



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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## Life Sciences: Fundamentals and Practice

### Ninth edition

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# Contents

## Chapter 1

### Biomolecules and Catalysis

<b>1.1</b>	<b>Amino acids and Proteins</b>	<b>2</b>		
1.1.1	Absolute configuration	5		
1.1.2	Optical activity	6		
1.1.3	Standard and non-standard amino acids	7		
1.1.4	Titration of amino acids	11		
1.1.5	Peptide and polypeptide	17		
1.1.6	Peptide bond	18		
1.1.7	Protein structure	21		
1.1.8	Denaturation of proteins	28		
1.1.9	Solubilities of proteins	28		
1.1.10	Simple and conjugated proteins	29		
<b>1.2</b>	<b>Fibrous and globular proteins</b>	<b>30</b>		
1.2.1	Collagen	31		
1.2.2	Elastin	33		
1.2.3	Keratins	34		
1.2.4	Myoglobin	34		
1.2.5	Hemoglobin	36		
1.2.6	Behavior of allosteric proteins	42		
<b>1.3</b>	<b>Protein folding</b>	<b>43</b>		
1.3.1	Molecular chaperones	45		
1.3.2	Amyloid	46		
1.3.3	Ubiquitin-mediated protein degradation	47		
1.3.4	N-end rule	49		
<b>1.4</b>	<b>Protein sequencing and assays</b>	<b>50</b>		
<b>1.5</b>	<b>Nucleic acids</b>	<b>56</b>		
1.5.1	Nucleotides	56		
1.5.2	Chargaff's rules	60		
<b>1.6</b>	<b>Structure of dsDNA</b>	<b>61</b>		
1.6.1	B-DNA	62		
1.6.2	Z-DNA	64		
1.6.3	Triplex DNA	65		
1.6.4	G-quadruplex	66		
1.6.5	Stability of the dsDNA helix	67		
1.6.6	DNA denaturation	67		
1.6.7	Quantification of nucleic acids	69		
1.6.8	Supercoiled forms of DNA	70		
1.6.9	DNA: A genetic material	73		
<b>1.7</b>	<b>RNA</b>	<b>75</b>		
1.7.1	Alkaline hydrolysis of RNA	76		
1.7.2	RNA World hypothesis	77		
1.7.3	RNA as genetic material	77		
<b>1.8</b>	<b>Carbohydrates</b>	<b>78</b>		
1.8.1	Monosaccharides	78		
1.8.2	Epimers	79		
1.8.3	Cyclic forms	81		
1.8.4	Derivatives of monosaccharide	83		
1.8.5	Disaccharides and glycosidic bond	85		
1.8.6	Polysaccharides	86		
1.8.7	Glycoproteins	89		
1.8.8	Reducing and non-reducing sugar	89		
<b>1.9</b>	<b>Lipids</b>	<b>90</b>		
1.9.1	Fatty acids	90		
1.9.2	Triacylglycerol and Wax	92		
1.9.3	Phospholipids	93		
1.9.4	Glycolipids	94		
1.9.5	Steroid	95		
1.9.6	Eicosanoid	95		
1.9.7	Plasma lipoproteins	98		



2.1.17	Warburg effect	188
2.1.18	Respiratory substrate and respiratory quotient	188
2.2	Glyoxylate cycle	189
2.3	Pentose phosphate pathway	190
2.4	Entner-Doudoroff pathway	192
2.5	Photosynthesis	193
2.5.1	Photosynthetic pigments	194
2.5.2	Absorption and action spectra	198
2.5.3	Fate of light energy absorbed by photosynthetic pigments	199
2.5.4	Concept of photosynthetic unit	201
2.5.5	Hill reaction	201
2.5.6	Oxygenic & Anoxygenic photosynthesis	202
2.5.7	Concept of pigment system	202
2.5.8	Photosynthesis in green plants	204
2.5.9	Light reactions	205
2.5.10	Carbon-fixation cycle	214
2.5.11	Starch and sucrose synthesis	219
2.6	Photorespiration	220
2.6.1	C <sub>4</sub> cycle	221
2.6.2	CAM pathway	224
2.7	Carbohydrate metabolism	227
2.7.1	Gluconeogenesis	227
2.7.2	Glycogen metabolism	231
2.8	Lipid metabolism	236
2.8.1	Synthesis & storage of triacylglycerols	236
2.8.2	Biosynthesis of fatty acids	238
2.8.3	Fatty acid oxidation	242
2.8.4	Biosynthesis of cholesterol	249
2.8.5	Steroid hormones and Bile acids	250
2.9	Amino acid metabolism	252
2.9.1	Amino acid synthesis	252
2.9.2	Amino acid catabolism	255
2.9.3	Molecules derived from amino acids	260
2.10	Nucleotide metabolism	261
2.10.1	Nucleotide synthesis	261
2.10.2	Nucleotide degradation	267

## Chapter 3

### Cell Structure and Functions

- 3.1 What is a cell? 274
- 3.2 Plasma membrane 275
  - 3.2.1 ABO blood group 285
  - 3.2.2 Transport across plasma membrane 288
- 3.3 Membrane potential 296
- 3.4 Transport of macromolecules across plasma membrane 306
  - 3.4.1 Endocytosis 306
  - 3.4.2 Fate of receptor 311
  - 3.4.3 Exocytosis 312
- 3.5 Ribosomes 313
  - 3.5.1 Protein targeting and translocation 315
- 3.6 Endoplasmic reticulum 316
  - 3.6.1 Transport from cytosol to ER 321
  - 3.6.2 Transport from ER to *cis*-Golgi 326
- 3.7 Golgi complex 328
  - 3.7.1 Transport of proteins through cisternae 330
  - 3.7.2 Transport from the TGN to lysosomes 330
- 3.8 Membrane fusion 332
- 3.9 Lysosome 334
- 3.10 Vacuoles 336
- 3.11 Mitochondria 336
- 3.12 Plastids 340
- 3.13 Peroxisome 342
- 3.14 Nucleus 344
- 3.15 Cytoskeleton 348
  - 3.15.1 Microtubules 348
  - 3.15.2 Microtubule-based motor proteins: Kinesins and Dyneins 351
  - 3.15.3 Cilia and Flagella 352
  - 3.15.4 Centriole 354
  - 3.15.5 Actin filament 355
  - 3.15.6 Myosin 358
  - 3.15.7 Muscle contraction 359
  - 3.15.8 Intermediate filaments 363
- 3.16 Cell junctions 364
- 3.17 Cell adhesion molecules 367
- 3.18 Extracellular matrix of animals 369
- 3.19 Plant cell wall 370
- 3.20 Cell signaling 372
  - 3.20.1 Signal molecules 372
  - 3.20.2 Receptors 373
  - 3.20.3 GPCR and G-proteins 376
  - 3.20.4 Ion channel-linked receptors 385
  - 3.20.5 Enzyme-linked receptors 386
  - 3.20.6 Chemotaxis in bacteria 395
  - 3.20.7 Quorum sensing 397
- 3.21 Cell Cycle 399
  - 3.21.1 Role of Rb in cell cycle regulation 410
  - 3.21.2 Role of p53 in cell cycle regulation 411
  - 3.21.3 Replicative senescence 413
- 3.22 Mechanics of cell division 414
  - 3.22.1 Mitosis 414
  - 3.22.2 Meiosis 421
  - 3.22.3 Nondisjunction and aneuploidy 426
- 3.23 Apoptosis 429
- 3.24 Cancer 433

## Chapter 4

### Prokaryotes and Viruses

- 4.1 Phylogenetic overview 448
- 4.2 Structure of bacterial cell 449
- 4.3 Bacterial genome 461
- 4.4 Bacterial nutrition 465
  - 4.4.1 Culture media 466
  - 4.4.2 Bacterial growth 468
- 4.5 Horizontal gene transfer and recombination 471
  - 4.5.1 Transformation 472
  - 4.5.2 Transduction 473
  - 4.5.3 Conjugation 477
- 4.6 Mapping of chromosomal genes 480
- 4.7 Bacterial taxonomy 485
- 4.8 General features of bacterial groups 486

4.9	Archaeobacteria	488
4.10	Bacterial toxins	490
4.11	Control of microbial growth	491
4.12	Viruses	495
4.12.1	Bacteriophages (Bacterial virus)	497
4.12.2	Life cycle of bacteriophage	498
4.12.3	Plaques assay	501
4.12.4	Genetic analysis of phage	504
4.12.5	Animal viruses	507
4.12.6	Plant viruses	517
4.13	Prions and Viroids	518
4.13.1	Bacterial and viral diseases	520

## Chapter 5

### Immunology

5.1	Innate immunity	523
5.2	Adaptive immunity	529
5.3	Cells of the immune system	531
5.3.1	Common lymphoid progenitor	531
5.3.2	Common myeloid progenitor	533
5.4	Organs involved in the adaptive immune response	535
5.4.1	Primary lymphoid organs	535
5.4.2	Secondary lymphoid organs/tissues	536
5.5	Antigens	537
5.6	Major histocompatibility complex	540
5.6.1	MHC and antigen presentation	542
5.6.2	Antigen processing and presentation	543
5.7	Immunoglobulins: Structure and function	546
5.7.1	Basic structure of antibody molecule	546
5.7.2	Different classes of antibody	549
5.7.3	Antigenic determinants on antibodies	551
5.8	Organization and expression of Ig genes	552
5.9	Generation of antibody diversity	558
5.10	B cell maturation and activation	560
5.11	Kinetics of the antibody response	573
5.11.1	Humoral immune response	575

5.12	Monoclonal antibodies and Hybridoma technology	577
5.13	T cells and cell-mediated immunity	579
5.13.1	Superantigens	592
5.14	The complement system	592
5.15	Hypersensitivity	596
5.16	Autoimmunity	598
5.17	Transplantation	598
5.18	Immunodeficiency diseases	601
5.19	Failures of host defense mechanisms	601
5.20	Vaccines	603

## Chapter 6

### Diversity of Life

6.1	Taxonomy	611
6.1.1	Nomenclature	612
6.1.2	Classification	612
6.1.3	Biological species concept	613
6.1.4	Phenetics and cladistics approaches of classification	614
6.2	Five-kingdom system	620
6.3	Protists	622
6.3.1	Protozoan protists	622
6.3.2	Photosynthetic protists	623
6.3.3	Slime mold	624
6.3.4	Oomycetes	625
6.4	Fungi	625
6.4.1	Mycorrhiza	627
6.4.2	Lichens	628
6.5	Plantae	628
6.5.1	Plant life cycle	629
6.5.2	Algae	631
6.5.3	Life cycle of land plants	633
6.5.4	Bryophytes	634
6.5.5	Pteridophytes	635
6.5.6	Gymnosperm	638
6.5.7	Angiosperms	638

6.6	Animalia	644
6.7	Animal's classification	652
6.7.1	Phylum Porifera	652
6.7.2	Phylum Cnidaria (Coelenterata)	652
6.7.3	Phylum Platyhelminthes (Flatworms)	653
6.7.4	Phylum Aschelminthes	653
6.7.5	Phylum Annelida	654
6.7.6	Phylum Mollusca	655
6.7.7	Phylum Arthropoda	655
6.7.8	Phylum Echinodermata	656
6.7.9	Phylum Hemichordata	656
6.7.10	Phylum Chordata	656

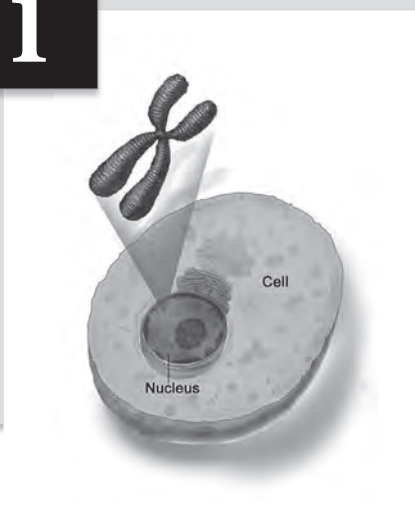
## Chapter 7

### Ecology

7.1	The Environment	665
7.1.1	Physical environment	665
7.1.2	Adaptation to the physical environment	670
7.2	Shelford's law of tolerance	672
7.3	Ecosystem	673
7.3.1	Ecosystem components	673
7.3.2	Productivity	674
7.3.3	Energy flow	677
7.3.4	Food chains	679
7.3.5	Ecological efficiencies	681
7.3.6	Ecological pyramid	683
7.3.7	Nutrient cycling	684
7.3.8	Decomposition	686
7.4	Ecosystem services	686
7.4.1	Control of trophic structure: top-down versus bottom-up control	687
7.5	Types of Ecosystems	688
7.5.1	Aquatic ecosystem	689
7.5.2	Terrestrial ecosystem	695
7.6	Biomes	697
7.7	Population ecology	700
7.7.1	Population characteristics	700

7.7.2	Population growth	703
7.7.3	Life table	707
7.7.4	Population regulation	708
7.7.5	Life history	710
7.8	Community ecology	712
7.8.1	Community structure	712
7.8.2	Species composition	712
7.8.3	Species diversity	713
7.8.4	Diversity index	715
7.8.5	Disturbance and species diversity	717
7.8.6	Diversity-Stability-Complexity relationships	717
7.8.7	Community gradient and boundaries	719
7.9	Island biogeography	720
7.10	Ecological interdependence and interactions	721
7.11	Lotka-Volterra model	726
7.12	Ecological niche	732
7.13	Effect of competition	734
7.14	Ecological succession	737
7.14.1	Pattern of succession	737
7.14.2	Types of ecological succession	739
7.14.3	Mechanism of succession	740
7.14.4	Models of succession	741
7.15	Biodiversity	743
7.15.1	Levels of biodiversity	743
7.15.2	Gradients and Magnitude of biodiversity	743
7.15.3	Uses of biodiversity	744
7.15.4	Threats to biodiversity	745
7.15.5	Extinction of species	747
7.15.6	IUCN Red List categories and criteria	748
7.15.7	Conservation of biodiversity	749
7.16	Behavioural ecology	751
7.16.1	Mating behaviour	755
	<b>Index</b>	<b>763</b>





# Biomolecules and Catalysis

## Learning objective

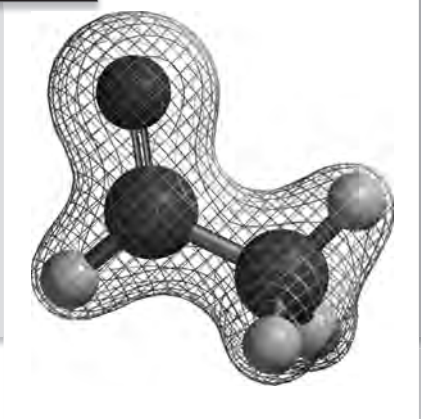
- 1.1 Amino acids and Proteins
- 1.2 Fibrous and globular proteins
- 1.3 Protein folding
- 1.4 Protein sequencing and assay
- 1.5 Nucleic acids
- 1.6 Structure of dsDNA

- 1.7 RNA
- 1.8 Carbohydrates
- 1.9 Lipids
- 1.10 Vitamins
- 1.11 Reactive oxygen species and antioxidants
- 1.12 Enzymes

**B**iomolecules 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.

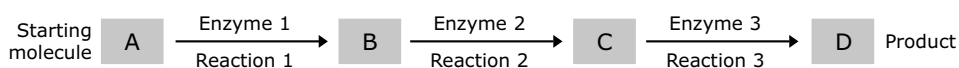


# Metabolism

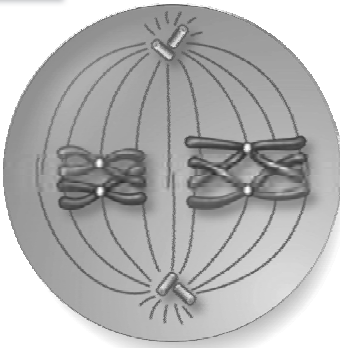
## Learning objective

- |                               |                             |
|-------------------------------|-----------------------------|
| 2.1 Respiration               | 2.6 Photorespiration        |
| 2.2 Glyoxylate cycle          | 2.7 Carbohydrate metabolism |
| 2.3 Pentose phosphate pathway | 2.8 Lipid metabolism        |
| 2.4 Entner-Doudoroff pathway  | 2.9 Amino acid metabolism   |
| 2.5 Photosynthesis            | 2.10 Nucleotide metabolism  |

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.

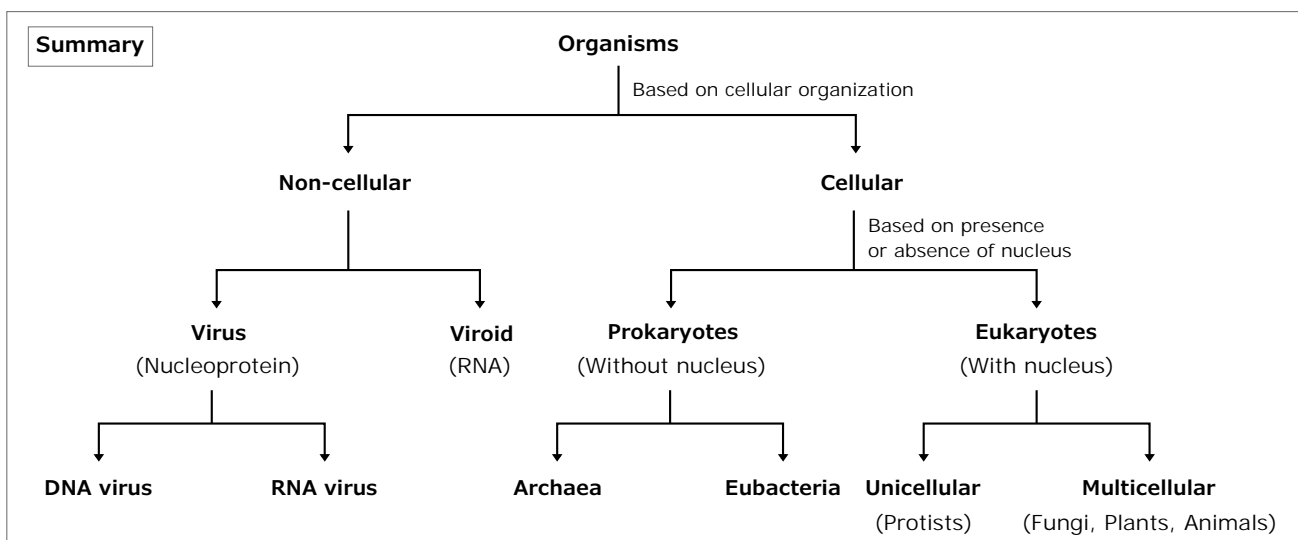


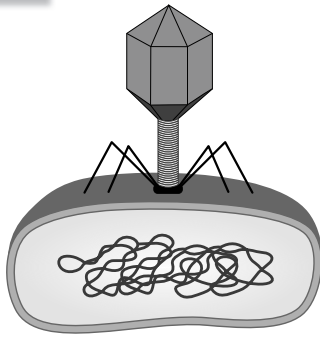
# Cell Structure and functions

## Learning objective

3.1 What is a cell?	3.9 Lysosome	3.17 Cell adhesion molecules
3.2 Plasma membrane	3.10 Vacuoles	3.18 Extracellular matrix of animals
3.3 Membrane potential	3.11 Mitochondria	3.19 Plant cell wall
3.4 Transport of macromolecules	3.12 Plastids	3.20 Cell signaling
3.5 Ribosomes	3.13 Peroxisome	3.21 Cell cycle
3.6 Endoplasmic reticulum	3.14 Nucleus	3.22 Mechanics of cell division
3.7 Golgi complex	3.15 Cytoskeleton	3.23 Apoptosis
3.8 Membrane fusion	3.16 Cell junctions	3.24 Cancer

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.





# Prokaryotes and Viruses

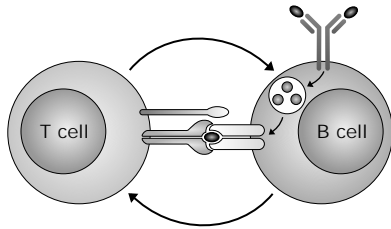
## Learning objective

- |  |  |
|--|--|
| 4.1 Phylogenetic overview                      | 4.8 General features of important bacterial groups |
| 4.2 Structure of bacterial cell                | 4.9 Archaeobacteria                                |
| 4.3 Bacterial genome                           | 4.10 Bacterial toxins                              |
| 4.4 Bacterial nutrition                        | 4.11 Control of microbial growth                   |
| 4.5 Horizontal gene transfer and recombination | 4.12 Viruses                                       |
| 4.6 Mapping of chromosomal genes               | 4.13 Prions and Viroids                            |
| 4.7 Bacterial taxonomy                         |  |

**P**rokaryotes (*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 *archaeobacteria* 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 <i>Mycoplasma</i>	Present
Ribosome	70S (cytosol)	80S (cytosol)
Unit-mem. bound organelle	Absent	Present
Cell wall	Present in <i>most</i> 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.





# Immunology

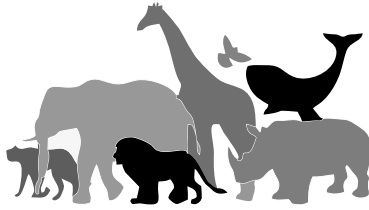
## Learning objective

5.1	Innate immunity	5.11	Kinetics of the antibody response
5.2	Adaptive immunity	5.12	Monoclonal antibodies and Hybridoma technology
5.3	Cells of the immune system	5.13	T cells and cell-mediated immunity
5.4	Organs involved in the adaptive immune response	5.14	The complement system
5.5	Antigens	5.15	Hypersensitivity
5.6	Major histocompatibility complex	5.16	Autoimmunity
5.7	Immunoglobulins: Structure and function	5.17	Transplantation
5.8	Organization and expression of Ig genes	5.18	Immunodeficiency diseases
5.9	Generation of antibody diversity	5.19	Failures of host defense mechanisms
5.10	B cell maturation and activation	5.20	Vaccines

**I**mmunology 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.



# Diversity of Life

## Learning objective

6.1 Taxonomy

6.2 Five-kingdom system

6.3 Protists

6.4 Fungi

6.5 Plantae

6.6 Animalia

6.7 Animal's classification

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.



# Ecology

## Learning objective

7.1	The Environment	7.9	Island biogeography
7.2	Shelford's law of tolerance	7.10	Ecological interdependence and interactions
7.3	Ecosystem	7.11	Lotka-Volterra model
7.4	Ecosystem services	7.12	Ecological niche
7.5	Types of Ecosystems	7.13	Effect of competition
7.6	Biomes	7.14	Ecological succession
7.7	Population ecology	7.15	Biodiversity
7.8	Community ecology	7.16	Behavioural ecology

**E**cology 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](mailto: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 than 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<sub>7</sub> 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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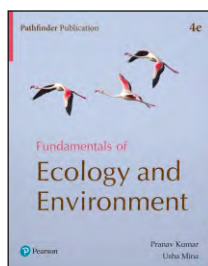
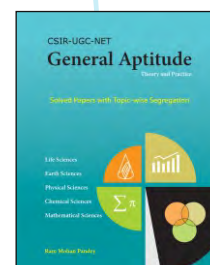
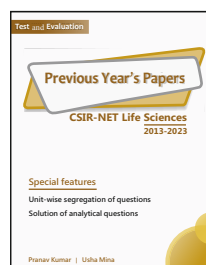
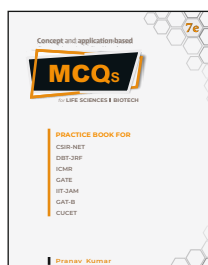
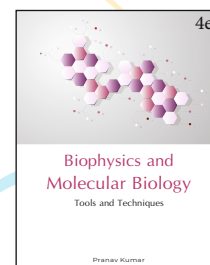
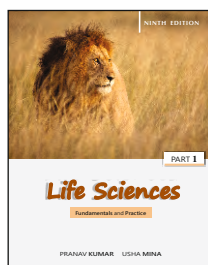
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NINTH EDITION



PART 2

# *Life Sciences*

Fundamentals and Practice

PRANAV KUMAR    USHA MINA

# Life Sciences

Fundamentals and Practice

Part-2

Ninth edition

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## Life Sciences: Fundamentals and Practice

### Ninth edition

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# Contents

## Chapter 1

### Genetics

<b>1.1</b>	<b>Mendel's principles</b>	<b>1</b>	<b>1.10</b>	<b>Cytogenetics</b>	<b>68</b>
1.1.1	Mendel's laws of inheritance	4	1.10.1	Human karyotype	68
1.1.2	Incomplete dominance and codominance	8	1.10.2	Chromosome banding	69
1.1.3	Multiple alleles	10	1.10.3	Chromosomal abnormalities	71
1.1.4	Lethal alleles	11		Variation in chromosome number	71
1.1.5	Penetrance and expressivity	12		Variation in chromosome structure	74
1.1.6	Probability	12	1.10.4	Position effect variegation	79
<b>1.2</b>	<b>Chromosomal basis of inheritance</b>	<b>15</b>	<b>1.11</b>	<b>Genome</b>	<b>80</b>
<b>1.3</b>	<b>Gene interaction</b>	<b>17</b>	1.11.1	Genome complexity	82
1.3.1	Genetic dissection	23	1.11.2	Gene	84
1.3.2	Complementation analysis	24	1.11.3	Introns	85
1.3.3	Pleiotropy	27	1.11.4	Gene duplication	88
<b>1.4</b>	<b>Linkage and gene mapping</b>	<b>27</b>	1.11.5	Acquisition of new genes	89
1.4.1	Genetic mapping	33	1.11.6	Gene families	90
1.4.2	Gene mapping from two point cross	34	1.11.7	Human nuclear genome	92
1.4.3	Gene mapping from three point cross	36	1.11.8	Yeast <i>S. cerevisiae</i> genome	93
1.4.4	Interference and coincidence	38	1.11.9	<i>E. coli</i> genome	93
<b>1.5</b>	<b>Tetrad analysis</b>	<b>40</b>	1.11.10	Organelle genome	93
1.5.1	Analysis of ordered tetrad	41	1.11.11	Transposable elements	95
1.5.2	Analysis of unordered tetrad	43	<b>1.12</b>	<b>Eukaryotic chromatin</b>	<b>103</b>
<b>1.6</b>	<b>Sex determination</b>	<b>44</b>	1.12.1	Packaging of DNA into chromosomes	105
1.6.1	Sex-linked traits/sex-linked inheritance	50	1.12.2	Heterochromatin and euchromatin	110
1.6.2	Sex-limited traits	52	1.12.3	Polytene chromosomes	113
1.6.3	Sex-influenced traits	52	1.12.4	Lampbrush chromosomes	114
<b>1.7</b>	<b>Pedigree analysis</b>	<b>53</b>	1.12.5	B-chromosomes	115
<b>1.8</b>	<b>Quantitative inheritance</b>	<b>57</b>	<b>1.13</b>	<b>DNA replication</b>	<b>116</b>
1.8.1	Quantitative trait locus analysis	61	1.13.1	Semiconservative replication	116
1.8.2	Heritability	61	1.13.2	Replicon and origin of replication	117
<b>1.9</b>	<b>Extranuclear inheritance and maternal effect</b>	<b>62</b>	1.13.3	DNA replication in <i>E. coli</i>	121
1.9.1	Maternal effect	67	1.13.4	Telomere replication	135
			1.13.5	Rolling circle replication	136

1.13.6	Replication of mitochondrial DNA	137
<b>1.14</b>	<b>Recombination</b>	<b>138</b>
1.14.1	Homologous recombination	138
1.14.2	Site-specific recombination	143
<b>1.15</b>	<b>DNA repair</b>	<b>145</b>
1.15.1	Direct repair	145
1.15.2	Excision repair	146
1.15.3	Mismatch repair	147
1.15.4	Recombinational repair	148
1.15.5	Repair of double strand DNA break	150
1.15.6	Gene conversion	151
1.15.7	SOS response	152
<b>1.16</b>	<b>Transcription</b>	<b>153</b>
1.16.1	Transcription unit	153
1.16.2	Prokaryotic transcription	156
1.16.3	Eukaryotic transcription	162
1.16.4	Role of activator and co-activator	167
1.16.5	Regulatory elements	168
1.16.6	DNA binding motifs	170
<b>1.17</b>	<b>RNA processing</b>	<b>173</b>
1.17.1	Processing of eukaryotic pre-mRNA	173
1.17.2	Processing of pre-rRNA	184
1.17.3	Processing of pre-tRNA	187
<b>1.18</b>	<b>mRNA degradation</b>	<b>188</b>
<b>1.19</b>	<b>Regulation of bacterial genes</b>	<b>190</b>
1.19.1	Operon model	191
1.19.2	Tryptophan operon in <i>E. coli</i>	199
1.19.3	Riboswitches	204
<b>1.20</b>	<b>Genetic switch in phage lambda</b>	<b>205</b>
<b>1.21</b>	<b>Regulation of eukaryotic genes</b>	<b>209</b>
1.21.1	Chromatin structure on transcription	210
1.21.2	DNA methylation and gene regulation	214
1.21.3	Post-transcriptional gene regulation	216
<b>1.22</b>	<b>RNA interference</b>	<b>217</b>
<b>1.23</b>	<b>Epigenetics</b>	<b>221</b>
<b>1.24</b>	<b>Genetic code</b>	<b>222</b>
<b>1.25</b>	<b>Protein synthesis</b>	<b>227</b>
1.25.1	Translational frameshifting	244
1.25.2	Antibiotics and toxins	245

1.25.3	Post-translational modification of polypeptides	247
--------	---	-----

<b>1.26</b>	<b>Mutation</b>	<b>249</b>
1.26.1	Mutagens	254
1.26.2	Types of mutation	258
1.26.3	Fluctuation test	263
1.26.4	Ames test	264

## Chapter 2

### Recombinant DNA Technology

<b>2.1</b>	<b>DNA cloning</b>	<b>271</b>
<b>2.2</b>	<b>Enzymes for DNA manipulation</b>	<b>273</b>
2.2.1	DNA polymerase	273
2.2.2	Nucleases	273
2.2.3	End-modification enzymes	277
2.2.4	Ligases	278
<b>2.3</b>	<b>Vectors</b>	<b>279</b>
2.3.1	Vectors for <i>E. coli</i>	280
2.3.2	Cloning vectors for yeast, <i>S. cerevisiae</i>	284
2.3.3	Vectors for plants	286
2.3.4	Vectors for animals	290
<b>2.4</b>	<b>Introduction of DNA into the host cells</b>	<b>290</b>
2.4.1	In bacterial cells	290
2.4.2	In plant cells	290
2.4.3	In animal cells	293
<b>2.5</b>	<b>Selectable and screenable marker</b>	<b>295</b>
<b>2.6</b>	<b>Selection of transformed bacterial cells</b>	<b>297</b>
<b>2.7</b>	<b>Selection of recombinant containing transformed bacterial cells</b>	<b>298</b>
<b>2.8</b>	<b>Expression vector</b>	<b>299</b>
2.8.1	Expression system	300
2.8.2	Fusion protein	301
<b>2.9</b>	<b>DNA library</b>	<b>302</b>
<b>2.10</b>	<b>Genetic markers</b>	<b>305</b>
<b>2.11</b>	<b>Genome mapping</b>	<b>312</b>
2.11.1	Radiation hybrids	314
<b>2.12</b>	<b>DNA profiling</b>	<b>315</b>
<b>2.13</b>	<b>Genetic manipulation of animal cells</b>	<b>316</b>

2.13.1	Transgenesis and transgenic animals	316	3.3	Absorption and radial movement of mineral nutrients	366
2.13.2	Gene knockout	317	3.4	Mineral nutrition	367
2.13.3	Formation and selection of recombinant ES cells	319	3.4.1	Nitrogen assimilation	371
2.14	Nuclear transfer technology and animal cloning	320	3.4.2	Biological nitrogen fixation	374
2.15	Gene therapy	321	3.5	Translocation in the phloem	378
2.16	Transgenic plants	325	3.5.1	Allocation and partitioning of photoassimilates	387
2.16.1	Procedure to make a transgenic plant	325	3.6	Plant hormones	387
2.16.2	Antisense technology	329	3.6.1	Auxin	388
2.16.3	Molecular farming	330	3.6.2	Gibberellins	393
2.17	Plant tissue culture	330	3.6.3	Cytokinins	396
2.17.1	Cellular totipotency	331	3.6.4	Abscisic acid	400
2.17.2	Tissue culture media	331	3.6.5	Ethylene	401
2.17.3	Types of cultures	333	3.6.6	Brassinosteroids	403
2.17.4	Somaclonal and gametoclonal variation	338	3.6.7	Strigolactones	403
2.17.5	Somatic hybridization and cybridization	338	3.6.8	Jasmonates	404
2.17.6	Applications of cell and tissue culture	339	3.7	Signaling photoreceptors	404
2.18	Animal cell culture	342	3.7.1	Phytochrome	404
2.18.1	Primary cultures	342	3.7.2	Cryptochrome	408
2.18.2	Cell line	342	3.7.3	Phototropin	411
2.18.3	Growth cycle	344	3.7.4	Photoperiodism	413
2.18.4	Culture media	345	3.7.5	Florigen	415
			3.8	Vernalization	416
			3.9	Flowering genes	416
			3.10	Plants movements	419
			3.11	Seed dormancy and Germination	422
			3.12	Plant development	425
			3.12.1	Pollination and Self-incompatibility	431
			3.13	Asexual reproduction	432
			3.14	Embryogenesis	434
			3.14.1	Apical meristems	437
				Root apical meristems	437
				Shoot apical meristem	438
			3.15	Plant secondary metabolites	441
			3.15.1	Terpenes	441
			3.15.2	Phenolics	443
			3.15.3	Glycosides	445
			3.15.4	Alkaloids	445

## Chapter 3

### Plant Physiology and Development

3.1	Plant-water relationship	352
3.1.1	Diffusion and osmosis	352
3.1.2	Chemical potential of water	354
3.1.3	Mass flow	356
3.2	Journey of water in plant	356
3.2.1	Absorption of water	356
3.2.2	Radial movement of water from root surface to the tracheary element	358
3.2.3	Ascent of sap	359
3.2.4	Transpiration	362
3.2.5	Guttation	365

## Chapter 4

### Human Physiology

- 4.1 Tissues 451
  - 4.1.1 Organ systems of the human body 460
- 4.2 Nervous Systems 461
  - 4.2.1 Histology of nervous tissue 462
    - Neurons 462
    - Neuroglia 464
  - 4.2.2 Structural organization of CNS 465
    - Blood-brain barrier 466
  - 4.2.3 Major parts of the brain 467
    - Limbic system 469
  - 4.2.4 Spinal cord 470
    - Reflex and reflex arc 473
  - 4.2.5 Peripheral nervous system 473
  - 4.2.6 Autonomic nervous system 475
    - Somatic system 478
- 4.3 Sensory organs 479
  - 4.3.1 Eye 479
  - 4.3.2 Ear 485
- 4.4 Endocrine System 488
  - 4.4.1 Hypothalamus 489
  - 4.4.2 Pituitary gland 491
  - 4.4.3 Pineal gland 493
  - 4.4.4 Thyroid gland 493
  - 4.4.5 Parathyroid gland 494
  - 4.4.6 Thymus gland 494
  - 4.4.7 Pancreas 494
  - 4.4.8 Adrenal glands 497
  - 4.4.9 Gonadal hormone 499
  - 4.4.10 Hormones from kidney, heart, placenta and gastrointestinal tract 499
  - 4.4.11 General mechanisms of hormone action 501
  - 4.4.12 Hormones and diseases 502
- 4.5 Respiratory System 505
  - 4.5.1 Respiratory organs 505
  - 4.5.2 Mechanics and breathing 509
  - 4.5.3 Respiratory volumes and capacities 511
  - 4.5.4 Exchange of oxygen and carbon dioxide 512
  - 4.5.5 Transport of oxygen and carbon dioxide 515
  - 4.5.6 Control of respiration 518
  - 4.5.7 Chemoreceptor 519
  - 4.5.8 Disorders of respiratory system 520
- 4.6 Cardiovascular System 521
  - 4.6.1 Blood 521
  - 4.6.2 Heart 527
  - 4.6.3 Blood vessels 534
  - 4.6.4 Circulatory routes 538
  - 4.6.5 Lymphatic system 541
  - 4.6.6 Intracellular and extracellular fluid 542
  - 4.6.7 Cardiovascular disorders 542
- 4.7 Digestive System 543
  - 4.7.1 Gastrointestinal tract 543
  - 4.7.2 Accessory digestive organs 552
  - 4.7.3 Digestion of foods 555
  - 4.7.4 Absorption of foods 558
  - 4.7.5 Regulation of digestive function 560
- 4.8 Excretory System 561
  - 4.8.1 Structure of the kidneys 562
  - 4.8.2 Nephron 564
  - 4.8.3 Urine formation 567
  - 4.8.4 Atrial Natriuretic peptide 574
  - 4.8.5 Countercurrent exchange 577
- 4.9 Reproductive System 578
  - 4.9.1 Male reproductive system 578
    - Testis 578
    - Accessory ducts 578
    - Accessory glands 579
    - Spermatogenesis 579
  - 4.9.2 Female reproductive system 581
    - Ovaries 581
    - Accessory ducts 582
    - External genitalia 582
    - Oogenesis 583
    - Folliculogenesis 584
    - Hormones control 585
  - 4.9.3 Female reproductive cycle 585
    - Ovarian cycle 585
    - Uterine cycle 585

## Chapter 5

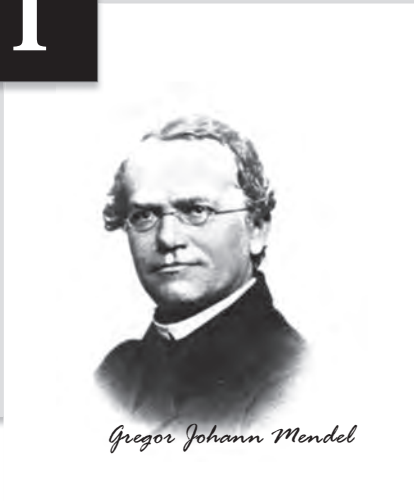
### Animal Development

- 5.1 Patterns and processes of animal development 593
  - 5.1.1 Cell-to-Cell communication 594
    - Wnt signaling 594
    - Hedgehog signaling 595
    - Notch signaling 597
  - 5.1.2 Cell fate commitment 599
  - 5.1.3 Morphogens 603
  - 5.1.4 Pattern formation and morphogenesis 604
- 5.2 Fertilization 607
- 5.3 Cleavage and gastrulation 615
  - Gastrulation 616
  - Early development in sea urchins – cleavage, gastrulation and axis formation 617
  - Gastrulation in the sea urchin 619
  - Early development in amphibia – cleavage, gastrulation and axis formation 621
  - Gastrulation in amphibia 622
  - Organogenesis 629
- 5.4 Embryonic development in *Drosophila* 629
- 5.5 Vulva development in *C. elegans* 639
- 5.6 Regeneration 641
- 6.5 Population genetics 663
  - 6.5.1 Calculation of allelic frequencies 664
  - 6.5.2 Hardy-Weinberg principle 665
  - 6.5.3 Inbreeding 670
    - Wahlund effect 674
    - Effective population size 675
- 6.6 Evolutionary processes 676
  - Natural selection 676
  - Genetic drift 677
  - Mutation 680
- 6.7 Species and speciation 682
  - Concept of species 682
  - Reproductive isolation 683
  - Speciation 684
  - Anagenesis and cladogenesis 686
  - Adaptive radiation 687
- 6.8 Macroeolution 687
- 6.9 Molecular phylogeny 689
  - Molecular clock 690
- 6.10 Phylogenetic tree 691
- 6.11 Geological time scale 693
- Index 699**

## Chapter 6

### Evolution

- 6.1 Origin of Life 649
- 6.2 Biological evolution and theories of evolution 652
  - 6.2.1 Lamarckism 652
  - 6.2.2 Darwinism 653
- 6.3 Natural selection 657
  - Evidences of natural selection 658
  - Level of natural selection 659
  - How selection works 659
  - Modes of natural selection 660
  - Sexual selection 661
- 6.4 Pattern of evolution 662



# 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



# Recombinant DNA technology

## Learning objective

2.1 DNA cloning	2.10 Genetic markers
2.2 Enzymes for DNA manipulation	2.11 Genome mapping
2.3 Vectors	2.12 DNA profiling
2.4 Introduction of DNA into the host cells	2.13 Genetic manipulation of animal cells
2.5 Selectable and screenable marker	2.14 Nuclear transfer technology and animal cloning
2.6 Selection of transformed bacterial cells	2.15 Gene therapy
2.7 Selection of recombinant containing bacterial cells	2.16 Transgenic plants
2.8 Expression vector	2.17 Plant tissue culture
2.9 DNA library	2.18 Animal cell culture

**R**ecombinant 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*.





# Plant Physiology and Development

## Learning objective

- |   |                                    |
|---|------------------------------------|
| 3.1 Plant-water relationship                            | 3.9 Flowering genes                |
| 3.2 Journey of water in plant                           | 3.10 Plants movements              |
| 3.3 Absorption and radial movement of mineral nutrients | 3.11 Seed dormancy and Germination |
| 3.4 Mineral nutrition                                   | 3.12 Plant development             |
| 3.5 Translocation in the phloem                         | 3.13 Asexual reproduction          |
| 3.6 Plant hormones                                      | 3.14 Embryogenesis                 |
| 3.7 Signaling photoreceptors                            | 3.15 Plant secondary metabolites   |
| 3.8 Vernalization                                       |                                    |

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 *Wolffia* 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.



# Human Physiology

## Learning objective

- |                        |                           |
|------------------------|---------------------------|
| 4.1 Tissues            | 4.6 Cardiovascular System |
| 4.2 Nervous Systems    | 4.7 Digestive System      |
| 4.3 Sensory organs     | 4.8 Excretory System      |
| 4.4 Endocrine System   | 4.9 Reproductive System   |
| 4.5 Respiratory System |                           |

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.



# Animal Development

## Learning objective

5.1 Patterns and processes of animal development

5.2 Fertilization

5.3 Cleavage and gastrulation

5.4 Embryonic development in *Drosophila*

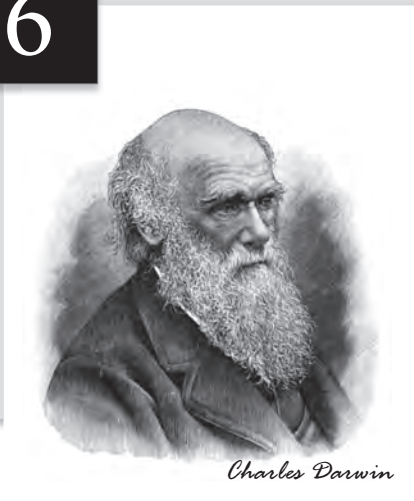
5.5 Vulva development in *C. elegans*

5.6 Regeneration

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.



# Evolution

## Learning objective

- |  |                            |
|--|----------------------------|
| 6.1 Origin of Life                                 | 6.7 Species and speciation |
| 6.2 Biological evolution and theories of evolution | 6.8 Macroevolution         |
| 6.3 Natural selection                              | 6.9 Molecular phylogeny    |
| 6.4 Pattern of evolution                           | 6.10 Phylogenetic tree     |
| 6.5 Population genetics                            | 6.11 Geological time scale |
| 6.6 Evolutionary processes                         |                            |

**E**volution 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. extraterrestrial 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](mailto: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 than 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<sub>7</sub> 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

# Pathfinder Publication



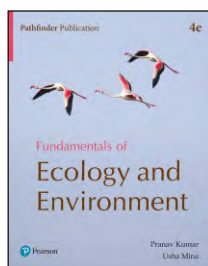
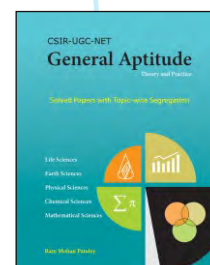
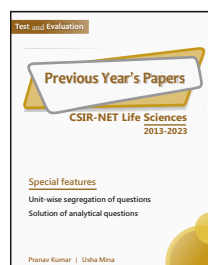
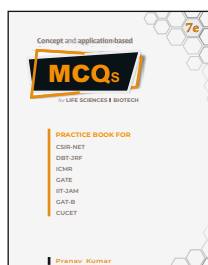
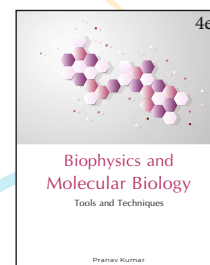
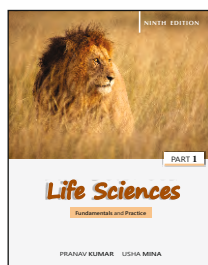
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Fundamentals of  
**Ecology *and***  
**Environment**



Fundamentals of

# **Ecology** *and* **Environment**

Fourth edition

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### Chapter 1

## The Environment

### 1.1 Physical environment 3

Soil 3

Weathering and soil formation 3

Soil composition 4

Soil profile 5

Soil erosion 6

Air and Atmosphere 8

Light 11

Temperature 13

Temperature and vegetation 16

### 1.2 Adaptation to the physical environment 17

Plant's adaptation to water stress 18

Animal's adaptation to thermal stress 18

Relationship between body size and environmental temperature 19

### 1.3 Metabolic rate and size of animals 21

### 1.4 Shelford's law of tolerance 22

### 1.5 Species concept 23

Ecotype and Ecads 24

### Chapter 2

## Ecosystem Ecology

### 2.1 Ecosystem components 29

### 2.2 Productivity 30

Patterns in primary productivity 32

Relationship between productivity and biomass 34

Measuring primary productivity 34

Oxygen emission method 34

Radioactive tracer method 35

Harvest analysis method 35

<b>2.3</b>	<b>Energy flow</b>	<b>36</b>
	Universal energy flow model	38
	Concept of the trophic level	39
2.3.1	Food chains	40
2.3.2	Ecological efficiencies	42
2.3.3	Ecological pyramid	44
<b>2.4</b>	<b>Nutrient cycling</b>	<b>46</b>
	General model of nutrient cycling	47
	Carbon cycle	48
	Nitrogen cycle	49
	Phosphorus cycle	51
	Sulfur cycle	52
	Decomposition	53
<b>2.5</b>	<b>Ecosystem services</b>	<b>54</b>
<b>2.6</b>	<b>Control of trophic structure: top-down versus bottom-up control</b>	<b>54</b>
<b>2.7</b>	<b>Types of ecosystems</b>	<b>56</b>
2.7.1	Aquatic ecosystem	56
	Variation in light and temperature in aquatic ecosystem	57
	Primary productivity in aquatic ecosystems	57
	Marine ecosystems	58
	Hot hydrothermal vents	59
	Coral reefs ecosystem	60
	Estuary	61
	Freshwater ecosystem	62
	Lake	62
	Thermal stratification	63
	Seasonal changes in water temperature	63
	Nutrient inputs and cycling	65
	River	65
	Wetlands	66
2.7.2	Terrestrial ecosystem	67
	Forest ecosystem	67
	Deforestation	68
	Afforestation	69
	Social forestry	69
	Grassland ecosystem	69
	Desert ecosystem	70
	Types of deserts	70
	Desertification	71
<b>2.8</b>	<b>Biomes</b>	<b>71</b>

Biome distribution	72
Biome types	72
Tundra biome	72
Desert biome	73
Tropical grassland (or Savanna biome)	73
Temperate grasslands	74
Tropical rainforests	74
Temperate deciduous forest biome	75
Taiga biome	76
Chaparral biome	76

## Chapter 3

### Population Ecology

<b>3.1</b>	<b>Population characteristics</b>	<b>79</b>
	Population density	80
	Natality	80
	Mortality	81
	Dispersion	82
	Age structure and Age pyramids	83
	Dispersal	84
<b>3.2</b>	<b>Population growth</b>	<b>84</b>
	Exponential growth	85
	Logistic growth	86
<b>3.3</b>	<b>Life table: Age-specific mortality and survival</b>	<b>89</b>
<b>3.4</b>	<b>Population regulation</b>	<b>91</b>
<b>3.5</b>	<b>Concept of metapopulation</b>	<b>93</b>
<b>3.6</b>	<b>Life history</b>	<b>94</b>
	Life history trade-offs	94
	r- and K-selection	95
	Grime's triangle of life history strategies	97
<b>3.7</b>	<b>Home range and Territory</b>	<b>98</b>

## Chapter 4

### Community Ecology

<b>4.1</b>	<b>Community structure</b>	<b>102</b>
4.1.1	Species composition	102
4.1.2	Species diversity	103

4.1.3	Diversity index	106
4.1.4	Species-area curve	110
4.1.5	Disturbance and species diversity	111
<b>4.2</b>	<b>Community interactions</b>	<b>112</b>
<b>4.3</b>	<b>Community: Functional classification</b>	<b>113</b>
<b>4.4</b>	<b>Diversity-Stability-Complexity relationships</b>	<b>114</b>
	Diversity and stability	114
	Complexity and stability	115
<b>4.5</b>	<b>Plant communities</b>	<b>117</b>
<b>4.6</b>	<b>Community gradient and boundaries</b>	<b>119</b>
<b>4.7</b>	<b>Equilibrium theory of island biogeography</b>	<b>120</b>
<b>4.8</b>	<b>Ecological interdependence and interactions</b>	<b>122</b>
<b>4.9</b>	<b>Lotka-Volterra model</b>	<b>131</b>
<b>4.10</b>	<b>Ecological niche</b>	<b>139</b>
	Ecological compression	143
<b>4.11</b>	<b>Effect of competition</b>	<b>143</b>
	Competitive exclusion principle	143
	Competitive exclusion and coexistence	145
	Resource partitioning	145
	Character displacement	147
<b>4.12</b>	<b>Ecological succession</b>	<b>149</b>
	Pattern of succession	150
	Species diversity and succession	152
	Types of ecological succession	152

## Chapter 5

### Biodiversity

<b>5.1</b>	<b>Levels of biodiversity</b>	<b>161</b>
<b>5.2</b>	<b>Gradients and Magnitude of biodiversity</b>	<b>162</b>
	Gradients of biodiversity	162
	Magnitude of biodiversity	163
	Biodiversity of India	164
<b>5.3</b>	<b>Uses of biodiversity</b>	<b>164</b>
<b>5.4</b>	<b>Threats to biodiversity</b>	<b>166</b>
<b>5.5</b>	<b>Extinction of species</b>	<b>168</b>
<b>5.6</b>	<b>IUCN Red List categories and criteria</b>	<b>170</b>
<b>5.7</b>	<b>Conservation of biodiversity</b>	<b>174</b>
	Biodiversity Hotspots	175

Flagship and Umbrella species 175

## **5.8 Protected Areas of India 177**

National parks 178

Wildlife sanctuary 178

Conservation reserves and Community reserves 178

Marine protected areas 178

Biosphere reserves 178

Sacred groves 181

## **5.9 Biodiversity conservation: International and National efforts 181**

International conservation strategies 181

Convention on Biological diversity 181

CITES 181

World Heritage Convention (WHC) 182

Convention on the Conservation of Migratory Species of Wild Animals 182

International Treaty on Plant Genetic Resources for Food and Agriculture 182

Convention on Wetlands (Ramsar Convention) 182

International Plant Protection Convention (IPPC) 183

National conservation strategies 184

Biological Diversity Act 184

Wildlife (Protection) Act 184

Project Tiger and Project Elephant 185

National Wildlife Action Plan 185

Forest Conservation Act 186

## **5.10 Biogeographic classification of India 186**

# Chapter 6

## Pollution

### **6.1 Air pollution 191**

6.1.1 Composition of air 191

6.1.2 Sources of air pollution 192

6.1.3 Types of air pollutants 192

6.1.4 Criteria air pollutants 193

Carbon monoxide 193

Ozone 194

Oxides of nitrogen 195

Particulate matter 196

Oxides of sulfur 196

Lead 197



6.1.5	Effects of air pollution	197
	Effect on human health	197
	Effect on plants	197
	Loss of biodiversity	197
	Acid rain	198
	Eutrophication	198
	Ozone depletion	198
	Greenhouse effect and Global warming	198
	Climate change	199
6.1.6	Air quality standards	199
	Ambient Air Quality Standards in India	199
	WHO air quality guidelines	201
	Air Quality Index	201
	National Air Quality Monitoring Programme	202
6.1.7	Indoor air pollution	202
6.1.8	Acid rain	203
6.1.9	Control of air pollution	204
6.1.10	Noise pollution	208
<b>6.2</b>	<b>Water pollution</b>	<b>209</b>
6.2.1	Causes of water pollution	210
6.2.2	Types of water pollutants	211
6.2.3	Indicators of water pollution	211
6.2.4	Groundwater pollution	212
6.2.5	Water quality indicators	213
6.2.6	Water quality standards	216
6.2.7	Effects of water pollution	218
6.2.8	Control of water pollution	219
6.2.9	Wastewater treatment	220
6.2.10	Bioaccumulation, bioconcentration and biomagnification	224
<b>6.3</b>	<b>Soil pollution</b>	<b>224</b>
<b>6.4</b>	<b>Solid waste management</b>	<b>225</b>
	Hazardous waste treatment	226
	Solid waste management	227
<b>6.5</b>	<b>Bioremediation</b>	<b>230</b>
	Bioremediation strategies	230
	Advantages of bioremediation	231
	Phytoremediation	231
<b>6.6</b>	<b>Bioindicator</b>	<b>232</b>
	Well-studied	234
<b>6.7</b>	<b>Environmental Impact Assessment</b>	<b>234</b>

## Chapter 7

# Climate Change

<b>7.1</b>	<b>Climate change</b>	<b>241</b>
	Climate change and Global warming	243
	Climate change: Evidence	243
<b>7.2</b>	<b>Greenhouse effect</b>	<b>244</b>
	Greenhouse gases	245
	Global-warming potential of greenhouse gases	246
	Increase in greenhouse gas concentrations	247
<b>7.3</b>	<b>Global warming</b>	<b>249</b>
<b>7.4</b>	<b>Climate change: Impacts</b>	<b>250</b>
<b>7.5</b>	<b>Responding to climate change</b>	<b>252</b>
<b>7.6</b>	<b>Earth Summit</b>	<b>253</b>
	Rio Conventions	253
	Kyoto protocol	254
	Doha Amendment	255
	Copenhagen Accord	256
	Paris Agreement	256
<b>7.7</b>	<b>Stratospheric ozone</b>	<b>257</b>
	Stratospheric ozone formation	257
	Stratospheric ozone depletion	258
	Ozone depletion potential	259
	Antarctic ozone hole	261
	Arctic ozone hole	262
	Montreal Protocol	263
	Progress after Montreal Protocol	264
<b>7.8</b>	<b>Environmental Laws in India</b>	<b>265</b>
	Forest and Biodiversity	266
	Environment and Pollution	266
<b>7.9</b>	<b>Environmental footprints</b>	<b>268</b>
	Carbon footprint	268
	Nitrogen footprint	269
	Water footprint	270
	Ecological footprint	270
	Index	274

## 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

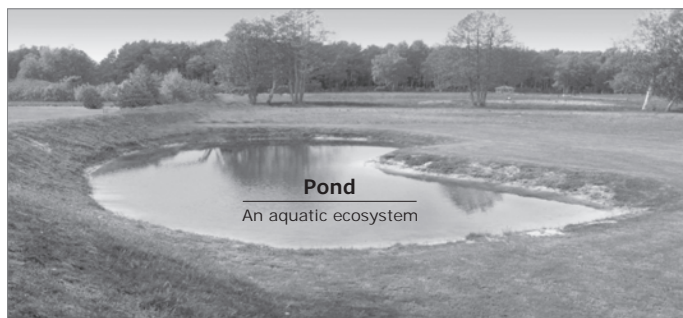
The process of soil formation includes the formation of unconsolidated materials by the weathering process and the soil profile development. Weathering refers to the **physical disintegration** and **chemical decomposition** of the rocks and minerals contained in them. Physical disintegration breaks 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.

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**.

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.

## 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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# Contents

## Section – A

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### Chapter-wise distribution of questions

#### Chapter 1

#### Biomolecules and Metabolism

##### Unit I Amino acids and Proteins 1

Amino acids and Peptides 1

Protein structure 7

Globular and Fibrous proteins 10

Protein techniques 15

Protein sequencing 20

Amino acid metabolism 22

##### Unit II Nucleic Acids 23

Nucleosides and Nucleotides 23

Nucleic acids 24

DNA 27

RNA 30

Electrophoresis and Sequencing 32

Nucleotide metabolism 33

##### Unit III Carbohydrates and Lipids 34

Monosaccharides and Disaccharides 34

Polysaccharides 37

Glycogenesis, Glycogenolysis & Gluconeogenesis 38

Lipids 40

Fatty acids 40

Triacylglycerol, Phospholipid and Glycolipid 41

Cholesterol and Lipoproteins 43

Fatty acid metabolism 45

Cholesterol metabolism 46

##### Unit IV Enzymes and Vitamins 47

Enzymes: General features 47

Enzyme kinetics 50

Enzymatic inhibition 53

Regulatory enzymes 55

Enzymatic reactions 56

Vitamins 57

#### Chapter 2

#### Cell Biology

##### Unit I Cell Structure and Function 59

Eukaryotic cell: Structure and function 59

Plasma membrane: Structure and transport 60

Membrane transport 63

Membrane potential 66

Endoplasmic reticulum 68

Golgi complex 70

Lysosome 72

Protein targeting 74

Cytoskeleton and Motility 78

Extracellular matrix and Cell junctions 83

Mitochondria and Chloroplast 85

Peroxisomes 87

Nucleus 88

**Unit II Cell signaling, Cell cycle and Cancer 92**

Cell signaling 92

Cell cycle and Cell division 97

Cancer 103

**Chapter 3****Plant Physiology****Unit I Respiration 115**

Glycolysis and Fermentation 115

Krebs cycle 117

Oxidative phosphorylation 119

Pentose phosphate pathway 123

**Unit II Photosynthesis 124**

Photosynthesis: General features 124

Light reactions 128

Calvin cycle 132

Photorespiration,  $C_4$  and CAM pathway 134

Transport of photoassimilate 138

**Unit III Transport, Mineral nutrition and Plant growth 140**

Transport of minerals and water 140

Transpiration 144

Plant nutrition 146

Plant hormones 148

Photomorphogenesis and Vernalization 152

Seed physiology 154

Plant movements 154

**Chapter 4****Human Physiology**

Nervous system 156

Sense organs 159

Blood vascular system 160

Respiratory system 162

Excretory system 163

Digestive system 165

Reproductive system 166

Endocrine system 167

**Chapter 5****Genetics****Unit I Classical Genetics 172**

Mendel's principle 172

Sex determination and Sex-linked inheritance 177

Quantitative inheritance 181

Cytogenetics 182

**Unit II Molecular Genetics 185**

DNA replication 185

Genome complexity 193

Transposable elements 194

Satellite DNA 195

Gene families 197

Transcription 198

RNA processing 204

Prokaryotic gene regulation 209

*lac* operon 209*trp* operon 213

Eukaryotic gene regulation 214

Genetic switch 216

DNA binding motifs 217

Genetic code 219

Ribosomes and tRNAs 221

Protein synthesis 222

DNA recombination 229

DNA repair 230

Gene mutation 232

**Chapter 6****Recombinant DNA technology**

Enzymes 243

Vector 247

DNA cloning 249

PCR	250
Protein expression	252
DNA library	253
Engineering plants and animals	254
Sequencing/Blotting/Electrophoresis/Labelling	256
Applications of recombinant DNA technology	258

## Chapter 7

### Prokaryotes and Viruses

Bacterial cell structure	261
Bacterial growth and Cultivation	263
Bacterial groups	265
Archaea	267
Bacterial genome	268
Gene transfer and recombination	269
Toxins	271
Virus	273
Viroids and Prions	277
Antibiotics	277
Miscellaneous	278

## Chapter 8

### Immunology

Innate and Adaptive immune response	280
Adaptive immunity	281
Cells and organs of the immune system	282
Antigens	284
MHC and Antigen presentation	285
Antibodies: Structure and Function	287
Organization and Expression of Ig genes	292
Antigen-antibody interactions: Principles and applications	293
B-cell: Generation, activation, differentiation and Response	295
T-cell: Maturation, activation, differentiation and Response	296
Cytokines and Complement system	298

Hypersensitivity and Autoimmunity	299
Vaccine	300

## Chapter 9

### Diversity of Life

Taxonomy	301
Monera	302
Protists	303
Fungi	304
Animals	305
Plants	308
Anatomy of angiospermic plants	309
Reproduction in angiosperms	311

## Chapter 10

### Ecology and Evolution

#### Unit I Ecology 314

Ecosystem	314
Biotic community and Succession	317
Population ecology	320
Biodiversity	322

#### Unit II Evolution 323

Population genetics	329
---------------------	-----

#### Answers of section - A 331



## Section – B

---

### Unit-wise distribution of questions

Unit 1	<b>Molecules and their interactions relevant to biology</b> <i>Answer-key</i>	356–374
Unit 2	<b>Cellular organization</b> <i>Answer-key</i>	375–399
Unit 3	<b>Molecular Genetics</b> <i>Answer-key</i>	400–431
Unit 4	<b>Cell signaling and Immunology</b> <i>Answer-key</i>	432–450
Unit 5	<b>Developmental Biology</b> <i>Answer-key</i>	451–470
Unit 6	<b>System Physiology – Plant</b> <i>Answer-key</i>	471–495
Unit 7	<b>System Physiology – Animal</b> <i>Answer-key</i>	496–517
Unit 8	<b>Inheritance Biology</b> <i>Answer-key</i>	518–546
Unit 9	<b>Diversity, Ecology and Evolution</b> <i>Answer-key</i>	547–591
Unit 10	<b>Biotechnology and Biophysical techniques</b> <i>Answer-key</i>	592–621

## Section – C

---

### Chemistry in Biology

Chemical context of Life	622–624
pH and Buffer	624–626
Bioenergenetics and Thermodynamics	626–628
<i>Answer-key</i>	

# Chapter 1

## 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 hydrophathy 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  $1.75 \times 10^{-5}$  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  $\text{H}_2\text{O}$  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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# Contents

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## **CSIR-JRF-NET | Previous Year's Solved Papers**

June 2013	1–25
December 2013	26–51
June 2014	52–77
December 2014	78–103
June 2015	104–129
December 2015	130–155
June 2016	156–181
December 2016	182–208
June 2017	209–236
December 2017	237–266
June 2018	267–295
December 2018	296–324
June 2019	325–354
December 2019	355–385
June 2020 (Shift-1)	386–418
June 2020 (Shift-2)	419–448
June 2021 (Shift-1)	449–481
June 2021 (Shift-2)	482–516
June 2022 (Shift-1)	517–550
June 2022 (Shift-2)	551–582
June 2023 (Shift-1)	583–618
June 2023 (Shift-2)	619–654
December 2023 (Shift-1)	655–688
December 2023 (Shift-2)	689–723

## Syllabus : CSIR–JRF–NET

- Unit 1**     Molecules and their interactions relevant to Biology
- Unit 2**     Cellular Organization
- Unit 3**     Fundamental Processes
- Unit 4**     Cell Communication and Cell signaling
- Unit 5**     Developmental Biology
- Unit 6**     System Physiology : Plant
- Unit 7**     System Physiology : Animal
- Unit 8**     Inheritance Biology
- Unit 9**     Diversity of Life forms
- Unit 10**   Ecological Principles
- Unit 11**   Evolution and Behaviour
- Unit 12**   Applied Biology
- Unit 13**   Methods in Biology

# 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 versus 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.**

**B.**

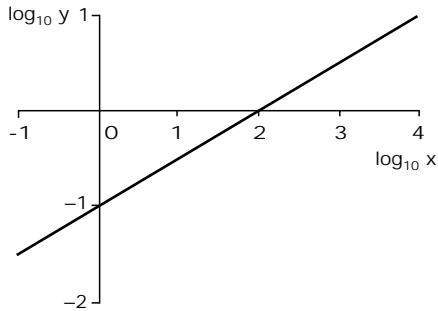
**C.**

**D.**
- 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.  $26 \times 25 \times 10 \times 9 \times 8 \times 7$                                       b.  $26 \times 26 \times 10 \times 10 \times 10 \times 10$   
 c.  $(26 \times 25 \times 24 \times 23 \times 10 \times 9)/(4 \times 3 \times 2 \times 2)$     d.  $26 \times 25 \times 24 \times 23 \times 10 \times 9$
004. In a grid puzzle, each row and column in the  $9 \times 9$  grid, as well as each  $3 \times 3$  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.  $\log y = (\log x)/2 + 1$

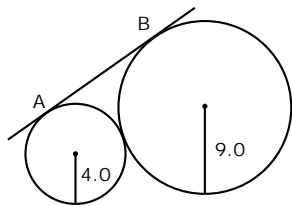
002. Starting at the same time policewomen A and B chase thief T. They all run in the same direction at constant speeds. A runs twice as fast and B thrice as fast as T. If A and B catch up with T at the same time, B must have started

- a. half as far behind T as A did  
b.  $1\frac{1}{2}$  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?

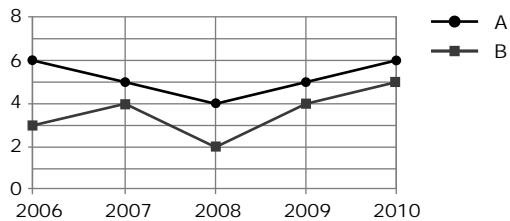
- a. A is the engineer      b. B is the lawyer      c. C is the teacher      d. D is not the doctor

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.

CSIR-UGC-NET

# General Aptitude

Theory and Practice

Solved Papers with Topic-wise Segregation

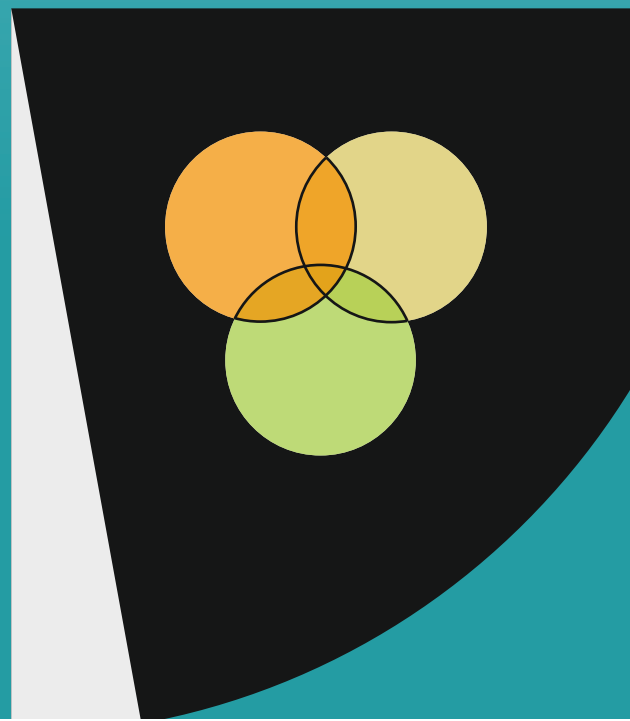
Life Sciences

Earth Sciences

Physical Sciences

Chemical Sciences

Mathematical Sciences



Ram Mohan Pandey

# General Aptitude

Theory and Practice

Solved Papers with Topic-wise Segregation

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M.Sc. (Mathematics),  
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**Pathfinder** Publication

New Delhi, India

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# Contents

## Unit 1

### Numerical Ability

- 1.1 Number System 01
- 1.2 Ratio and Proportion 33
- 1.3 Mixtures and Alligation 39
- 1.4 Average 45
- 1.5 Percentage 50
- 1.6 Profit and Loss 57
- 1.7 Time, Speed and Distance 63
- 1.8 Trains 72
- 1.9 Boats and Streams 77
- 1.10 Time and Work 81
- 1.11 Venn Diagram 88

## Unit 2

### Modern Maths

- 2.1 Permutations and Combinations 95
- 2.2 Probability 105
- 2.3 Functions and Graphs 116
- 2.4 Logarithms 128
- 2.5 Algebra 131
- 2.6 Statistics 141

## Unit 3

### Data Interpretation

- 3.1 Pie charts 147
- 3.2 Bar graph 154
- 3.3 Line graphs 160

## Unit 4

### Geometry and Mensuration

- 4.1 Lines and Angles 179
- 4.2 Triangles 189
- 4.3 Quadrilaterals 202
- 4.4 Circles 211
- 4.5 Polygons 225
- 4.6 Coordinate Geometry 231
- 4.7 Mensuration 240

## Unit 5

### Logical Reasoning

- 5.1 Blood Relations 255
- 5.2 Calendar 259
- 5.3 Clock 264
- 5.4 Coding-Decoding 271
- 5.5 Direction Sense 275
- 5.6 Logical Puzzles 281
- 5.7 Missing terms 294
- 5.8 Number Series 304
- 5.9 Syllogism 308
- 5.10 True/False Logic 316

### Previous Year's Question Papers with Solutions

01.	Dec - 2012	Life Science, Physical Science, Earth Science	323
02.	Dec - 2012	Mathematical Science, Chemical Science	329
03.	June - 2013	Life Science, Mathematical Science, Earth Science	335
04.	June - 2013	Chemical Science, Physical Science	340
05.	Dec - 2013	Life Science, Mathematical Science, Earth Science	345
06.	Dec - 2013	Chemical Science, Physical Science	352
07.	June - 2014	Life Science, Mathematical Science, Earth Science	357
08.	June - 2014	Chemical Science, Physical Science	363
09.	Dec - 2014	Life Science, Mathematical Science, Earth Science	369
10.	Dec - 2014	Chemical Science, Physical Science	376
11.	June - 2015	Life Science, Mathematical Science, Earth Science	381
12.	June - 2015	Chemical Science, Physical Science	388
13.	Dec - 2015	Life Science, Physical Science	394
14.	Dec - 2015	Mathematical Science, Chemical Science, Earth Science	400
15.	June - 2016	Life science, Physical Science	406
16.	June - 2016	Mathematical Science, Chemical Science, Earth Science	410
17.	Dec - 2016	Life Science, Physical Science	416
18.	Dec - 2016	Mathematical Science, Chemical Science, Earth Science	421
19.	June - 2017	Life Science, Physical Science	427
20.	June - 2017	Mathematical Science, Chemical Science, Earth Science	431
21.	Dec - 2017	Life Science, Physical Science	436
22.	Dec - 2017	Mathematical Science, Chemical Science, Earth Science	441
23.	June - 2018	Life Science, Physical Science	447
24.	June - 2018	Mathematical Science, Chemical Science, Earth Science	452
25.	Dec - 2018	Life Science, Physical Science	458
26.	Dec - 2018	Mathematical Science, Chemical Science, Earth Science	464
27.	June - 2019	Life Science, Physical Science	469
28.	June - 2019	Mathematical Science, Chemical Science, Earth science	475
29.	Dec - 2019	Life Science, Physical Science, Earth Science	480
30.	Dec - 2019	Mathematical Science, Chemical Science	485
31.	June - 2020	Earth Science	491
32.	June - 2020	Life Science (Shift - 1)	497
33.	June - 2020	Chemical Science (Shift - 1)	502
34.	June - 2020	Chemical Science (Shift - 1)	507
35.	June - 2020	Life Science (Shift - 2)	512
36.	June - 2020	Mathematical Science (Shift - 2)	517
37.	June - 2020	Mathematical Science (Shift - 2)	522
38.	June - 2020	Physical Science	526

# Unit 1

## Numerical Ability

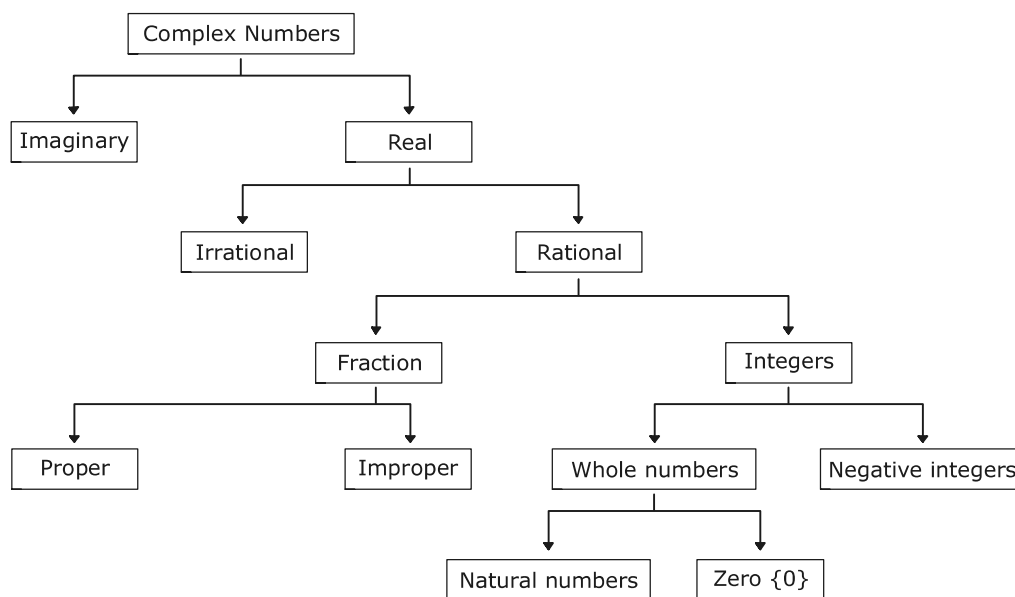
### 1.1 Number System

#### 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.

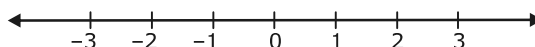
#### Classification of numbers

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  $\times r!$ , where  $r$  is the number of objects in each group  
 $= (3 \times 2)! = 3 \times 2 \times 1 = 6$ .

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.

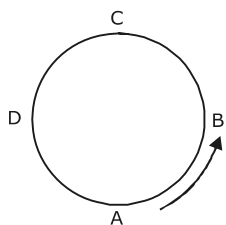
$$\text{So, } {}^n P_r = \frac{n!}{(n-r)!}$$

For example, the symbol  ${}^6 P_3$  will denote the number of permutations or arrangements of 6 different things taken 3 at a time.

$$\text{So, } {}^6 P_3 = \frac{6!}{(6-3)!} = \frac{6!}{3!} = \frac{6 \times 5 \times 4 \times 3 \times 2 \times 1}{3 \times 2 \times 1} = 120$$

#### 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  $360^\circ$  that represents 100% of the value.

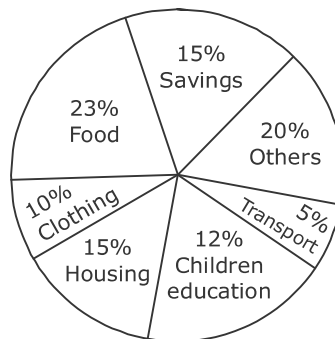
Hence, we have

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

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 = Rs.  $\left(\frac{12}{100} \times 75000\right)$  = 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.



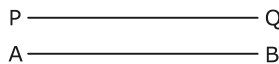
**Ray:** A line with one end point is called a ray. The end point is called the origin.



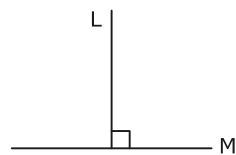
**Line segment:** A line with two end points is called a segment.



**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  $PQ \parallel AB$ .



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



We denote it by  $L \perp M$ .

#### 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  $90^\circ$  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's daughter	Niece
Sister's husband	Brother-in-law
Brother's wife	Sister-in-law
Grandson's or Grand daughter's daughter	Great grand daughter