the ability to process and transmit heritable information to progeny, and 3. **metabolism**: the ability to capture and utilize the energy and material resources, staying away from thermodynamic equilibrium.

The origin of life on Earth is a unique event and also one of the great mysteries. *Where and how did life on Earth originate*? It is difficult to determine because it began almost four billion years ago. Did life come from outer space? For a long time, it was believed that life didn't begin on Earth. It came from outside (i.e. extraterrestial origin). However, due to lack of any validation, it remained merely speculative. For many years it was also believed that life came out of decaying and rotting organic matters. This theory was termed as **theory of spontaneous generation**. Scientists have disproved this theory by performing controlled experiments. Louis Pasteur by careful experimentation demonstrated that life comes only from pre-existing life. Living things, no matter how small, do not come spontaneously from non-living matters. Living things come only from other living things (**biogenesis**). However, this did not answer how the first life form came on Earth.

A letter from Bruce Alberts

(author of Molecular Biology of the Cell)

To: "Usha Mina" <ushamina@mail.jnu.ac.in>
Sent: Tuesday, January 3, 2023 11:14:02 AM
Subject: Re: Review of book

Some feedback on your two Life Sciences volumes – for authors only
Bruce Alberts

Dear Usha and Pranav,

I have finally finished reading through many sections of your large two-volume introductory biology textbook, and I write to provide some feedback that might possibly help with your next edition.

Let me start by saying how impressed I am that such a wide-ranging textbook was written by only two authors. For those sections where I am most knowledgeable – which I read closely -- I find it to be remarkably accurate. As you well know, most such textbooks that attempt to cover all of biology are written by a sizeable team of authors – each with a different expertise -- who in addition acknowledge help from a large number of other experts. And it is great to learn that you are able to provide these two volumes at a low price that Indian students can afford.

My first question concerns the way that this material has been divided up into two separate volumes. If I were a student, I would have felt a need to learn about genetic mechanisms (which you call “genetics”) in volume 1, before learning about how proteins are sorted through internal membranes, for example.

A major concern that I would have is one of level. I find that in many places you go into considerably more detail that we do in MBOC (molecular biology of the cell), even though the latter book is aimed at a more advanced student population than I believe yours is. Biology is such a huge subject that we can easily lose students in all the details, when what is most important for them learn are the concepts. Students often feel a need to memorize such details: in our interviews with sets of students who had just used our textbook, we found that many (most?) lack the judgement to ignore them when preparing for exams. For the same reason, we also leave out many of the scientific words in our book, like 2.2_7 helix, linking number, abzyme, etc.

I hope that you find these comments useful, and I write to wish you the very best in 2023, as well as to encourage you in all of your future efforts!

With my best wishes,

Bruce

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by **Pranav Kumar**

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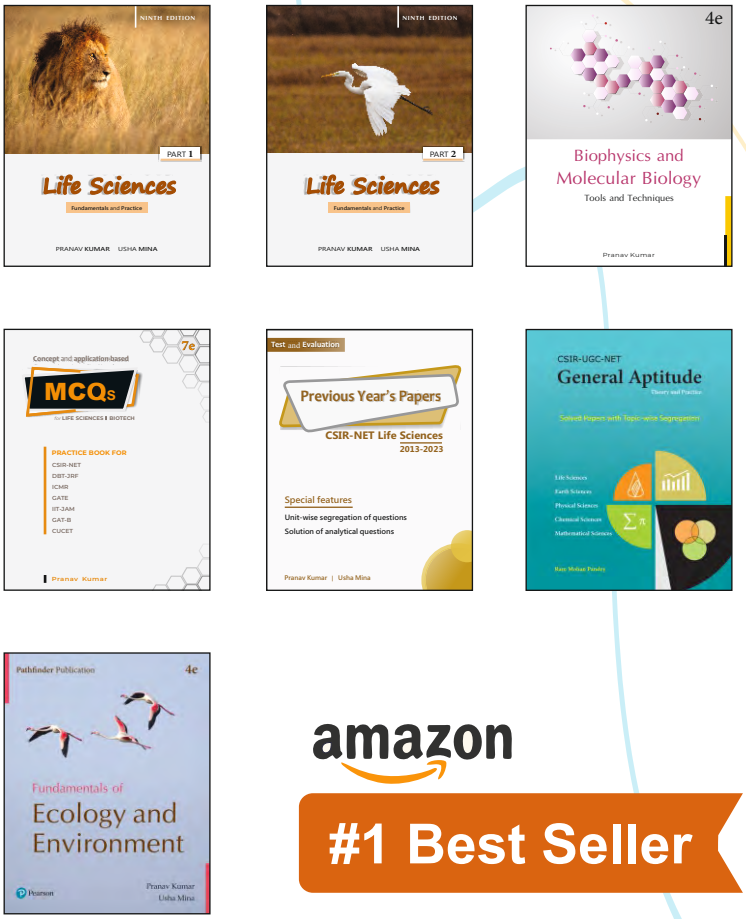

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Fundamentals of

Ecology *and* Environment

Pearson

Pranav | Usha

Fundamentals of

Ecology *and* Environment

Fourth edition

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Chapter 1

The Environment

Organisms and their environments are dynamic and interdependent. The term '**environment**' etymologically means *surroundings*. It includes everything (biotic as well as abiotic) that surrounds an organism. Any factor, abiotic or biotic, that influences living organisms is called **environmental factor** (or *ecological factor* or *ecofactor*). **Abiotic factors** include factors such as temperature, sunlight levels, pH, salinity and soil composition. In contrast, **biotic factors** encompass producers, consumers and decomposers.

1.1 Physical environment

Soil

Soil constitutes the uppermost weathered layer of the Earth's crust. It is a mixture of weathered mineral rock particles, organic matter (i.e. both living and dead), water and air. Soil is a biologically active matrix and home of diverse organisms. The scientific discipline dedicated to the study of soil is known as **pedology**.

Weathering and soil formation

The process of soil formation includes the formation of unconsolidated materials by the weathering process and the soil profile development. Weathering refers to the **physical disintegration** and **chemical decomposition** of the rocks and minerals contained in them. Physical disintegration breaks down rock into smaller fragments and eventually into sand and silt particles that are commonly made up of individual minerals. Simultaneously, the minerals decompose chemically, releasing soluble materials and synthesizing new minerals. New minerals form either by minor chemical alterations or by a complete chemical breakdown of the original mineral and resynthesis of new minerals. Based on the location of soil mineral particles formation and deposition, the soils are classified as *residual soil* and *transported soil*. If the soil mineral particles have been formed in place from the bedrock below, it is called **residual soil**. If the soil mineral particles have been carried from some other location by wind, water, gravity or ice then it is termed as **transported soil**. The transported soil can be classified into **colluvium** (transported by gravity), **alluvium** (transported by the movement of water), **glacial soil** (transported by the movement of glaciers) and **eolian soil** (transported by wind).

Chapter 2

Ecosystem Ecology

An **ecosystem**, also known as an **ecological system**, represents a structural and functional unit of nature that encompasses all organisms within a physically defined space. These organisms interact with each other and their physical environment. Essentially, any system that encompasses interacting **biotic** (living) and **abiotic** (nonliving) components can be classified as an ecosystem.

The concept of an ecosystem was first formally proposed by the English botanist Arthur Tansley in 1935. The term **biogeocoenosis** (proposed in the 1940s by the Soviet ecologist V. N. Sukachev) frequently used in Russian literature is roughly equivalent to the ecosystem. Its literal meaning is '*life and Earth functioning together*.' A key advance in the adoption of the ecosystem concept occurred after the appearance of a popular textbook by Eugene Odum. Odum's textbook was organized around the ecosystem concept. After Odum's textbook, a famous article in Science by Francis Evans (1956) mentioned the ecosystem as '*the basic unit in ecology*.' In the broadest sense, *an ecosystem is the interacting system made up of all the living and non-living objects in a physically defined space.*

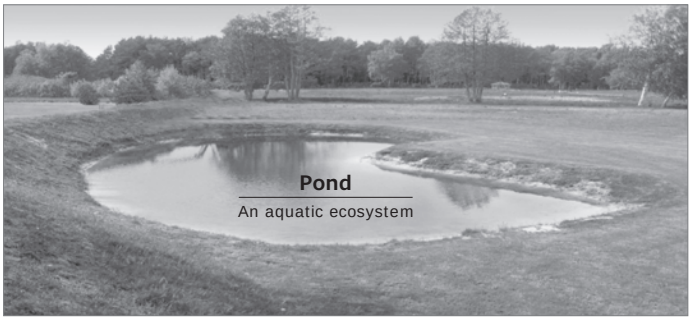

Figure 2.1 An aquatic ecosystem. A physically defined space comprising all the organisms which are interacting with one another and with their physical environment.

According to this simple definition, the size, location and timescale at which ecosystems are defined can therefore precisely match the question that the scientist is trying to answer. An ecosystem could be of any size depending on the communities to be studied and its boundaries can be either real or arbitrary. An ecosystem may be as small as a single tree or as large as the entire Earth and can be studied for time periods as long as millions of years.

An ecosystem can be visualized as a functional unit of nature. It has all components: biological and physical, necessary for survival. Accordingly, it is the basic unit around which theories and experiments of ecology are organized.

Chapter 3

Population Ecology

Each species in an ecosystem exists as a population. A **population** is a group of individuals of the same species that live together in a region. In essence, a population, also referred to as a biological population consists of a group of interbreeding or potentially interbreeding individuals found in the same space or area at the same time. The study of populations (especially population abundance) and how they change over time is called **population ecology**. It studies the spatial and temporal patterns of the abundance and distribution of organisms and mechanisms that produce those patterns. The study of population ecology includes understanding, explanation and prediction of population growth, regulation and dynamics or demography.

Multicellular organisms are of two kinds, unitary organisms and modular organisms. Most animal populations are made up of **unitary organisms**. In unitary organisms, the form is highly determinate consisting usually of a strictly defined number of parts (such as legs or wings) established only during embryogenesis. Their pattern of development and final form are predictable. For example, all dogs have four legs, all squid have two eyes, etc. In **modular organisms**, on the other hand, neither timing nor form is predictable. These organisms grow by the repeated iteration of modules, usually to yield a branching pattern. Examples of modular organisms include plants and many sessile benthic invertebrates. In modular organisms, a single genetic individual (or *genet*) can consist of many modules (or *ramets*) capable of existence as individuals. In plants, a **genet** is an individual that has arisen from a seed. A **ramet** is a new plant which has arisen through vegetative propagation and is now a completely independent plant with its own roots and shoots. For example, a population of grasses may consist of several genets, each of which has several ramets.

3.1 Population characteristics

Scientists study a population by examining how individuals within that population interact with each other and how the population as a whole interacts with its environment. A population has several characteristics or attributes which are a function of the whole group and not of the individual. Different populations can be compared by measuring these attributes. These attributes are *population density, natality, mortality, distributions*, etc. The study of the group characteristics of a population, their changes over time and the prediction of future changes is known as **demography**.

Demography is the study of the vital statistics of populations and how they change over time.

Chapter 4

Community Ecology

An **ecological community** is a group of species that coexist in a space and time and interact with one another directly or indirectly. The term 'community' means different things to different ecologists. Most definitions of ecological communities include the idea of a collection of species found in a particular place. For instance, Whittaker (1975) defined ecological community as,

'…an assemblage of populations of plants, animals, bacteria and fungi that live in an environment and interact with one another, forming together a distinctive living system with its own composition, structure, environmental relations, development and function.'

Simply, an ecological community is a group of interacting species that inhabit a particular location at a particular time. Most communities are extraordinarily complex. However, the main features of ecological communities include the following.

Firstly, a community represents the biotic or a living component of the ecosystem. Organisms within a community include primary producers, consumers and decomposers. In terrestrial communities, the community structure is largely defined by the vegetation.

Secondly, considering the functional aspect, communities are made up of organisms with interlocking food chains and each species depends on many other species in a community which is taxonomically unrelated.

Thirdly, a community may be of any size. It can range from small pond communities to large tropical rainforests.

Community ecology is a field that examines the effects of abiotic and biotic features on community or assemblage structure. Community ecologists study the number of species and their relative abundance in a particular location and ask why the number of species and their abundance changes over time. They also do study communities in different locations and differences in the species diversity with location. In a broad sense, the goal of community ecology is to understand the origin and maintenance of biological diversity within communities.

A **community** is a group of interacting populations of different species present together in space, whereas **assemblage** is a taxonomically related group of species populations that occur together in space.

There are two contrasting concepts of the community – *organismal* and *individualistic concepts*. The **organismal concept** of communities (put forward by Clements, 1916) views the community as a unit, an association of species, in which each species is representing an interacting, integrated component of the whole and development of the community through time (a process termed *succession*) is viewed as the development of the organism. This type of community organization is commonly known as a **closed community**.

Chapter 5

Biodiversity

Biodiversity, short for **biological diversity**, refers to the sum total of all the variety and variability of life in a defined area. In contrast to the more specific term *species diversity*, the term *biodiversity* was coined to emphasize the many complex kinds of variations that exist within and among organisms at different levels of the organization. It refers to the totality of genes, species and ecosystems of a region. United Nations Earth Summit defined biological diversity as:

'*Biological diversity means the variability among living organisms from all sources including, inter alia (among other things), terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems*.'

Convention on Biological Diversity, **1992**

5.1 Levels of biodiversity

Biodiversity includes three hierarchical levels: Genetic, species and ecosystem diversity.

Genetic diversity

Genetic diversity refers to the variation in the genetic composition of individuals within or among species. Genetic diversity enables populations to adapt to their environments and respond to natural selection. The extent of genetic variation serves as the raw material for speciation. Genetic diversity can be observed at multiple levels of biological organization, including kingdoms, phyla, families, as well as among species and within species. The most significant genetic diversity is typically observed between organisms from different kingdoms (e.g., plants versus animals), between phyla (e.g., arthropods versus chordates), between classes (e.g., birds versus reptiles), and so on.

Species diversity

According to the biological species concept, species are groups of actually or potentially interbreeding natural populations that are reproductively isolated from other such groups. Hence, species diversity refers to the variety of species within a region, i.e., **species richness**. However, in the broader sense, species diversity includes not only species richness but also **species evenness**.

Chapter 6

Pollution

Pollution is any undesirable change in the physical, chemical, or biological characteristics of the air, water and land that can harmfully affect the living organisms and the ecosystem as a whole. Any substance introduced into the environment that adversely affects the physical, chemical or biological properties of the environment that have a harmful effect on the ecosystem as a whole is termed as **pollutant**. There are three major types of environmental pollution: air pollution, water pollution and soil pollution.

6.1 Air pollution

Air pollution may be defined as any atmospheric condition in which *substances* are present at concentrations above their normal permissible levels to produce a *measurable effect* on man, animals, vegetation or materials. Substances mean any natural or anthropogenic (man-made) chemical compounds capable of being airborne. They may exist in the atmosphere as gases, liquid drops or solid particles.

According to Air (prevention and control) act, 1981, an *air pollutant* is any solid, liquid or gaseous substance (including noise) present in the atmosphere in such concentration as may be or tend to be injurious to human being or other living creatures or plants or property or environment.

6.1.1 Composition of air

Air is a heterogenous mixture of different gases that makes the atmosphere. *Atmosphere* is the gaseous mass or envelope surrounding the Earth and retained by the Earth's gravitational field. The troposphere is the lowest portion of Earth's atmosphere. It contains approximately 80% of the atmosphere's mass. By volume, standard dry air contains 78.08% nitrogen, 20.9% oxygen, 0.9% argon, 0.040% carbon dioxide, and small amounts of other gases. There are two common ways by which one can represent the composition of air – *percentage of gas by volume* or *percentage of the gas by mass.* It is important to note that, the composition of different gases (in dry air) by mass is a fixed one whereas the percentage composition of the gases by volume or mass in wet air (i.e. air containing moisture) is dependent on humidity or the moisture in the air.

Chapter 7

Climate Change

Climate refers to the long-term patterns of weather conditions in a specific location, region, or across the entire planet. It is typically characterized by analyzing meteorological data over a period of at least 30 years, and this analysis includes variables such as temperature, humidity, atmospheric pressure, wind patterns, precipitation, and other meteorological factors.

'*Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation and wind. Climate in a wider sense is the state, including a statistical description, of the climate system*.'

IPCC, **2001**

The terms **climate** and **weather** have different meanings. *Weather* represents the short-term state of atmospheric conditions (such as temperature, pressure, humidity, precipitation, wind speed and direction, and more) for a specific place and time. It exhibits both temporal (time-related) and spatial (location-related) variations.

7.1 Climate change

Climate change is a large-scale, long-term shift in weather patterns and atmospheric conditions on a global scale.

According to **IPCC**, 'Climate change *refers to a change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use*.'

The **UNFCCC** defines climate change as, '*a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods*'.

The UNFCCC, thus, makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes.

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Chemistry in Biology

Chapter 1

Biomolecules and Metabolism

Unit I Amino acids and Proteins

Amino acids and Peptides

01. Which of the following statements about standard amino acids are *correct*?

P. Lysine has butylammonium side chain.

Q. Average mass of an amino acid residue is ~110 Da.

R. Universal genetic code specifies only standard amino acids.

S. Proline has a secondary amino group.

a. P and Q
b. Q and S
c. P, Q, R and S
d. Q and R

02. Which of the following statement is *not* true?

a. The pI is the pH value at which a protein has overall charge of +1.
b. At a pH value equal to pI, a protein will not move in the electric field.
c. An acidic protein will have a pI less than 7.
d. A basic protein will have a pI greater than 7.

03. Which of the following statements is *not* true about the amino acids?

a. Only 22 amino acids are used in ribosome-mediated protein synthesis.
b. All amino acids exist in two stereoisomeric forms.
c. Amino acids have an N-terminus, C-terminus, and R groups.
d. There are more than 300 different kinds of amino acids present in the cell.

04. Choose the *incorrect* statement about standard amino acids.

a. Aspartate has the smallest pI value.
b. Arginine has the largest pI value.
c. pK_a value of side chain is maximum for aspartate.
d. Side chain of isoleucine has maximum hydropathy value.

05. Which of the following is *not* true about alanine?

a. At pH 1, the overall charge is +1.
b. At pH 1, it will move towards cathode.
c. An equimolar mixture of d and *l* alanine does not rotate the plane polarized light.
d. It contains branched side chain.

Unit 1

Molecules and their interactions relevant to biology

Structure of molecules, chemical bonds and principles of biophysical chemistry.

01. What is the pH of a solution that has a hydrogen ion concentration of 1.75×10^{-5} mol/L?

a. 2.26
b. 1.2
c. 4.76
d. 5.8

02. A polar molecule

a. is slightly negative at one end and slightly positive at the other end.
b. has an extra electron, giving it a negative charge.
c. has an extra neutron, making it weigh more.
d. has covalent bonds.

03. When a thermodynamic equilibrium state at a given temperature and pressure is reached, the

a. free energy of the state at equilibrium is always higher than that of any other state at the same T and P.
b. enthalpy of the state at equilibrium is always lower than that of any other state at the same T and P.
c. free energy of the state at equilibrium is always lower than that of any other state at the same T and P.
d. enthalpy of the state at equilibrium may be higher than that of any other state at the same T and P.

04. Which of the following statements are *correct*?

P. Polarity of water makes it an excellent solvent.
Q. Water has high tensile strength.
R. Cohesive property of water is due to H-bonding.
S. Water has high dielectric constant.

a. P and S
b. Q and R
c. Q, R and S
d. P, Q, R and S

05. Which non-covalent bond is responsible for the high melting and boiling points of water?

a. H-bond
b. van der Waals force
c. Hydrophobic force
d. Covalent bond

06. In which of the following systems is the entropy the greatest?

a. Water vapour
b. Liquid water at pH 7.0 and 37°C
c. Supercooled water (liquid water at a temperature less than 0°C)
d. Ice

Chemistry in Biology

Chemical context of Life, pH and buffer, Bioenergetics and Thermodynamics

Chemical context of Life

01. Which of the following statements about H_2O are *correct*?

P. It is electrically neutral.

Q. It is a polar molecule.

R. It has a high dielectric constant.

S. It acts as an excellent solvent.

T. It is amphoteric but not amphiprotic.

a. Q and S
b. P, Q and T
c. P, Q, R and S
d. P, Q, R, S and T

02. Which of the following statements accurately describe the chemical composition of cells?

P. Composed of fewer than 30 elements.

Q. Predominantly consisting of elements with relatively low atomic numbers.

R. The most abundant elements found in cells include H, O, N, and C.

S. Among the macromolecules present in cells, proteins are the most abundant.

a. P and Q
b. Q and R
c. P, Q and S
d. P, Q, R and S

03. Which of the following statements accurately describe covalent bond?

P. A covalent bond forms as a result of equal sharing of electron pairs between two atoms.

Q. Covalent bonds may be either polar or non-polar.

R. Energy of a covalent bond depends on the number of covalent bonds (i.e., bond order).

S. Energy of a covalent bond is dependent on the medium.

a. P and Q
b. Q and R
c. P, Q and R
d. P, Q, R and S

04. Which of the following statements accurately describe van der Waals forces?

P. They are weak electrostatic interactions.

Q. They involve intermolecular interactions.

R. They occur only between polar molecules.

S. They represent the weakest interaction among non-covalent interactions.

a. P and Q
b. Q and R
c. P, Q and S
d. P, Q, R and S

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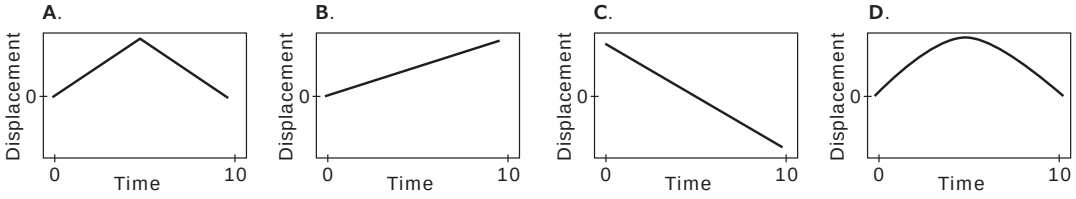
Life Sciences : December 2023 (Shift - 1)

PART – A

001. The number $681^{32} - 319^{32}$ is divisible by

a. both 362 and 1000 b. 362 but not 1000 c. 1000 but not 362 d. neither 362 nor 1000

002. Which one of the following graphs represents the displacement verus time relation for the motion of a ball thrown upward and returning toward the ground, remaining in air for 10 seconds? (Ignore air resistance.)



a. A b. B c. C. d. D

003. Vehicle number plates have two letters out of the 26 letters of the English alphabet followed by four decimal digits. How many different number plates are possible if repetition of letters and digits is allowed?

a. 26 × 25 × 10 × 9 × 8 × 7 b. 26 × 26 × 10 × 10 × 10 × 10

c. (26 × 25 × 24 × 23 × 10 × 9)/(4 × 3 × 2 × 2) d. 26 × 25 × 24 × 23 × 10 × 9

004. In a grid puzzle, each row and column in the 9 × 9 grid, as well as each 3 × 3 subgrid shown with heavy borders, must contain all the digits 1 – 9.

1					8			9
		2						8
	8		5	4	9			
	4		2			9		
3		9				2		1
		1		**?**	5		4	
			9	1	2		3	
7						1		
2			7					6

In the given partially filled grid, the digit in the square marked "?" is

a. 3 b. 9 c. 8 d. 7

005. In an examination 3 medals were awarded for each of 5 subjects. If three candidates won exactly four medals each, and no candidate won Just one medal, the total number of medal winners

a. was exactly 4 b. was exactly 5

c. could be either 5 or 6 d. was exactly 6

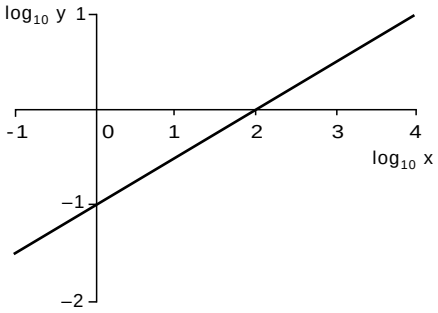
006. What is the difference, 11 hours after synchronisation, in the time shown by a standard watch and a watch whose hour and minute hands coincide every 64 minutes?

a. 11 min b. 16 min c. 22 min d. 44 min

Life Sciences : December 2023 (Shift - 2)

PART – A

001. Which of the following equations represents the graph shown?



a. log y = (log x) – 1
b. log y = (log x)/2 – 1
c. log y = (log x) – log(1)
d. log y = (log x)/2 + 1

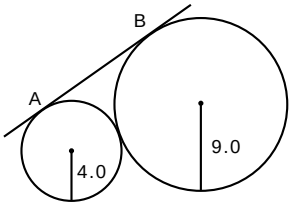
002. Starting at the same time policewomen A and B chase thief T. They all run in the same direction at constant speeds. A runs twice as fast and B thrice as fast as T. If A and B catch up with T at the same time, B must have started

a. half as far behind T as A did
b. 1½ times as far behind T as A did
c. twice as far behind T as A did
d. 3 times as far behind T as A did

003. Among A, B, C and D, one is a doctor, one is a teacher, one is an engineer, and the other is a lawyer. The teacher is older to B but younger than D. B is older to the doctor and younger than C. Which among the following is a conclusive inference?

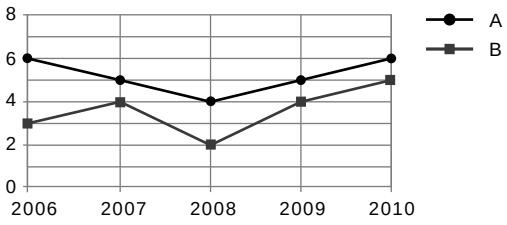
a. A is the engineer
b. B is the lawyer
c. C is the teacher
d. D is not the doctor

004. Two circles of radii 9.0 units and 4.0 units touch each other externally as in the figure. Then the length (in units) of their common tangent AB is



a. $6\sqrt{3}$
b. 13
c. 12
d. $12\sqrt{2}$

005. Incomes (in lakhs) of two persons A and B, over the years 2006-2010 are shown in the graph.



Which of the following statements is *true*?

a. Over the years, trends of income of A and B are the same.
b. The largest difference in incomes of A and B is in the year 2008.

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Contents

Previous Year's Question Papers with Solutions

Unit 1

Numerical Ability

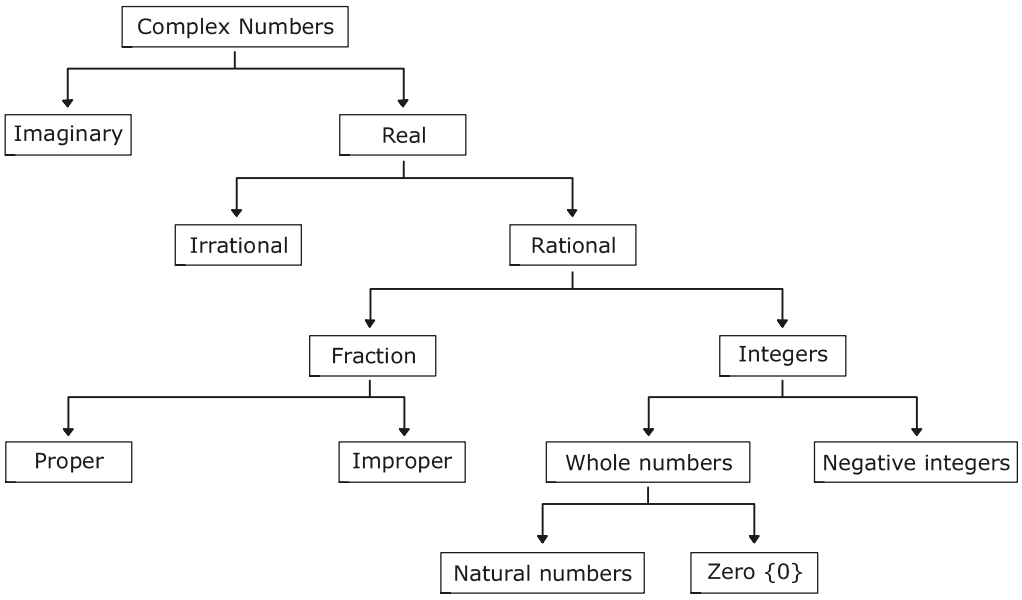
1.1 Number System

1.1.1 Numbers

A *number* is a mathematical object used in counting and measuring. It is denoted by a group of digits, called *numerals*. In our everyday life we represent numbers by using ten digits which are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 and these numbers are called decimal numbers. It was taken from Hindu-Arabic system.

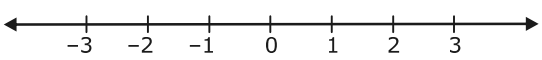
Classification of numbers

There are a number of different ways to classify numbers used in counting and measuring.



Real number

It is defined as the set of all numbers that can be represented on the number line. A number line is a straight line with an arbitrary defined point zero (0).



To the right of this point lie all positive numbers and to the left, all negative numbers. Also, every point on the number line represents a unique real number.

Unit 2

Modern Maths

2.1 Permutations and Combinations

Arrangement

It is defined as the number of groups or selections of things multiplied by the number of objects in each group. Let there be three different objects A, B and C. The possible groups that can be formed out of the three taken two at a time are AB, BC, and AC. Here three such groups are possible. Now the two objects in each of these groups can be arranged in two different ways such as

a. AB and BA

b. BC and CB

c. AC and CA

Number of arrangements = number of groups or selections × r!, where r is the number of objects in each group
= (3 × 2)! = 3 × 2 × 1 = 6.

Hence, we see that in the case of arrangements change of position of objects causes change in the arrangement.

Permutations

Each of the different *arrangements* can be made by taking some or all of a number of given things or objects at a time is called a permutation. In permutation, order of appearance of things or objects is taken into account.

The symbol ${}^{n}P_{r}$ denotes the number of permutations of *n* different things taken *r* at a time. The letter P stands for permutation.

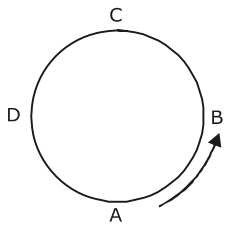
So, $${}^{n}P_{r} = \frac{n!}{(n-r)!}$$

For example, the symbol ${}^{6}P_{3}$ will denote the number of permutations or arrangements of 6 different things taken 3 at a time.

So, $${}^{6}P_{3} = \frac{6!}{(6-3)!} = \frac{6!}{3!} = \frac{6\times5\times4\times3\times2\times1}{3\times2\times1} = 120$$

Circular permutation

Consider four persons A, B, C and D who are to be arranged along a circle. If one circular arrangement is as follows:



Unit 3

Data Interpretation

3.1 Pie charts

For a pie chart, central angle is 360° that represents 100% of the value.

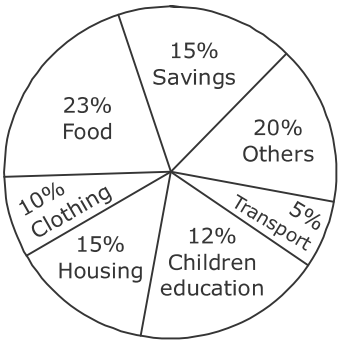
Hence, we have

360° = 100%	3.6° = 1%	18° = 5%
180° = 50%	36° = 10%	54° = 15%
90° = 25%	72° = 20%	108° = 30%
45° = 12.5%	144° = 40%	

Based on these values, we can have the following examples,

Examples

Directions (01-03): The pie-chart given below shows the spendings of a family on various items and its savings during a year.



01. If the total income of the family is Rs. 75000. The expenditure on children education was

a. Rs. 9000 b. Rs. 900

c. Rs. 7500 d. Rs. 750

Sol. Expenditure on children education $= \text{Rs.}\left(\frac{12}{100}\times 75000\right) = \text{Rs. } 9000$. Hence, option (a) is the correct answer.

02. What percent of the income was spent on transport and other items?

a. 25% b. 20%

c. 30% d. 32%

Sol. Clearly 25% of income was spent on transport and other items. Hence, option (a) is the correct answer.

Unit 4

Geometry and Mensuration

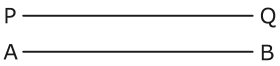
4.1 Lines and Angles

Line: A line has length. It has neither width nor thickness. It can be extended indefinitely in both directions.

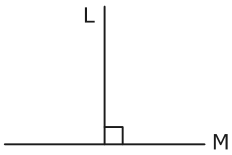
Ray: A line with one end point is called a ray. The end point is called the origin.

Line segment: A line with two end points is called a segment.

Parallel lines: Two lines, which lie in a plane and do not intersect, are called parallel lines. The distance between two parallel lines is constant. We denote it by PQ || AB.



Perpendicular lines: Two lines, which lie in a plane and intersect each other at right angle, are called perpendicular lines.



We denote it by L ⊥ M.

Properties

- Three or more points are said to be collinear if they lie on a line, otherwise they are said to be non-collinear.
- Two or more lines are said to be coplanar if they lie in the same plane, otherwise they are said to be non-coplanar.
- A line, which intersects two or more given coplanar lines in distinct points, is called a transversal of the given lines.
- A line which is perpendicular to a line segment, i.e. intersect at 90° and passes through the midpoint of line segment is called the perpendicular bisector of the segment.
- Every point on the perpendicular bisector of a segment is equidistant from the two endpoints of the segment.
- If two lines are perpendicular to the same line, they are parallel to each other or it can be said, "Lines which are parallel to the same line are parallel to each other".

Unit 5

Logical Reasoning

5.1 Blood Relations

The questions which are asked under this chapter depend upon relation. Hence, it is necessary for the candidate to have a sound knowledge of the blood relations. Some most frequently asked relations are given below.

Father's father	Grandfather
Father's mother	Grandmother
Father's brother	Paternal uncle
Father's sister	Paternal aunt
Children of uncle	Cousin
Wife of uncle	Aunt
Children of aunt	Cousin
Husband of aunt	Uncle
Mother's father	Maternal Grandfather
Mother's mother	Maternal Grandmother
Mother's brother	Maternal uncle
Mother's sister	Maternal aunt
Children of maternal uncle	Cousin
Wife of maternal uncle	Maternal aunt
Son's wife	Daughter-in-law
Daughter's husband	Son-in-law
Husband's or wife's sister	Sister-in-law
Husband's or wife's brother	Brother-in-law
Brother's son	Nephew
Brother' daughter	Niece
Sister's husband	Brother-in-law
Brother's wife	Sister-in-law
Grandson's or Grand daughter's daughter	Great grand daughter