

National Curriculum of Pakistan 2026

BIOLOGY

Grades 9-12



NATIONAL CURRICULUM COUNCIL WING
MINISTRY OF FEDERAL EDUCATION AND
PROFESSIONAL TRAINING, ISLAMABAD
GOVERNMENT OF PAKISTAN



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Acknowledgement

It is with great pride that the National Curriculum Council Wing, Ministry of Federal Education and Professional Training, presents the Rationalised National Curriculum 2026 for Biology (Grades IX–XII). Building on the National Curriculum 2022–23, this revision streamlines content to improve coherence, reduce unnecessary overlap, and strengthen conceptual understanding while aligning with national priorities and international standards.

Developed through a consultative, evidence-based process involving subject experts, universities, provincial education departments, textbook boards, assessment bodies, teacher education institutions, and practitioners, the curriculum promotes inquiry-based learning, scientific reasoning, practical application, and meaningful assessment.

The National Curriculum Council Wing sincerely acknowledges the invaluable contributions of all stakeholders whose expertise and commitment have made this rationalisation process possible. Their collective efforts have ensured a curriculum that is relevant, manageable, competency-based, and future-ready for the learners of Pakistan.

Dr. Tabassum Naz

Director

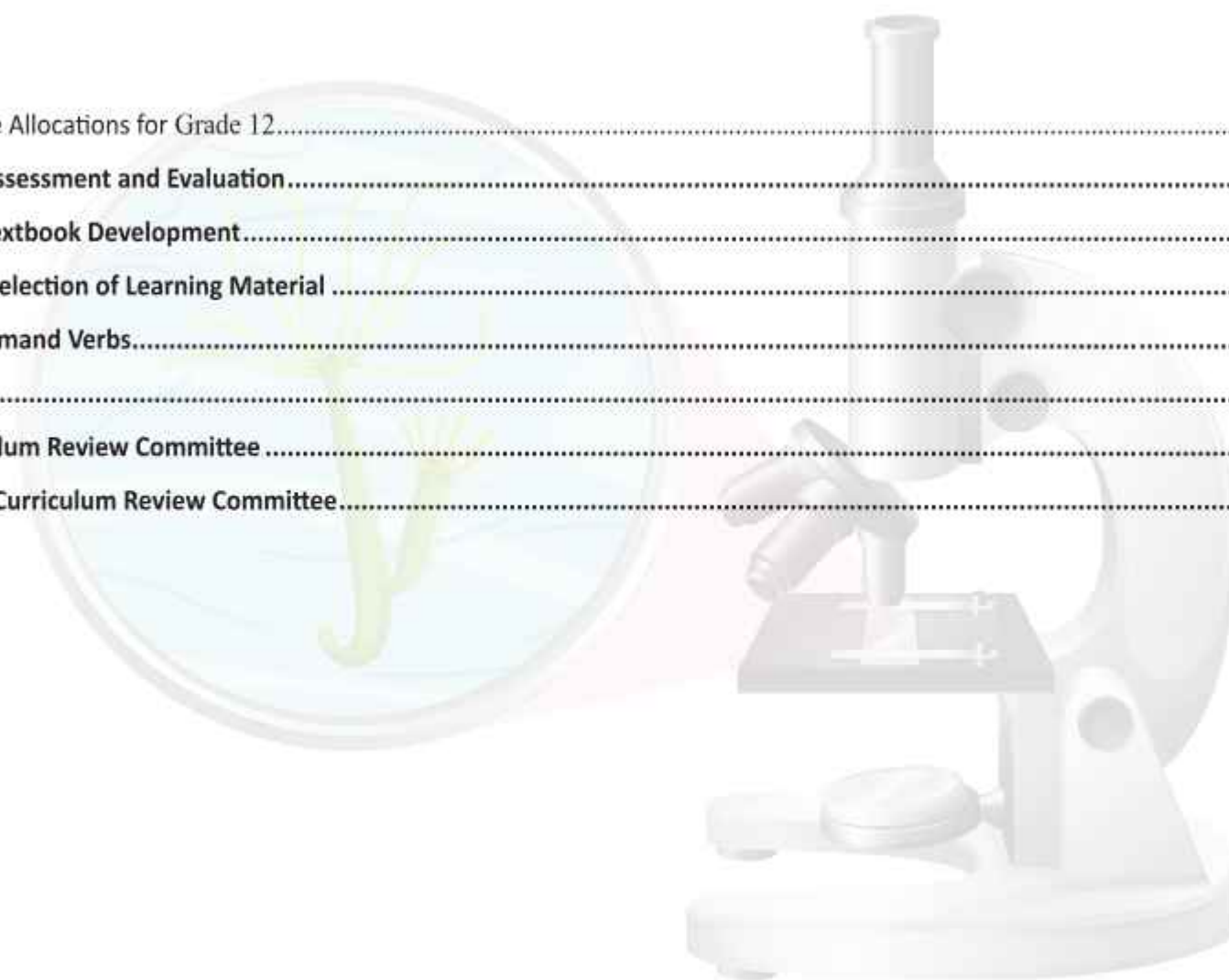
National Curriculum Council Wing

Ministry of Federal Education and Professional Training

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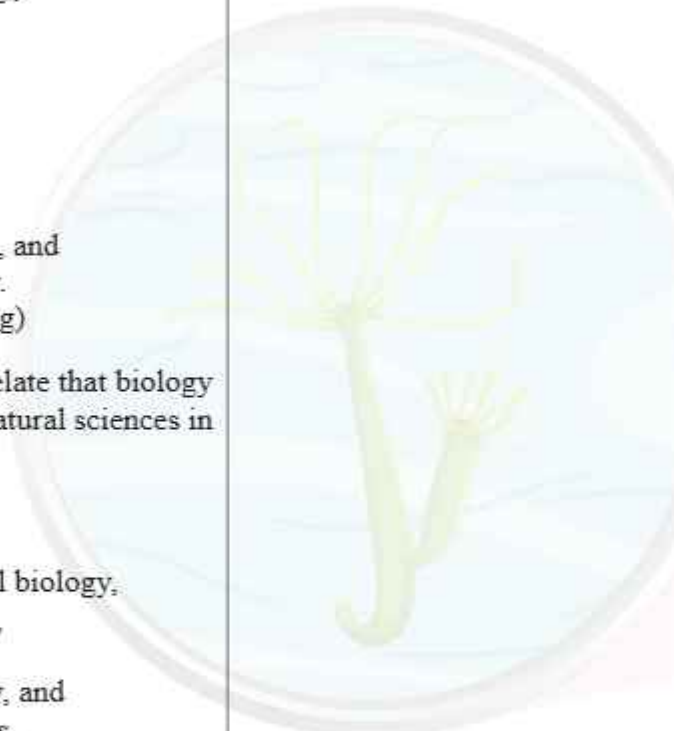
Progression Grid

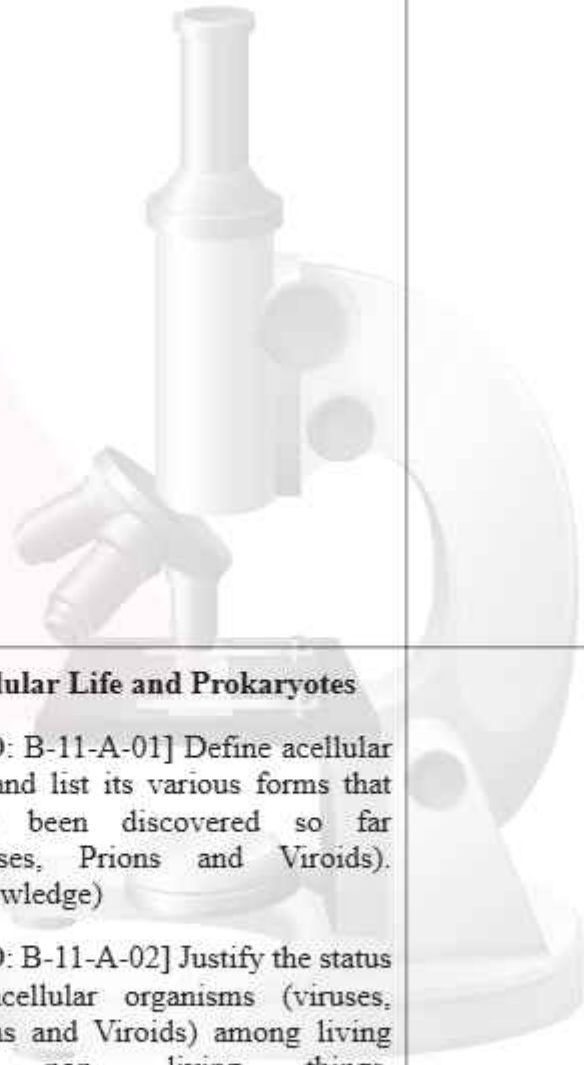
The national Curriculum of Pakistan for Biology (Grades 9-12) is organized through a hierarchical framework that moves from broad academic aspirations to specific classroom achievements. To maintain this focus on active mastery, every level of this hierarchy is framed as an action-oriented goal, beginning with the foundational phrase, "Students will be able to..." This ensures that the curriculum remains a roadmap for what students can do and understand, rather than a mere list of content to be covered.

Curriculum Architecture

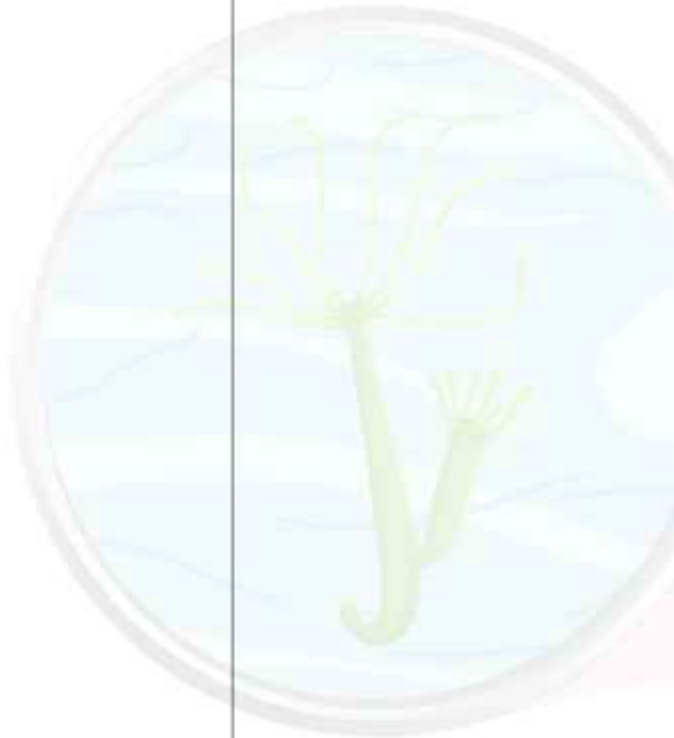
1. **Domain:** A broad, high-level category that organizes the vast body of knowledge into manageable, thematic clusters. Domains are non-prescriptive and represent the "Big Ideas" of the subject.
2. **Standard:** A definitive statement of what students should know and be able to do in a domain at the end of a multi-year educational cycle (e.g., from Grade 9 to 12).
3. **Benchmark:** A developmental milestone that translates a Standard into age-appropriate expectations for specific grade clusters (e.g., up to Grade 10 vs. up to Grade 12). Benchmarks differentiate the breadth and depth of a topic as a student matures cognitively.
4. **Student Learning Outcome (SLO):** A specific, measurable, and observable statement that describes exactly what a student will know and be able to do at the conclusion of a particular lesson. SLOs are the "building blocks" that allow a student to eventually reach a Benchmark and, ultimately, a Standard. The learning depth of each SLO is defined with these headers:
 - a. **Knowledge:** It is the foundational layer. It is the ability to remember and recognize specific facts, scientific terms, and structural components. Such SLOs often begin with verbs like *Identify, List, Name, Recall, State, Define etc.*
 - b. **Understanding:** This moves beyond rote memory to making sense of the information. It is the ability to understand and interpret the meaning of scientific processes. This also includes the ability to analyze information. These SLOs often begin with verbs like *Describe, Explain, Summarize, Distinguish, Paraphrase, Compare, Contrast, and Differentiate.*
 - c. **Application:** This is where students use their learning to produce results or make judgments. It is the ability to apply procedures or concepts. This includes the ability to evaluate and create new ways to represent data or solve problems. These SLOs often begin with verbs like *Create, Draw, Calculate, Demonstrate, Solve, Use, Check, Critique, Judge, Justify, Construct (graphs), and Design.*

Grade 9	Grade 10	Grade 11	Grade 12
Domain A: Nature of Biology and Classification			
Standards: • Evaluate biology as a multi-disciplinary field, apply the scientific method and biostatistical tools to investigate life. • Analyze the diversity of life including acellular, prokaryotic, and eukaryotic entities by applying taxonomic principles.			
Benchmarks: 1. Critically analyze the intersection of biology with other disciplines. 2. Apply the scientific method to design experiments and interpret biological data. 3. Identify the diagnostic features of major groups on the basis of the Three-Domain and Five-Kingdom systems.		Benchmarks: 1. Evaluate the molecular and structural complexity of acellular life. 2. Analyze diversity in prokaryotes, protist and fungi. 3. Analyze the comparative life cycles of the plant divisions. 4. Comprehend the diagnostic features of major animal groups.	
Introduction to Biology [SLO: B-09-A-01] Define biology. (Knowledge) [SLO: B-09-A-02] State that the Holy Quran instructs to reveal the study of life by referring up to 05 verses. (Knowledge) [SLO: B-09-A-03] Define major fields of biology as botany, zoology and microbiology. (Knowledge) [SLO: B-09-A-04] Define with examples that biology has many sub-fields i.e., - Cytology, - Embryology, - Genetics, - Molecular biology.			

Grade 9	Grade 10	Grade 11	Grade 12
- Pathology, - Ecology, - Marine biology, - Immunology, - Morphology, - Anatomy, - Histology, - Physiology, - Taxonomy, - Palaeontology, and - Pharmacology. (Understanding) [SLO: B-09-A-05] Relate that biology connects with other natural sciences in terms of, - Biophysics, - Biochemistry, - Computational biology, - Biogeography, - Biostatistics, - Biotechnology, and - Bio-economics. (Understanding) [SLO: B-09-A-06] Describe the steps of scientific method i.e., - Recognition of a scientific problem, - Observation and building up hypotheses, - Drawing deductions, - Devising experiments. and			

Grade 9	Grade 10	Grade 11	Grade 12
- Inferring results. (Understanding) [SLO: B-09-A-07] Evaluate the terms 'hypothesis', 'theory' and 'law' in the context of research in the Biological Sciences (Malaria). (Application) [SLO: B-10-A-08] Define biostatistics and demonstrate its uses (any five). (Knowledge, Application) [SLO: B-09-A-09] Define and calculate mean, median and mode. (Understanding, Application) [SLO: B-09-A-10] Sketch a bar chart for a given set of biological data. (Application)			
Classification [SLO: B-09-A-11] Define biodiversity and classification. (Knowledge) [SLO: B-09-A-12] Describe advantages of classification (any four). (Understanding) [SLO: B-09-A-13] Explain and compare the three domains into which living organisms are broadly classified. (Application)		Acellular Life and Prokaryotes [SLO: B-11-A-01] Define acellular life and list its various forms that have been discovered so far (viruses, Prions and Viroids). (Knowledge) [SLO: B-11-A-02] Justify the status of acellular organisms (viruses, Prions and Viroids) among living and non-living things. (Understanding)	

Grade 9	Grade 10	Grade 11	Grade 12
[SLO: B-09-A-14] Discuss the five-kingdom system of classification with salient features and examples of each kingdom. (Understanding) [SLO: B-09-A-15] Describe the ranks (taxa) of classification with examples of Human and Pea and define species. (Understanding) [SLO: B-09-A-16] Outline rules and significance of binomial nomenclature and give examples of pea, wheat, potato, human, frog, domestic cat. (Understanding) [SLO: B-09-A-17] Describe the main features of virus and the complications of classifying viruses. (Understanding)		[SLO: B-11-A-03] Classify viruses on the bases of their hosts and structure. (Understanding) [SLO: B-11-A-04] Describe the structure of a model virus (bacteriophage). (Understanding) [SLO: B-11-A-05] Describe the Lytic and Lysogenic life cycles of bacteriophage. (Understanding) [SLO: B-11-A-06] Justify why bacteriophage shift from lysogenic to lytic cycle. (Understanding) [SLO: B-11-A-07] Describe structure of Human Immunodeficiency Virus (HIV) and explain its life cycle in helper T-cells. (Understanding) [SLO: B-11-A-08] Describe the structure of prions and viroids and list the diseases caused by them. (Understanding) [SLO: B-11-A-09] List and classify the symptoms of AIDS into asymptomatic carrier stage, AIDS related complex stage and Full-blown AIDS stage. (Understanding, Application)	

Grade 9	Grade 10	Grade 11	Grade 12
		[SLO: B-11-A-10] How to apply some common preventive control measures to avoid the transmission of HIV. (Application) [SLO: B-11-A-11] Discuss useful aspects of viruses i.e., as targeted drug delivery vehicle and vaccine preparation. (Application) [SLO: B-11-A-12] Describe the classification of organisms according to the three-domain system proposed by Carl Woese. (Understanding) [SLO: B-11-A-13] Outline the taxonomic position of prokaryotes in terms of domains archaea and bacteria and in terms of kingdom Monera. (Understanding) [SLO: B-11-A-14] Compare the characteristics of domain archaea and domain bacteria. (Application) [SLO: B-11-A-15] Describe and illustrate the detailed structure (cell membrane, cytoplasm, ribosome, bacterial chromosome, plasmid, mesosome, pili and fimbriae) and shapes of a generalized prokaryotic cell. (Understanding, Application)	

Grade 9	Grade 10	Grade 11	Grade 12
		[SLO: B-11-A-16] Describe detailed structure and chemical composition of bacterial cell wall and other coverings (capsule and slime) also compare Gram-positive and Gram-negative cell wall. (Understanding, Application) [SLO: B-11-A-17] Justify the endospore formation in bacteria as a mechanism of survival to withstand unfavourable conditions. (Application) [SLO: B-11-A-18] Describe with diagram the structure of bacterial flagellum and compare it with eukaryotic flagella (only three points). (Understanding) [SLO: B-11-A-19] Describe the types of genetic recombination in bacteria (conjugation, transduction and translation). (Understanding, Application) [SLO: B-11-A-20] Illustrate binary fission in bacteria and narrate and sketch the phases in the growth in bacteria. (Understanding) [SLO: B-11-A-21] Classify bacteria on the basis of methods of obtaining	

Grade 9	Grade 10	Grade 11	Grade 12
		energy and carbon (autotrophic and heterotrophic). (Understanding). [SLO: B-11-A-22] Compare the photosynthesis mechanisms in cyanobacteria and other photosynthetic bacteria. (Understanding, Application) Protists and Fungi [SLO: B-11-A-23] Describe the salient features with examples of protists (protozoa, algae, Myxomycota and Oomycota) without further classification. (Understanding) [SLO: B-11-A-24] Justify how protists are important for humans. (Application) [SLO: B-11-A-25] Outline the characteristics of fungi and classify fungi into Zygomycota, Ascomycota, Deuteromycota and Basidiomycota and give the diagnostic features of each group. (Understanding) [SLO: B-11-A-26] Describe and illustrate the life cycle of mushroom (Agaricus). (Understanding)	

Grade 9	Grade 10	Grade 11	Grade 12
		[SLO: B-11-A-27] Describe the ecological importance and pathological role of fungi. (Understanding) Diversity in Plants [SLO: B-11-A-28] Describe the distinguishing characteristics of the major divisions of kingdom plantae and outline the classification through flowchart. (Knowledge) [SLO: B-11-A-29] List diagnostic characters of bryophytes. (Knowledge) [SLO: B-11-A-30] Briefly describe the life cycle of <i>Funaria</i>. (Understanding) [SLO: B-11-A-31] State the general characteristics of pteridophytes. (Knowledge) [SLO: B-11-A-32] Describe the life cycle of ferns. (Understanding) [SLO: B-11-A-33] Briefly describe the evolution of seed habit in plants. (Understanding)	

Grade 9	Grade 10	Grade 11	Grade 12
		[SLO: B-11-A-34] List the general characteristic of gymnosperms. (Knowledge) [SLO: B-11-A-35] Describe the life cycle of Pinus. (Understanding) [SLO: B-11-A-36] Describe the general characteristic of angiosperms and classify them (up to monocots and dicots). (Understanding) Diversity in Animals [SLO: B-11-A-37] Elaborate and sketch flow sheet diagram for animal classification into phyla by using following criteria: - tissue organization - embryonic germ layers - type of body symmetry - presence/absence and types of coeloms - pattern of early embryonic development - presence or absence of vertebral column (Knowledge, Understanding) [SLO: B-11-A-38] Enlist the distinguishing characteristics of the following animal phyla;	

Grade 9	Grade 10	Grade 11	Grade 12
		- Porifera, - Cnidaria, - Platyhelminthes, - Aschelminthes, - Annelida, - Arthropoda, - Mollusca, - Echinodermata, and - Hemichordata (Knowledge, Understanding) [SLO: B-11-A-39] Enlist the distinguishing characteristics of phylum Chordata. (Knowledge) [SLO: B-11-A-40] State the salient features of the subphyla: Urochordata, Cephalochordata, and Vertebrata. (Knowledge) [SLO: B-11-A-41] Describe the diagnostic features with three examples of vertebrate classes (Pisces, Amphibia, Reptilia, Aves and Mammalia). (Knowledge).	
Domain B: Molecular Biology Standards: • Evaluate the unique properties of water as the medium of life.			

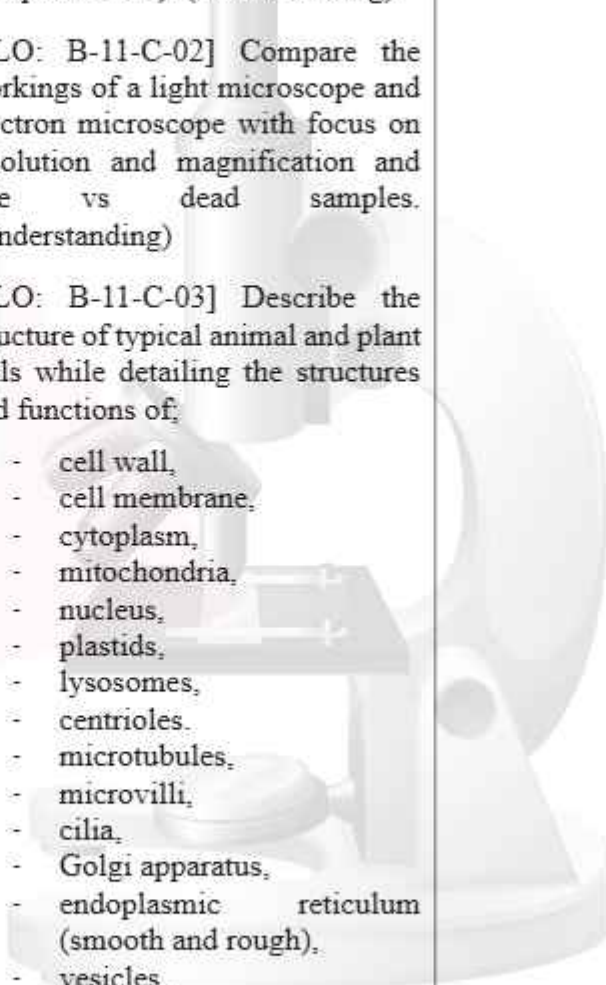
Grade 9	Grade 10	Grade 11	Grade 12
Analyze the structural organization, synthesis, and functional roles of carbohydrates, lipids, proteins, and nucleic acids.			
Benchmark: 1. Describe the basic structure, properties and roles of the four major classes of biomolecules.		Benchmark: 1. Justify the role of water as medium of life. 2. Describe in detail the structure of the four major biomolecules, their types and reactions inside cells and tissues.	
Biological Molecules [SLO: B-09-B-01] Define bio-elements (major and minor) and biological molecule (carbohydrates, lipids, proteins, DNA, RNA). (Knowledge) [SLO: B-09-B-02] Outline the structure of proteins (primary, secondary, tertiary, quaternary) and sketch the generalized structure of an amino acid. (Understanding, Application) [SLO: B-09-B-03] State the making of proteins from amino acids. (Application) [SLO: B-09-B-04] Explain the structure of triglyceride (fat /oil). (Understanding) [SLO: B-09-B-05] Classify carbohydrates as monosaccharides, disaccharides and polysaccharides			Biological Molecules [SLO: B-11-B-01] Evaluate the properties of water (high polarity, hydrogen bonding, high specific heat, high heat of vaporization, cohesion, hydrophobic exclusion, ionization and lower density of ice) which make it the medium of life. (Understanding, Application) [SLO: B-11-B-02] Define carbohydrates and classify them (as monosaccharides, disaccharides and polysaccharides). (Understanding, Application). [SLO: B-11-B-03] Define monosaccharides and classify them (with examples) on the basis of number of Carbon atoms. (Understanding, Application) [SLO: B-11-B-04] Compare the open and closed chain structures of glucose and fructose and compare the structural isomers and

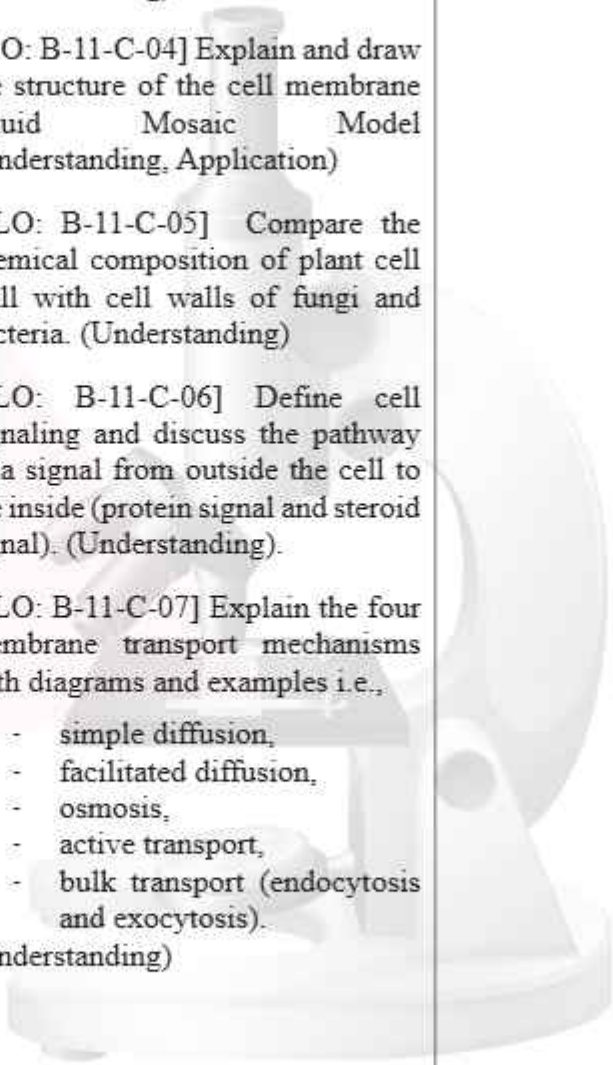
Grade 9	Grade 10	Grade 11	Grade 12
with examples (structural formulas to be excluded). (Understanding) [SLO: B-09-B-06] Describe briefly the structure of DNA as a double helix made of nucleotides (structural formulas of N-bases not required). (Understanding) [SLO: B-09-B-07] Outline function of DNA as carrier of hereditary information. (Understanding) [SLO: B-09-B-08] Describe briefly the structure of RNA as single strand made of nucleotides (structural formulas of N-bases not required). (Understanding) [SLO: B-09-B-09] Compare the structure of DNA and RNA. (Application) [SLO: B-09-B-10] Describe the chemical tests for; - starch (iodine solution), - glucose and maltose (Benedict's solution), - protein (biuret test), and - lipids (ethanol emulsion test). (Application)		stereoisomers of glucose. (Application) [SLO: B-11-B-05] Distinguish the properties and roles of disaccharides i.e., sucrose, maltose, lactose. (Understanding, Application) [SLO: B-11-B-06] Describe glycosidic bonds in disaccharides (sucrose, maltose, lactose). (Understanding) [SLO: B-11-B-07] Describe the structure, properties and roles of polysaccharides (starch, glycogen, cellulose and chitin). (Understanding, Application) [SLO: B-11-B-08] Define protein and amino acid and draw the structural formula of amino acids (Glycine and Alanine). (Knowledge, Application) [SLO: B-11-B-09] Outline the synthesis and breakage of peptide linkages. (Application) [SLO: B-11-B-10] Classify proteins as globular and fibrous proteins. (Understanding)	

Grade 9	Grade 10	Grade 11	Grade 12
		[SLO: B-11-B-11] Describe the structure of haemoglobin molecule, including the formation of its quaternary structure. (Application) [SLO: B-11-B-12] Describe the structure of collagen molecule, and their arrangement to form collagen fibers. (Application) [SLO: B-11-B-13] Justify the significance of the sequence of amino acids through the example of sickle cell haemoglobin. (Understanding/Application) [SLO: B-11-B-14] List the roles of structural proteins and functional proteins with three examples. (Knowledge) [SLO: B-11-B-15] Define lipids and describe the properties and roles of acylglycerols, phospholipids, terpenes, waxes, cholesterol, and steroids. (Knowledge, Understanding) [SLO: B-11-B-16] Illustrate the molecular structure of; - an acylglycerol, - a phospholipid, and - a terpene.	

Grade 9	Grade 10	Grade 11	Grade 12
		(Application) [SLO: B-11-B-17] Describe nucleic acids and molecular structure of nucleotides. (Understanding) [SLO: B-11-B-18] Distinguish among the nitrogenous bases found in the nucleotides of nucleic acids. (Application) [SLO: B-11-B-19] Sketch the structure of a mononucleotide (ATP) and a dinucleotide (NAD). (Application) [SLO: B-11-B-20] Illustrate the formation of phosphodiester bond. (Application) [SLO: B-11-B-21] Explain the double helical structure of DNA. (Understanding) [SLO: B-11-B-22] Explain the general structure of RNA. (Understanding) [SLO: B-11-B-23] Distinguish in terms of functions and roles, the three types of RNA. (Understanding) [SLO: B-11-B-24] Define conjugated molecules and describe	

Grade 9	Grade 10	Grade 11	Grade 12
		the roles of common conjugated molecules i.e., - Peptidoglycan - glycolipids, - glycoproteins, - lipoproteins, and - nucleoproteins. (Understanding)	
Domain C: Cell Biology Standards: 1. Analyze prokaryotic and eukaryotic cells to distinguish their structural differences and functional roles, and evaluate sub-cellular organelles of eukaryotic cells using light and electron microscopy. 2. Analyze levels of biological organization from molecules to complex organ systems, and evaluate cellular processes such as movement across membranes, cell signaling and cell reproduction.			
Benchmarks: 1. Compare the structures of prokaryotic and eukaryotic cells, and plant versus animal cells. 2. Describe the modes of material transport across the cell membrane. 3. Identify specialized cells and describe the levels of biological organization, exemplified by the adaptation of the leaf for photosynthesis. 4. Outline the cell cycle and the general stages and significance of mitosis and meiosis in producing diploid and haploid cells.		Benchmarks: 1. Evaluate the validity of the Cell Theory and analyze the detailed ultrastructure and biochemical roles of all eukaryotic organelles. 2. Compare the resolution and magnification of light and electron microscopy. 3. Justify how tissue specialization supports the organism as a whole. 4. Synthesize the complex phases of meiosis (I and II) and mitosis, evaluating their roles in genetic variation and tissue repair. 5. Investigate the unique properties of stem cells in developmental biology and medicine.	
Cells [SLO: B-09-C-01] Define a cell and describe the structures of the		Cells	

Grade 9	Grade 10	Grade 11	Grade 12
components of plant and animal cells (cell wall, cell membrane, cytoplasm, nucleus, mitochondria, chloroplast, centriole, ribosomes) and outline their roles. (Understanding) [SLO: B-09-C-02] Compare the structure of animal and plant cells with the help of diagrams. (Application) [SLO: B-09-C-03] Describe the structure of a prokaryotic cell and compare it with a general eukaryotic cell. (Understanding, Application) [SLO: B-09-C-04] Identify different types of cells (mesophyll cell, epidermal cell, neuron, muscle, red blood cell, liver cell) and sketch their structures. (Application) [SLO: B-09-C-05] State the role of the cell membrane in maintaining equilibrium while exchanging matter. (Understanding) [SLO: B-09-C-06] Define the modes of movement of molecules across cell membrane i.e., - diffusion, - facilitated diffusion, - osmosis, - filtration, - active transport,		[SLO: B-11-C-01] State cell theory (including how to validate it and exceptions to it). (Understanding) [SLO: B-11-C-02] Compare the workings of a light microscope and electron microscope with focus on resolution and magnification and live vs dead samples. (Understanding) [SLO: B-11-C-03] Describe the structure of typical animal and plant cells while detailing the structures and functions of: - cell wall, - cell membrane, - cytoplasm, - mitochondria, - nucleus, - plastids, - lysosomes, - centrioles, - microtubules, - microvilli, - cilia, - Golgi apparatus, - endoplasmic reticulum (smooth and rough), - vesicles, - peroxisome, - vacuoles, and - ribosomes.	

Grade 9	Grade 10	Grade 11	Grade 12
- endocytosis, and - exocytosis. (Knowledge) [SLO: B-09-C-07] Define turgor and describe its importance in plants. (Knowledge) [SLO: B-09-C-08] Explain the effects on cells when they are immersed in solutions of different concentrations. (Application) Levels of Organization [SLO: B-09-C-09] Describe the levels of organization of multicellular organisms from sub-cellular level to individual level with examples of each level. (Knowledge) [SLO: B-09-C-10] Distinguish between tissues, organs and organ systems with examples from animals and plants. (Understanding) [SLO: B-09-C-11] Describe the major animal tissues i.e., - epithelial tissue, - connective tissue, - muscular tissue and - nervous tissue. (Understanding)		(Understanding) SLO: B-11-C-04] Explain and draw the structure of the cell membrane (Fluid Mosaic Model) (Understanding, Application) [SLO: B-11-C-05] Compare the chemical composition of plant cell wall with cell walls of fungi and bacteria. (Understanding) [SLO: B-11-C-06] Define cell signaling and discuss the pathway of a signal from outside the cell to the inside (protein signal and steroid signal). (Understanding). [SLO: B-11-C-07] Explain the four membrane transport mechanisms with diagrams and examples i.e., - simple diffusion, - facilitated diffusion, - osmosis, - active transport, - bulk transport (endocytosis and exocytosis). (Understanding) 	

Grade 9	Grade 10	Grade 11	Grade 12
[SLO: B-09-C-12] Describe the major plant tissues i.e., - simple tissues (meristematic tissues, permanent tissues) and - compound tissues (xylem tissues and phloem tissues). (Understanding) [SLO: B-09-C-13] Identify and label the structures of a leaf, and explain how these structures are adaptations for photosynthesis and gas exchange. (Application)			
Cell Division [SLO: B-09-C-14] Briefly define the phases of cell cycle [interphase (G1, S, G2, G0) and M-Phase]. (Understanding) [SLO: B-09-C-15] Differentiate between diploid and haploid cells. (Knowledge) [SLO: B-09-C-16] Define mitosis and briefly describe its stages with labelled diagrams. (Understanding, Application) [SLO: B-09-C-17] Define meiosis and briefly describe its stages (excluding substages of prophase-I) with labelled		Cell Division [SLO: B-11-C-08] Define cell cycle and explain the phase of Interphase (G0, G1, S and G2 phases) highlighting the checkpoint between each phase. (Understanding) [SLO: B-11-C-09] Describe the phases of mitosis with diagrams. (Understanding, Application) [SLO: B-11-C-10] Describe the phases of meiosis (I and II) with diagrams. (Understanding, Application)	

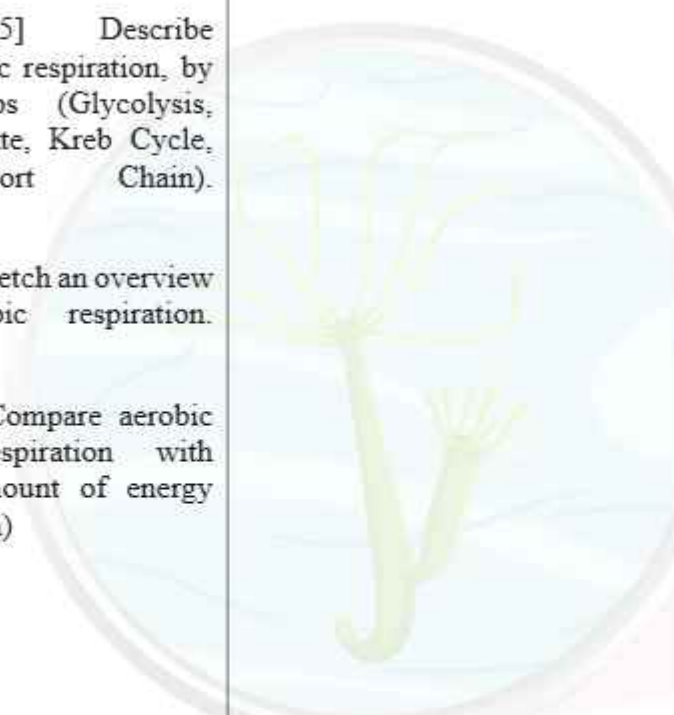
Grade 9	Grade 10	Grade 11	Grade 12
diagrams. (Understanding, Application) [SLO: B-09-C-18] Compare the processes of mitosis and meiosis. (Application) [SLO: B-09-C-19] Outline the significance of mitosis and meiosis. (Understanding) [SLO: B-09-C-20] Define stem cells as unspecialized cell. (Knowledge)		[SLO: B-11-C-11] Analyze how uncontrolled mitosis can lead to the development of tumors. (Understanding) [SLO: B-11-C-12] Explain non-disjunction of chromosome as meiotic error and its consequences. (Understanding) [SLO: B-11-C-13] Define stem cells and categorize them as totipotent, pluripotent, multipotent, oligopotent and unipotent. (Understanding) [SLO: B-11-C-14] Evaluate the advantages and disadvantages of using induced Pluripotent Stem Cells. (Application)	
Domain D: Metabolism Standards: 1. Evaluate the role of enzymes, analyzing their molecular mechanisms, classification, and the factors that regulate metabolic rate and biochemical specificity. 2. Analyze the complex pathways of photosynthesis and cellular respiration, evaluating how energy is captured and utilized via ATP, chemiosmosis, and specialized metabolic cycles.			
Benchmarks: 1. Explain the characteristics and specificity of enzymes, illustrating their mechanism of action and the impact of environmental factors on activity.		Benchmarks: 1. Analyze enzyme kinetics through the lock & key and induced-fit hypothesis and evaluate the roles of cofactors, and inhibitors	

Grade 9	Grade 10	Grade 11	Grade 12
2. Comprehend the concept of metabolism and describe the processes of photosynthesis and respiration (aerobic and anaerobic) using word and symbol equations. 3. Identify the role of chlorophyll, evaluate limiting factors in photosynthesis, and explain the physiological basis of oxygen debt and lactic acid accumulation.		2. Explain enzymatic classification and investigate the biochemical differences in enzyme optima. 3. Evaluate the stages of photosynthesis and aerobic respiration. 4. Synthesize the concept of chemiosmosis, analyze the absorption/action spectra of pigments, and compare the energy values of different respiratory substrates.	
Enzymes [SLO: B-09-D-01] Define Enzymes and describe their characteristics. (Knowledge, Understanding) [SLO: B-09-D-02] Describe the mechanism of enzyme action. (Understanding) [SLO: B-09-D-03] Assess the factors (enzyme conc., temperature, pH) which could influence enzyme activity. (Application) [SLO: B-09-D-04] Describe the specificity of different enzymes for different substrates. (Understanding)		Enzymes [SLO: B-11-D-01] Define enzymes and categorize them as intracellular and extracellular enzymes. (Understanding) [SLO: B-11-D-02] Explain the mode of action of enzymes in terms of, - the lock-and-key hypothesis, - the induced-fit hypothesis. (Understanding) [SLO: B-11-D-03] Define energy of activation and discuss through graph how an enzyme speeds up a reaction by lowering the energy of activation. (Understanding) [SLO: B-11-D-04] Define cofactors and differentiate among the three types of cofactors i.e., inorganic ions, prosthetic group and	

Grade 9	Grade 10	Grade 11	Grade 12
		coenzymes, with examples. (Understanding) [SLO: B-11-D-05] Describe enzymatic inhibition, its types (reversible and irreversible) and its significance. (Understanding) [SLO: B-11-D-06] Categorize the reversible inhibitors into competitive and non-competitive inhibitors. (Understanding) [SLO: B-11-D-07] Explain feedback inhibition with example (regulation of ATP synthesis). (Understanding, Application) [SLO: B-11-D-08] Explain the effect of temperature on the rate of enzyme action with example of human and thermophilic bacteria. (Application) [SLO: B-11-D-09] Investigate the effect of pH on enzyme activity and compare the optimum pH of different enzymes like trypsin, pepsin, papain. (Application) [SLO: B-11-D-10] Demonstrate that the concentration of enzyme affects the rate of enzyme action. (Application)	

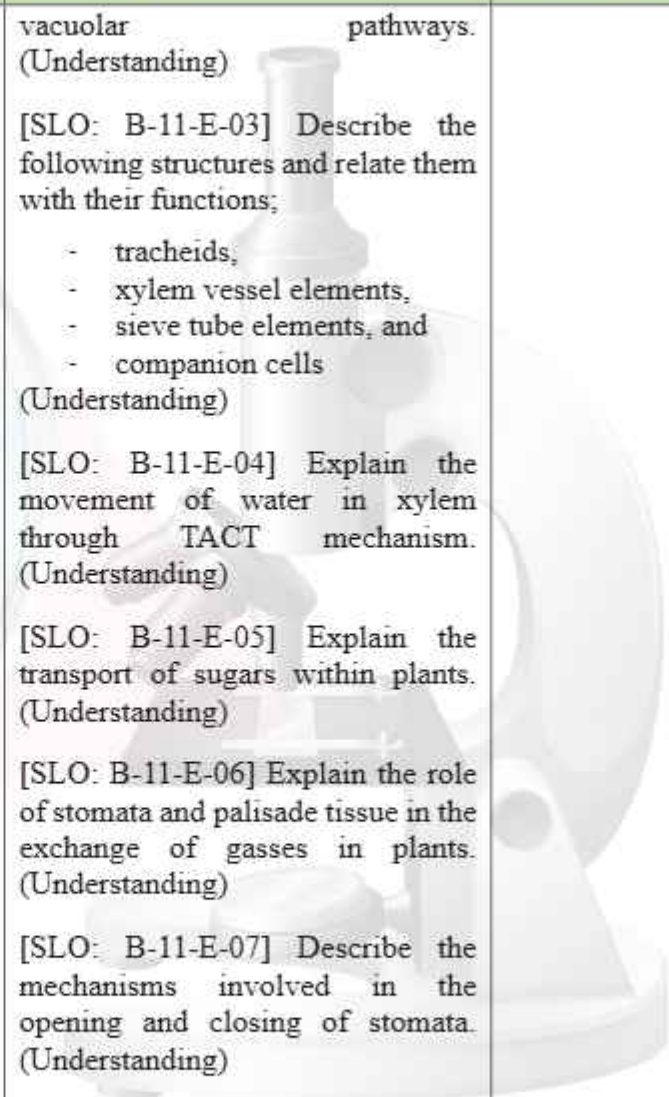
Grade 9	Grade 10	Grade 11	Grade 12
		[SLO: B-11-D-11] Classify enzymes on the basis of the reactions catalyzed i.e., - oxidoreductases, - transferases, - hydrolases, - isomerases, - ligases, and - lyases (Understanding, Application) [SLO: B-11-D-12] Classify enzymes on the basis of the substrates they use e.g., - lipases, - diastase, - amylase, - proteases. (Understanding, Application)	
Bioenergetics [SLO: B-09-D-05] Define metabolism, catabolism and anabolism with examples. (Knowledge) [SLO: B-09-D-06] Discuss the role of ATP as energy currency. (Understanding) [SLO: B-09-D-07] Define photosynthesis and explain overall		Bioenergetics [SLO: B-11-D-13] Explain the role of light, carbon dioxide and water in photosynthesis. (Understanding) [SLO: B-11-D-14] Identify the general kinds of photosynthetic pigments; - chlorophyll a, - chlorophyll b, - carotene, and	

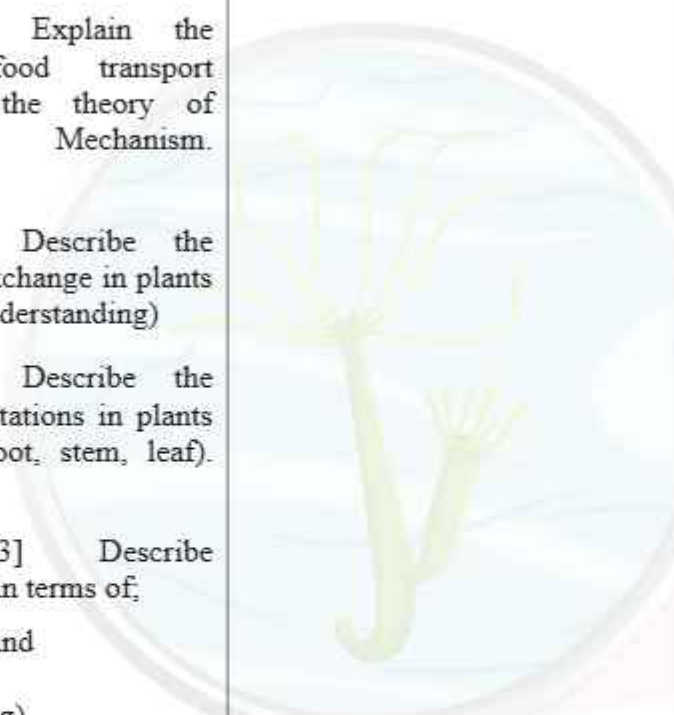
Grade 9	Grade 10	Grade 11	Grade 12
mechanism of photosynthesis. (Knowledge, Understanding) [SLO: B-09-D-08] Describe two phases of photosynthesis (light dependent and light-independent phase). (Understanding) [SLO: B-09-D-09] State the role of chlorophyll during photosynthesis. (Knowledge) [SLO: B-09-D-10] Describe the concept of limiting factors in photosynthesis. (Understanding) [SLO: B-09-D-11] Narrate the effects of following factors on the rate of photosynthesis; - light intensity, - CO₂ concentration, and - temperature. (Understanding) [SLO: B-09-D-12] Define cellular respiration and its types. (Knowledge) [SLO: B-09-D-13] Explain lactic acid fermentation and alcoholic fermentation as the types of anaerobic respiration. (Understanding) [SLO: B-09-D-14] Explain why lactic acid accumulation in muscles and		- xanthophyll. (Understanding) [SLO: B-11-D-15] Describe the roles of photosynthetic pigments in the absorption and conversion of light energy. (Understanding) [SLO: B-11-D-16] Explain and compare the absorption spectra of chlorophyll 'a', 'b' and carotenoids and action spectrum for photosynthesis. (Understanding) [SLO: B-11-D-17] Describe the arrangement of photosynthetic pigments in the form of Photosystem-I and II. (Understanding) [SLO: B-11-D-18] Describe and sketch the mechanism of light-dependent reactions in terms of; - non-cyclic photophosphorylation and - cyclic photophosphorylation. (Understanding, Application) [SLO: B-11-D-19] Explain the Calvin cycle (the regeneration of RuBP is required in outline only) and sketch its pathway. (Understanding, Application)	

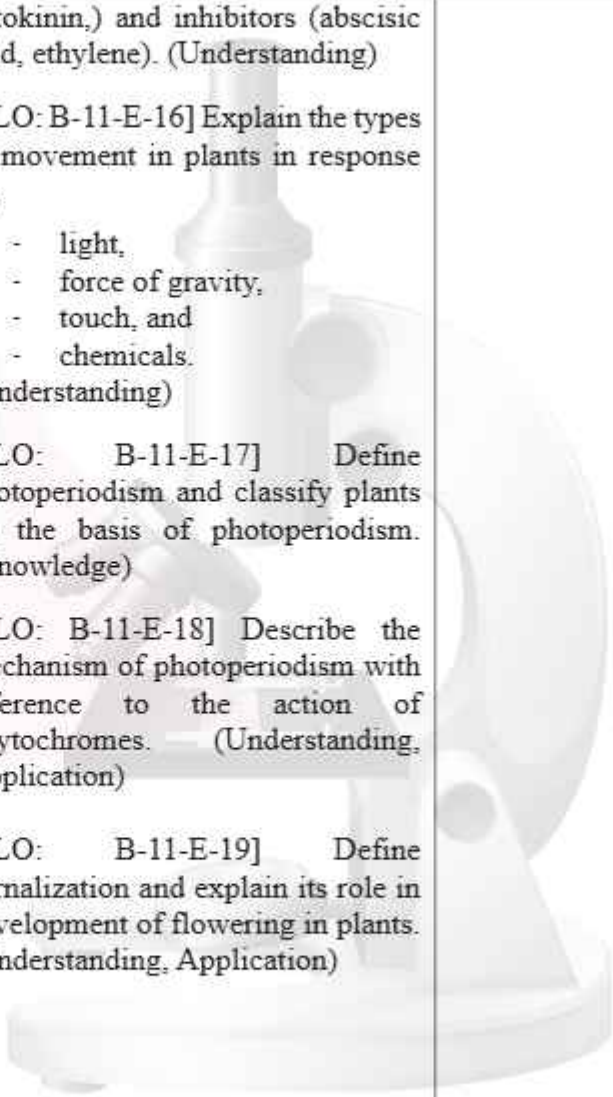
Grade 9	Grade 10	Grade 11	Grade 12
blood during exercise causes 'oxygen debt'. (Understanding) [SLO: B-09-D-15] Describe mechanism of aerobic respiration, by outlining the steps (Glycolysis, Oxidation of Pyruvate, Kreb Cycle, Electron Transport Chain). (Understanding) [SLO: B-09-D-16] Sketch an overview diagram of aerobic respiration. (Application) [SLO: B-09-D-17] Compare aerobic and anaerobic respiration with reference to the amount of energy released. (Application)		[SLO: B-11-D-20] State the main events which occur during aerobic respiration in eukaryotic cells. (Knowledge) [SLO: B-11-D-21] Describe the events of glycolysis (naming the reactants, products and enzymes of each step). (Understanding) [SLO: B-11-D-22] Illustrate the link reaction as conversion of pyruvate to acetyl CoA. (Understanding, Application) [SLO: B-11-D-23] Describe and sketch the steps of Krebs cycle (naming the reactants, products and enzymes of each step). (Understanding, Application) [SLO: B-11-D-24] Trace the passage of electrons through the electron transport chain (details of carriers are not required). (Understanding) [SLO: B-11-D-25] Describe chemiosmosis and relate it with electron transport chain. (Understanding, Application) [SLO: B-11-D-26] Explain the substrate-level phosphorylation for	

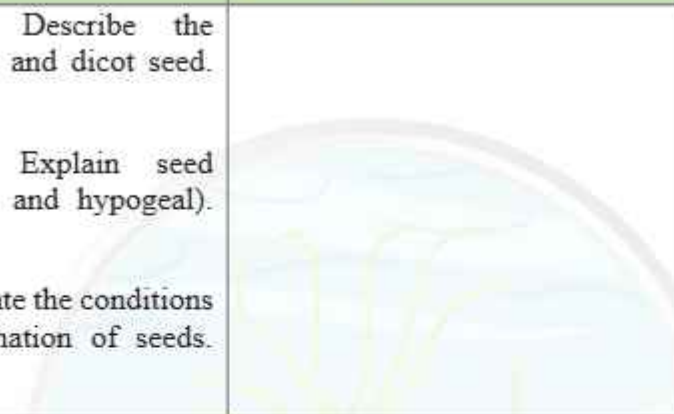
Grade 9	Grade 10	Grade 11	Grade 12
		the synthesis of ATP. (Understanding) [SLO: B-11-D-27] Explain the relative energy values of carbohydrates, lipids and proteins as respiratory substrates. [SLO: B-11-D-28] Outline the process of anaerobic respiration in terms of glycolysis and conversion of pyruvate into lactic acid or ethanol. (Knowledge) [SLO: B-11-D-29] Justify why the energy yield from aerobic respiration is much greater than the energy yield from anaerobic respiration. (Understanding) [SLO: B-11-D-30] Outline the interlinked pathway of energy production from fats, proteins, and carbohydrates. (Understanding, Application) [SLO: B-11-D-31] Define photorespiration and outline the events occurring through it. (Understanding) [SLO: B-11-D-32] Rationalize how the disadvantageous process of	

Grade 9	Grade 10	Grade 11	Grade 12
		photorespiration evolved. (Application)	
Domain E: Plant Physiology Standards: 1. Analyze the structural adaptations and biophysical mechanisms including water potential, the TACT mechanism, and pressure-flow that facilitate the transport of water, minerals, and nutrients, while evaluating the processes of primary and secondary growth. 2. Evaluate the responses of plants to their environment through hormonal coordination, photoperiodism, and osmotic adjustments and analyze the diversity of reproductive strategies and life cycles in flowering plants.			
Benchmarks: 1. Describe the internal structure of roots, explaining how plants uptake water and minerals. 2. Apply the concepts of transpiration and the Pressure Flow Mechanism to explain the movement of substances. 3. Describe basic coordination in plants and the role of auxin. 4. Compare sexual and asexual reproduction, identifying flower structures, seed structure, and germination.		Benchmarks: 1. Apply the concepts of water relations (water potential, solute potential and pressure potential) to analyze the movement of water and solutes by evaluating the ultrastructure of xylem and phloem. 2. Justify the development of annual rings and the roles of various Plant Growth Regulators and explain photoperiodism. 3. Evaluate the complex osmotic and structural adaptations in plants and analyze the movement responses to touch, gravity, and chemicals.	
Plant Physiology [SLO: B-09-E-01] Define mineral nutrition in plants. (Knowledge) [SLO: B-09-E-02] Categorize mineral nutrients into macronutrients and micronutrients. (Understanding)		Plant Physiology [SLO: B-11-E-01] Discuss the water potential, solute potential and pressure potential to elaborate the transport of water in plants. (Understanding, Application) [SLO: B-11-E-02] Describe the movement of water through roots in terms of symplast, apoplast and	

Grade 9	Grade 10	Grade 11	Grade 12
[SLO: B-09-E-03] State the importance of nitrogen and magnesium for plants. (Knowledge) [SLO: B-09-E-04] Conceptualize transport in plants and its needs. (Application) [SLO: B-09-E-05] Explain the internal structure of monocot and dicot roots. (Understanding) [SLO: B-09-E-06] Describe how roots take up water and mineral salts by active and passive absorption. (Understanding) [SLO: B-09-E-07] Describe transpiration and relate it with leaf surface area and stomatal opening and closing. (Understanding) [SLO: B-09-E-08] Describe the effects of the following factors on the rate of transpiration; - temperature, - wind, and - humidity. (Understanding) [SLO: B-09-E-09] Describe the mechanism of transport of water and		vacuolar pathways. (Understanding) [SLO: B-11-E-03] Describe the following structures and relate them with their functions; - tracheids, - xylem vessel elements, - sieve tube elements, and - companion cells (Understanding) [SLO: B-11-E-04] Explain the movement of water in xylem through TACT mechanism. (Understanding) [SLO: B-11-E-05] Explain the transport of sugars within plants. (Understanding) [SLO: B-11-E-06] Explain the role of stomata and palisade tissue in the exchange of gasses in plants. (Understanding) [SLO: B-11-E-07] Describe the mechanisms involved in the opening and closing of stomata. (Understanding) [SLO: B-11-E-08] Explain the osmotic adjustments in hydrophytic (marine and freshwater), xerophytic	

Grade 9	Grade 10	Grade 11	Grade 12
salt in plants (ascent of sap). (Understanding) [SLO: B-09-E-10] Explain the mechanism of food transport (translocation) by the theory of Pressure Flow Mechanism. (Understanding) [SLO: B-09-E-11] Describe the process of gaseous exchange in plants (leaf, stem, root). (Understanding) [SLO: B-09-E-12] Describe the mechanism and adaptations in plants for the excretion (root, stem, leaf). (Understanding) [SLO: B-09-E-13] Describe movements in plants in terms of, - gravitropism and - phototropism. (Understanding) [SLO: B-09-E-14] State the role of auxin in controlling shoot growth. (Knowledge) Reproduction in Plants [SLO: B-09-E-15] Differentiate between asexual and sexual reproduction. (Knowledge)		and mesophytic plants and plants in saline soil. (Understanding) [SLO: B-11-E-09] List the adaptations in plants to cope with low and high temperatures. (Understanding) [SLO: B-11-E-10] Explain the turgor pressure and its significance in providing support to herbaceous plants. (Understanding) [SLO: B-11-E-11] Describe the structure of supporting tissues (collenchyma, sclerenchyma) in plants. (Understanding) [SLO: B-11-E-12] Define growth and explain primary and secondary growth in plants. (Understanding) [SLO: B-11-E-13] Justify the formation of growth rings as annual rings in plants. (Application) [SLO: B-11-E-14] Explain influence of apical meristem on the growth of lateral shoots (apical dominance). (Understanding) [SLO: B-11-E-15] Outline the role of important plant growth regulators and classify them as growth promoter (Auxin, gibberellin,	

Grade 9	Grade 10	Grade 11	Grade 12
[SLO: B-09-E-16] Discuss the advantages and disadvantages of asexual and sexual reproduction. (Understanding) [SLO: B-09-E-17] Distinguish between natural and artificial vegetative propagation. (Understanding) [SLO: B-09-E-18] Explain natural vegetative propagation in plants (through stem, suckers and leaves). (Understanding) [SLO: B-09-E-19] Describe the two methods of artificial vegetative propagation (stem cuttings and grafting). (Understanding) [SLO: B-09-E-20] Identify the parts of a flower and their functions. (Understanding) [SLO: B-09-E-21] Describe sexual reproduction in plants by explaining the life cycle of a flowering plant. (Understanding) [SLO: B-09-E-22] Describe the adaptations in the structures of wind-pollinated and insect-pollinated flowers. (Application)		cytokinin,) and inhibitors (abscisic acid, ethylene). (Understanding) [SLO: B-11-E-16] Explain the types of movement in plants in response to; - light, - force of gravity, - touch, and - chemicals. (Understanding) [SLO: B-11-E-17] Define photoperiodism and classify plants on the basis of photoperiodism. (Knowledge) [SLO: B-11-E-18] Describe the mechanism of photoperiodism with reference to the action of phytochromes. (Understanding, Application) [SLO: B-11-E-19] Define vernalization and explain its role in development of flowering in plants. (Understanding, Application) 	

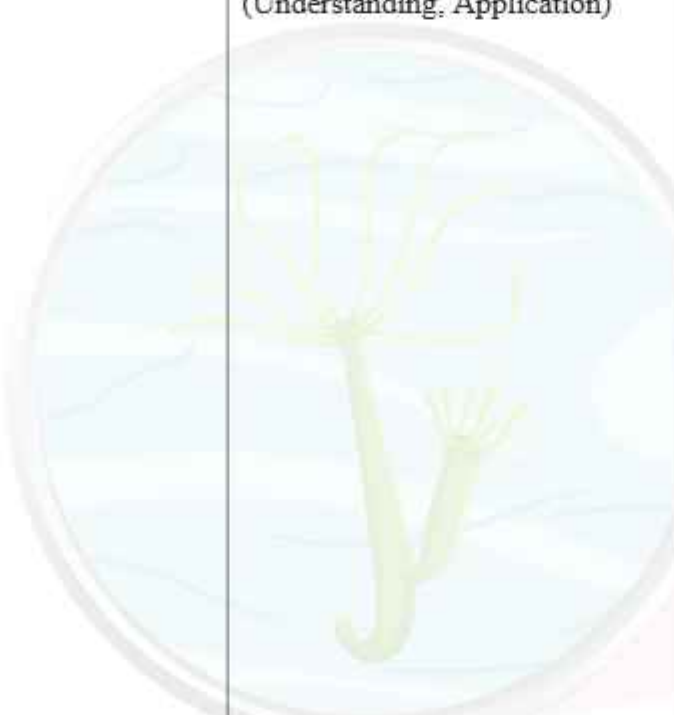
Grade 9	Grade 10	Grade 11	Grade 12
[SLO: B-09-E-23] Describe the structure of monocot and dicot seed. (Understanding) [SLO: B-09-E-24] Explain seed germination (epigeal and hypogeal). (Understanding) [SLO: B-09-E-25] State the conditions necessary for germination of seeds. (Understanding)			
Domain F: Human Physiology Standards: - Analyze the coordinated functioning of human organ systems including digestive, respiratory, circulatory, and urinary and evaluate the homeostatic mechanisms that maintain the internal environment. - Evaluate the role of the nervous and endocrine systems in signal transduction and response, analyze the musculoskeletal basis of movement, and investigate the biological principles governing human reproduction and development. - Analyze the causes, symptoms, and treatments of common human disorders, evaluating the impact of lifestyle choices and environmental factors on systemic health.			
Benchmarks: - Describe the structure and function of the alimentary canal, lungs, heart, and kidneys. - Apply knowledge of breathing mechanisms, double circulation, and urine formation to explain how the body processes nutrients, exchanges gases, and removes waste. - Explain the stimulus-response model and major endocrine glands. - Identify the parts of the male and female reproductive systems.		Benchmarks: - Explain the functions of the major organs in the human body. - Evaluate the molecular and hormonal regulation of homeostasis. - Analyze the electrochemistry of nerve impulses and synaptic transmission. - Synthesize the sliding filament model of muscle contraction, evaluate the hormonal control of the menstrual cycle.	
	Human Digestive System [SLO: B-10-F-01] Define	Human Digestive System	

Grade 9	Grade 10	Grade 11	Grade 12
	ingestive heterotrophic mode of nutrition in animals, narrating the following steps; - ingestion, - digestion, - absorption, - assimilation, and - egestion. (Knowledge) [SLO: B-10-F-02] Describe the structures and functions of the main regions of the alimentary canal and the associated organs. (Understanding, Application) [SLO: B-10-F-03] Describe swallowing and peristalsis. (Understanding) [SLO: B-10-F-04] Analyze the action of enzymes in specific regions of alimentary canal (oral cavity, stomach, small intestine) with respect to their substrates and products. (Understanding, Application) [SLO: B-10-F-05] State the roles (any five) of the liver. (Knowledge) [SLO: B-10-F-06] Describe the structure of a villus and the roles	[SLO: B-11-F-01] Describe the mechanical and chemical digestion in the oral cavity. (Understanding) [SLO: B-11-F-02] Illustrate with a diagram the structure of the stomach and relate each component with the mechanical and chemical digestion in the stomach. (Understanding, Application) [SLO: B-11-F-03] Identify the role of the nervous system and gastrin hormone on the secretion of gastric juice. (Knowledge) [SLO: B-11-F-04] Describe the major actions carried out on food in the three regions of the small intestine. (Understanding) [SLO: B-11-F-05] Trace the absorption of digested products from the small intestine lumen to the blood. (Understanding) [SLO: B-11-F-06] Describe the components of large intestine and their roles. (Understanding) [SLO: B-11-F-07] List the storage and metabolic role of the liver. (Knowledge)	

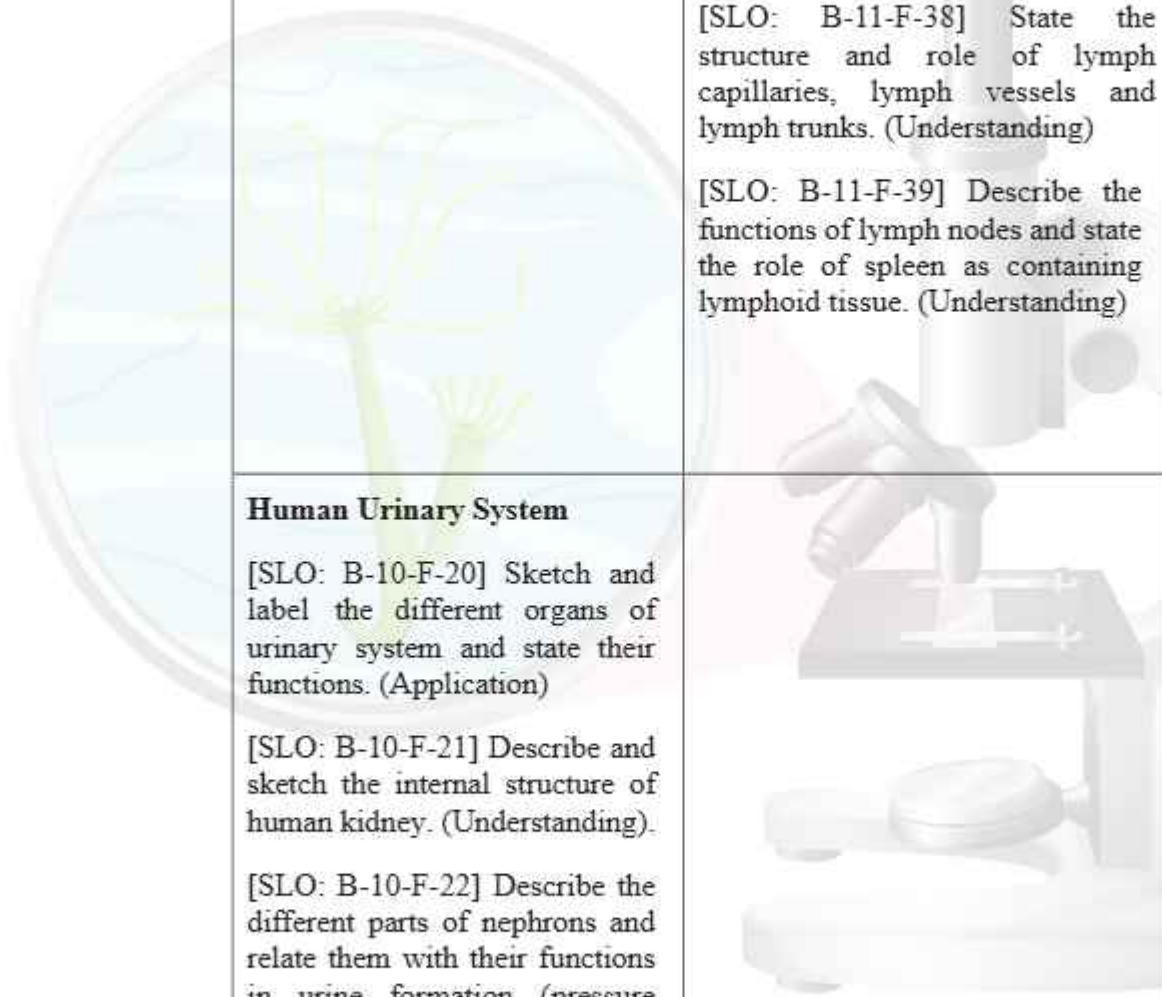
Grade 9	Grade 10	Grade 11	Grade 12
	of capillaries and lacteals in absorption of nutrients. (Understanding) [SLO: B-10-F-07] State the symptoms, causes, treatments and preventions of the disorders of gut i.e., - diarrhea, - constipation, and - ulcer. (Understanding)	[SLO: B-11-F-08] Describe composition of bile and relate the constituents with respective roles and gallstone formation. (Understanding) [SLO: B-11-F-09] Outline the structure of pancreas and explain its function as an exocrine gland. (Understanding) [SLO: B-11-F-10] Relate the secretion of bile and pancreatic juice with the secretin and cholecystokinin hormones. (Understanding)	
	Human Respiratory System [SLO: B-10-F-08] Describe the roles of the parts of the air passageway and lungs. (Understanding) [SLO: B-10-F-09] Describe the mechanism of breathing and state the effects of physical activity on breathing rate. (Understanding, Application) [SLO: B-10-F-10] Differentiate between the composition of inspired and expired air.	Human Respiratory System [SLO: B-11-F-11] Define the respiratory surface and list its properties. (Knowledge) [SLO: B-11-F-12] Describe the main structural features and functions of the components of human respiratory system. (Understanding) [SLO: B-11-F-13] Explain the ventilation mechanism in humans. (Understanding)	

Grade 9	Grade 10	Grade 11	Grade 12
	(Understanding) [SLO: B-10-F-11] Discuss briefly the diseases related to respiratory system e.g., - bronchitis, - emphysema, - pneumonia, and - lung cancer. (Understanding)	[SLO: B-11-F-14] Discuss the transport of oxygen and carbon dioxide through blood. (Understanding) [SLO: B-11-F-15] State the causes, symptoms and treatment of; - sinusitis, - Chronic Obstructive Pulmonary Disease, and - pulmonary tuberculosis. (Understanding) [SLO: B-11-F-16] Describe the effects of three toxic substances of cigarette smoke (nicotine, carbon monoxide and tar) on human health. (Understanding) [SLO: B-11-F-17] List the effects of active smoking and passive smoking on health. (Knowledge)	
	Human Blood Circulatory System [SLO: B-10-F-12] Define blood circulatory system and identify its major organs and their roles. (Understanding) [SLO: B-10-F-13] Describe	Transport Systems in Humans [SLO: B-11-F-18] State the components of human blood circulatory system. (Knowledge) [SLO: B-11-F-19] Describe the external and internal structure of the heart and rationalize the thickness	

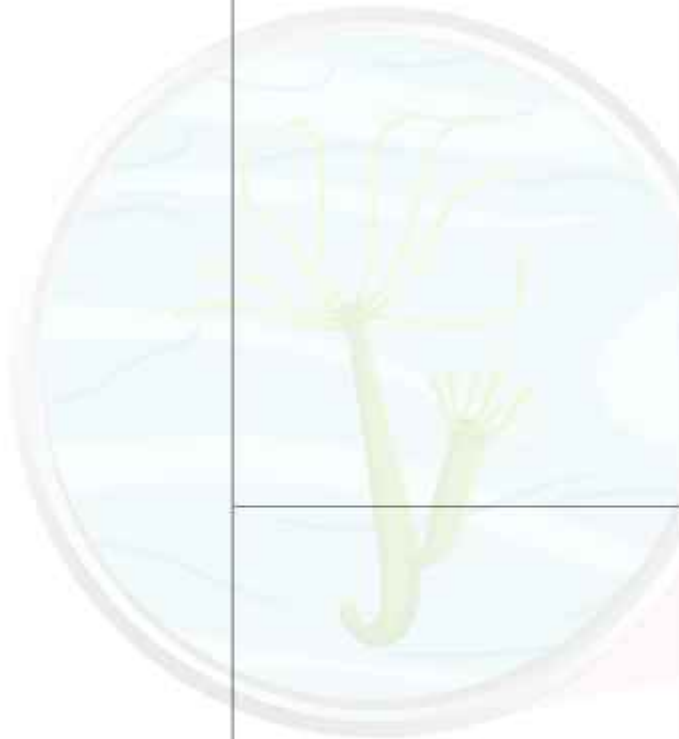
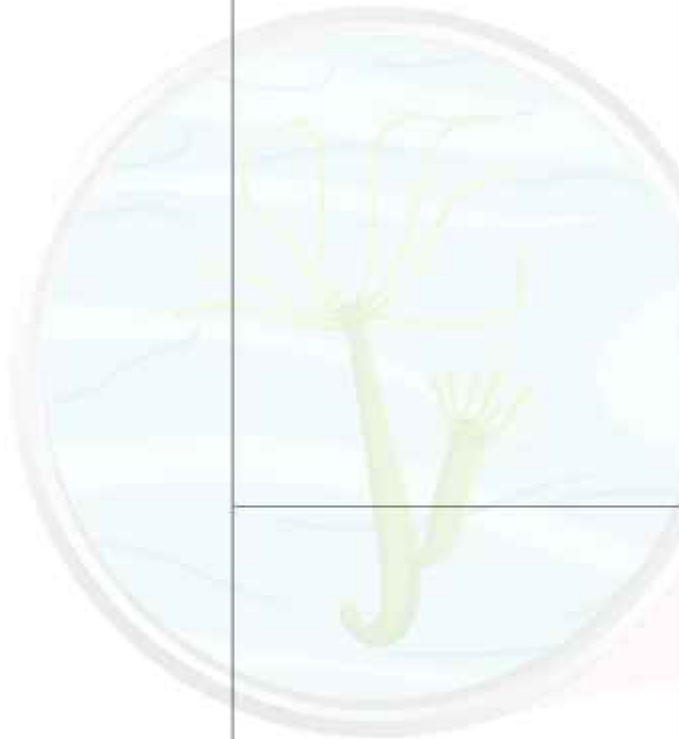
Grade 9	Grade 10	Grade 11	Grade 12
	double-circuit circulation in terms of the major pathways of blood through circulatory system. (Understanding) [SLO: B-10-F-14] Identify the different components of blood and state their roles. (Knowledge) [SLO: B-10-F-15] Compare the structure and function of an artery, a vein and a capillary. (Application) [SLO: B-10-F-16] Explain the structure of the heart with a diagram. (Understanding) [SLO: B-10-F-17] Describe the circulation of blood through atria and ventricles of the heart. [SLO: B-10-F-18] Explain coronary artery disease and its effects in terms of; - angina, - myocardial infarction, - cardiac arrest. (Understanding/Application) [SLO: B-10-F-19] State the possible risk factors of coronary artery disease including diet,	of the walls of its chambers. (Understanding) [SLO: B-11-F-20] Trace the flow of blood through the heart as regulated by the valves. (Understanding) [SLO: B-11-F-21] Discuss the phases of heartbeat. (Understanding) [SLO: B-11-F-22] Explain the role of SA node, AV node and Purkinje fibers in controlling the heartbeat. (Understanding) [SLO: B-11-F-23] List the principles and uses of Electrocardiogram. (Understanding, Application) [SLO: B-11-F-24] Describe the detailed structure and functions of; - arteries, - veins, and - capillaries. (Understanding) [SLO: B-11-F-25] Describe the role of arterioles in vasoconstriction and vasodilation. (Understanding)	

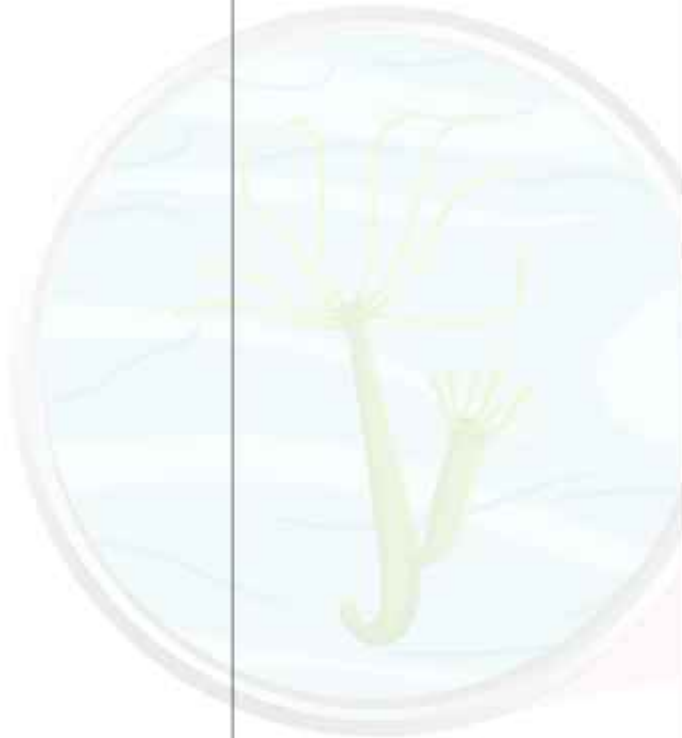
Grade 9	Grade 10	Grade 11	Grade 12
	sedentary lifestyle, stress, smoking, heredity, and age. (Understanding, Application) 	[SLO: B-11-F-26] Trace the path of the blood through; - pulmonary circulation - systemic circulation (coronary, hepatic- portal and renal circulation). (Understanding) [SLO: B-11-F-27] Compare the rate of blood flow through arteries, arterioles, capillaries, venules and veins. (Understanding, Application) [SLO: B-11-F-28] Define blood pressure and explain systolic and diastolic pressures. (Knowledge, Understanding) [SLO: B-11-F-29] State the role of baroreceptors and volume receptors in regulating the blood pressure. (Understanding) [SLO: B-11-F-30] Define the term thromboembolism and differentiate between thrombus and embolus. (Understanding, Application) [SLO: B-11-F-31] Identify the factors causing atherosclerosis and arteriosclerosis. (Understanding)	

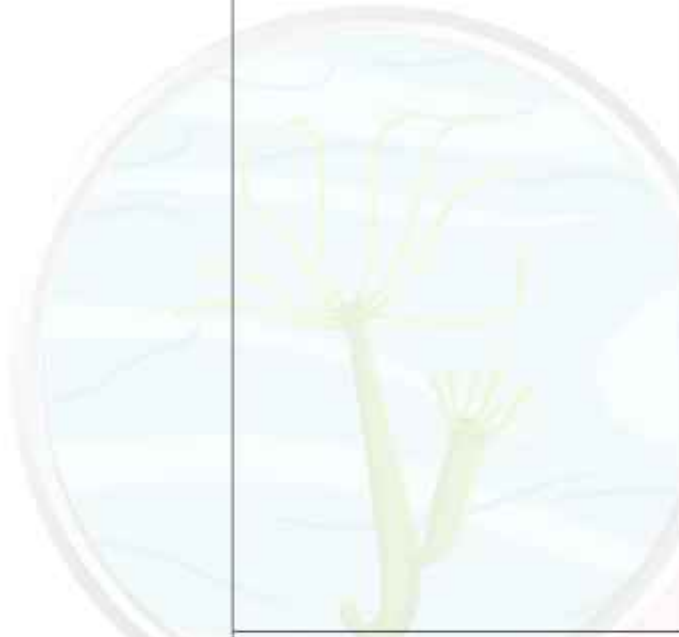
Grade 9	Grade 10	Grade 11	Grade 12
		[SLO: B-11-F-32] Categorize angina pectoris, heart attack, and heart failure as the stages of cardiovascular disease development. (Understanding, Application) [SLO: B-11-F-33] State the heart problem related to the malfunctioning of cardiac valves. (Understanding) [SLO: B-11-F-34] Describe the basic principle of angiography. (Understanding) [SLO: B-11-F-35] Outline the main principles of; - coronary bypass, - angioplasty, and - open-heart surgery. (Understanding) [SLO: B-11-F-36] Define hypertension and hypotension and describe the factors that can lead to these conditions. (Knowledge, Understanding) [SLO: B-11-F-37] Describe the formation, composition and	

Grade 9	Grade 10	Grade 11	Grade 12
		function of intercellular (interstitial) fluid and lymph. (Understanding) [SLO: B-11-F-38] State the structure and role of lymph capillaries, lymph vessels and lymph trunks. (Understanding) [SLO: B-11-F-39] Describe the functions of lymph nodes and state the role of spleen as containing lymphoid tissue. (Understanding)	
	Human Urinary System [SLO: B-10-F-20] Sketch and label the different organs of urinary system and state their functions. (Application) [SLO: B-10-F-21] Describe and sketch the internal structure of human kidney. (Understanding). [SLO: B-10-F-22] Describe the different parts of nephrons and relate them with their functions in urine formation (pressure filtration, selective reabsorption and tubular secretion).		Homeostasis [SLO: B-12-F-01] Define homeostasis and relate the homeostatic mechanisms with the negative and positive feedback systems. (Understanding) [SLO: B-12-F-02] Define thermoregulation and describe the thermoregulatory strategies in man. (Understanding) [SLO: B-12-F-03] List various nitrogenous compounds excreted during the process of excretion in humans. (Knowledge)

Grade 9	Grade 10	Grade 11	Grade 12
	(Understanding) [SLO: B-10-F-23] State that the kidney plays an important role in osmoregulation. (Knowledge) [SLO: B-10-F-24] Identify the causes and treatment of kidney stones. (Understanding, Application) [SLO: B-10-F-25] Outline the causes of kidney failure and treatments (dialysis and kidney transplant). (Understanding, Application)		[SLO: B-12-F-04] Outline different organs of the urinary system. (Knowledge) [SLO: B-12-F-05] Describe the structure of kidney. (Understanding) [SLO: B-12-F-06] Explain the detailed structure of a nephron. (Understanding) [SLO: B-12-F-07] Explain the processes of glomerular filtration, selective re-absorption and tubular secretion as the events in kidney functioning. (Understanding) [SLO: B-12-F-08] Explain regulatory mechanism involved in concentration of urine. (Understanding) [SLO: B-12-F-09] Justify the functioning of kidneys as both excretion and osmoregulation. (Understanding, Application) [SLO: B-12-F-10] Explain the causes and treatments of kidney stones. (Understanding)

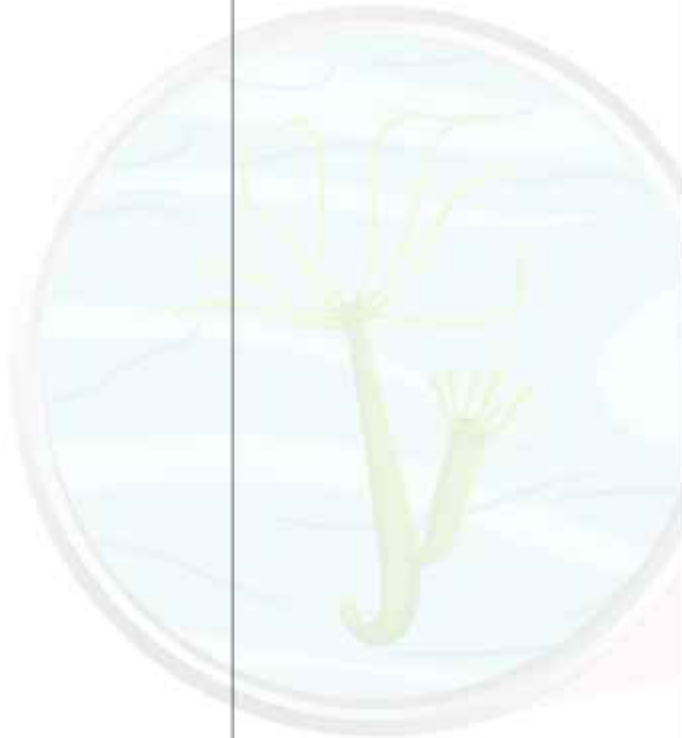
Grade 9	Grade 10	Grade 11	Grade 12
			[SLO: B-12-F-11] Outline the causes of kidney failure. (Knowledge) [SLO: B-12-F-12] Explain in detail the mechanism and problems related to dialysis. (Understanding, Application) [SLO: B-12-F-13] Describe the principles and the problems associated with kidney transplant. (Understanding, Application)
			Musculoskeletal System [SLO: B-12-F-14] Describe the structure of bone and compare it with that of cartilage. (Understanding) [SLO: B-12-F-15] Explain the functions of; - osteoblasts, - osteoclasts, and - osteocytes. (Understanding)

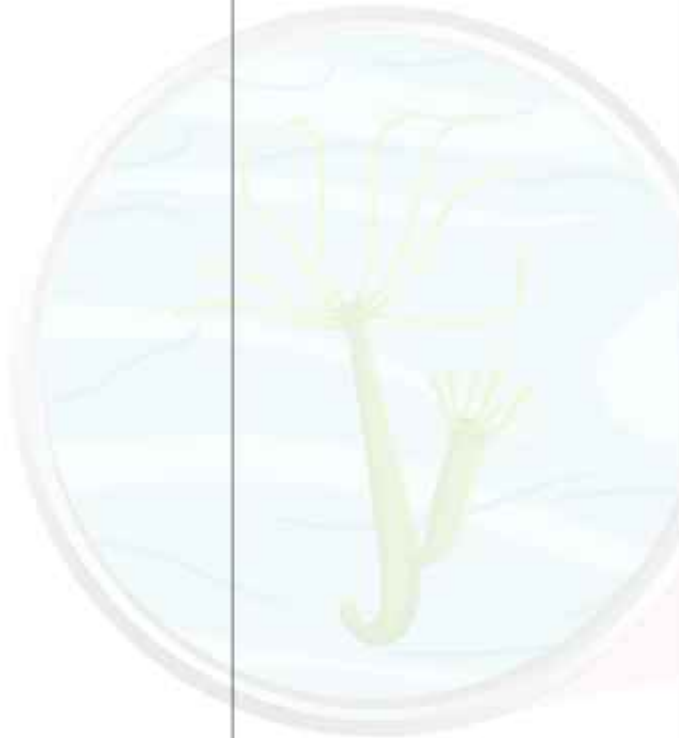
Grade 9	Grade 10	Grade 11	Grade 12
			[SLO: B-12-F-16] List the bones of the appendicular and axial skeleton of man. (Knowledge) [SLO: B-12-F-17] Describe the following types of joints with examples i.e., - fibrous joints, - cartilaginous joints, and - synovial joints (with six sub-types). (Understanding) [SLO: B-12-F-18] State the causes, symptoms and treatments of; - arthritis, - osteoporosis, and - gout. (Understanding) [SLO: B-12-F-19] State different types of fractures (simple, compound and complicated) and describe the repair process of simple fractures. (Understanding, Application) [SLO: B-12-F-20] Compare smooth muscles, cardiac muscles and skeletal muscles. (Understanding)

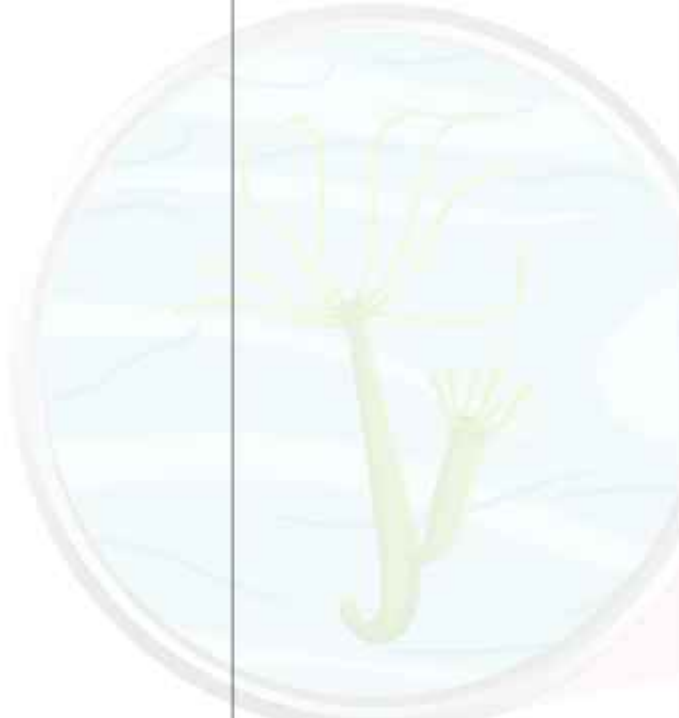
Grade 9	Grade 10	Grade 11	Grade 12
			[SLO: B-12-F-21] Annotate the ultrastructure of the skeletal muscle. (Understanding, Application) [SLO: B-12-F-22] Explain the sliding filaments model of muscle contraction. (Understanding) [SLO: B-12-F-23] Describe the action of antagonistic muscles in the movement of knee joint. (Understanding, Application) [SLO: B-12-F-24] State the causes, symptoms and treatments of muscular dystrophy and cramps. (Understanding) [SLO: B-12-F-25] Justify the impact of exercise on muscles health. (Understanding)
	Coordination [SLO: B-10-F-26] Define coordination and its types (nervous and chemical). (Understanding) [SLO: B-10-F-27] Define stimulus-response model with examples of receptors, coordinators, and effectors. (Understanding)		Nervous System [SLO: B-12-F-26] Introduce the steps of nervous coordination (reception of stimuli, integration, response to the stimuli). (Knowledge) [SLO: B-12-F-27] Recognize receptors as transducers sensitive to various stimuli. (Knowledge)

Grade 9	Grade 10	Grade 11	Grade 12
	[SLO: B-10-F-28] Outline the types of neurons with diagrams. (Understanding) [SLO: B-10-F-29] Discuss the central nervous system and the peripheral nervous system. (Understanding) [SLO: B-10-F-30] Define Nerve impulse. (Knowledge) [SLO: B-10-F-31] Define synapse and neurotransmitters with examples. (Knowledge) [SLO: B-10-F-32] Define reflex action and explain and sketch reflex arc with example of withdrawal of hand as a reflex. (Understanding, Application) [SLO: B-10-F-33] Identify the important endocrine glands and state the functions of their hormones (limited to pituitary, thyroid, parathyroid, adrenal, pancreas, testes, and ovaries). (Knowledge/Understanding) [SLO: B-10-F-34] Compare nervous and hormonal coordination in terms of speed and duration of effect.		[SLO: B-12-F-28] Identify the three types of neurons involved in nerve impulse transmission. [SLO: B-12-F-29] Identify muscles and glands as the effectors. (Knowledge) [SLO: B-12-F-30] Annotate the detailed structure of sensory neuron, associative neuron, and motor neuron and describe their functions. (Understanding, Application) [SLO: B-12-F-31] Differentiate between myelinated and non-myelinated neurons. [SLO: B-12-F-32] Define nerve impulse and describe the generation and transmission of nerve impulse highlighting the factors responsible for the resting membrane potential and active membrane potential. (Knowledge, Understanding) [SLO: B-12-F-33] Evaluate from a graph the phenomena of polarization, depolarization and hyperpolarization of membrane. (Application)

Grade 9	Grade 10	Grade 11	Grade 12
	(Application)		[SLO: B-12-F-34] Outline and sketch the structure of synapse and explain synaptic transmission of nerve impulse. (Understanding, Application) [SLO: B-12-F-35] Classify neurotransmitters as inhibitory and excitatory and list some common examples. (Knowledge) [SLO: B-12-F-36] Compare the velocities of nerve impulse in the axon membrane and in the synapse. (Understanding) [SLO: B-12-F-37] Identify the main divisions of the nervous system. (Knowledge) [SLO: B-12-F-38] Explain briefly the structure and major parts of the brain and their functions. (Understanding) [SLO: B-12-F-39] Explain and sketch the structure (cross section) of spinal cord and state its function. (Understanding, Application) [SLO: B-12-F-40] List cranial and spinal nerves in man. (Knowledge) [SLO: B-12-F-41] Explain the structure, types and functions of the

Grade 9	Grade 10	Grade 11	Grade 12
			autonomic nervous system. (Understanding) [SLO: B-12-F-42] Classify nervous disorders into vascular, infectious, structural, functional and degenerative disorders. (Knowledge) [SLO: B-12-F-43] Describe the causes, symptoms and treatment of one type of each category of nervous disorders e.g., - stroke as vascular, - meningitis as infectious, - brain tumor as structural, - headache as functional, and - Alzheimer disease as degenerative disorder. (Understanding) [SLO: B-12-F-44] Name the important diagnostic tests for nervous disorders i.e., EEG, CT scan and MRI and their uses. (Knowledge) Endocrine System [SLO: B-12-F-45] Define endocrine glands. State the role of hormones as chemical messengers. (Knowledge)

Grade 9	Grade 10	Grade 11	Grade 12
			[SLO: B-12-F-46] Explain the neurosecretory role of hypothalamus. (Understanding) [SLO: B-12-F-47] Locate the endocrine glands (pituitary, thyroid, parathyroid, pancreas, adrenal, gonads) in human body, name the hormones they release and state their functions. (Understanding) [SLO: B-12-F-48] Relate the problems associated with the imbalance of these hormones. (Understanding) [SLO: B-12-F-49] Outline the concept of feedback mechanism of hormones and describe positive feedback with reference to oxytocin and negative feedback with reference to insulin and glucagon. (Understanding, Application)
	Reproductive System [SLO: B-10-F-35] Describe the process of gametogenesis and fertilization. (Understanding) [SLO: B-10-F-36] Describe and sketch the male and female		Reproductive System & Development [SLO: B-12-F-50] Describe the human male reproductive system and accessory glands and identify their functions. (Understanding)

Grade 9	Grade 10	Grade 11	Grade 12
	 reproductive systems of rabbit. (Understanding)		[SLO: B-12-F-51] Define male reproductive hormones and explain their functions. (Understanding) [SLO: B-12-F-52] Explain the structures present in the female reproductive system and describe their functions. (Understanding) [SLO: B-12-F-53] Describe the menstrual cycle and the hormones involved. (Understanding) [SLO: B-12-F-54] Explain the process of embryo implantation establishment of early pregnancy. (Understanding) [SLO: B-12-F-55] Describe developmental changes in humans, outlining major developments of the embryo during the first, second, and third trimesters. (Understanding)

Domain G: Inheritance and Evolution

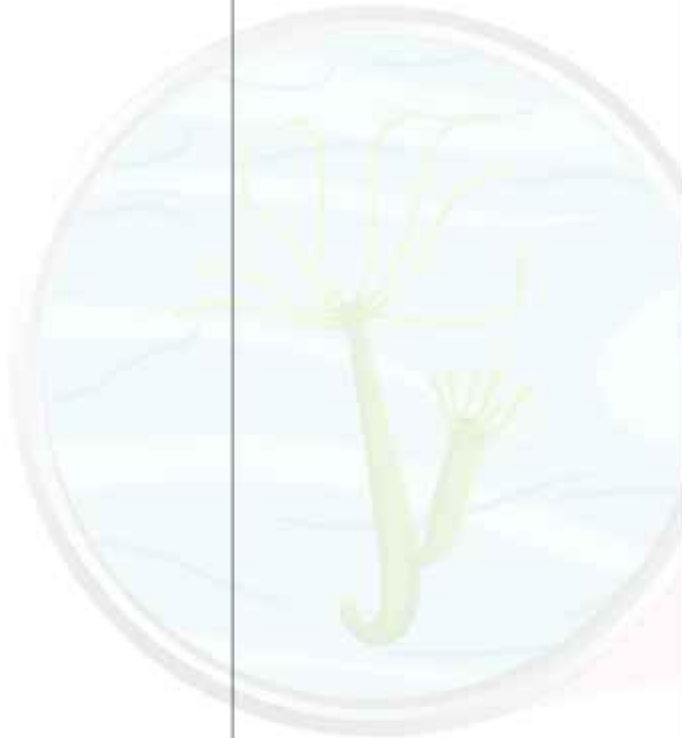
Standards:

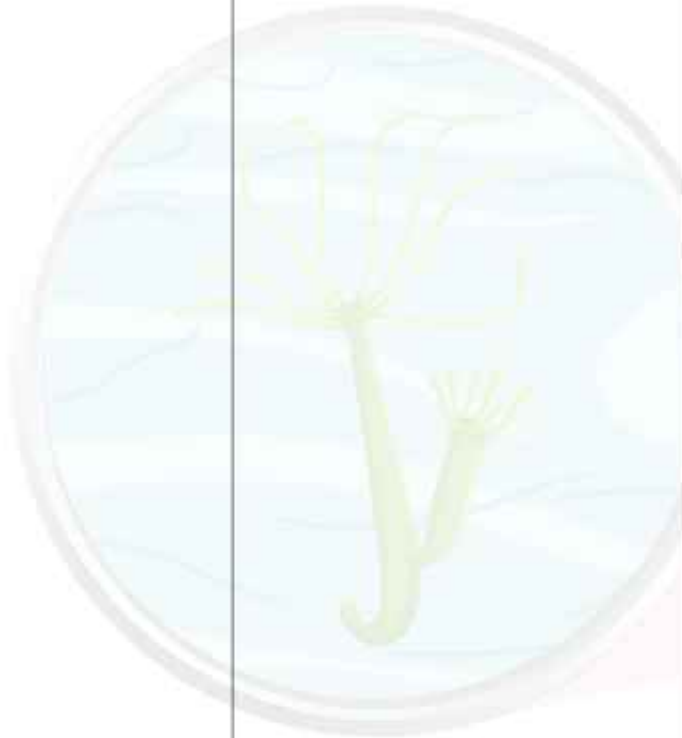
1. Explain the structure of nucleic acids and chromosomes, analyzing the molecular mechanisms of DNA replication, gene expression mechanism and its regulation as the basis of heredity.
2. Analyze the principles of heredity (Mendelian laws to non-Mendelian inheritance patterns) and evaluate how gene linkage and mutations contribute to biological variation.
3. Evaluate the mechanisms of evolution, utilizing evidence from multiple scientific disciplines and mathematical models (Hardy-Weinberg) to analyze how selection, genetic drift change in allele frequencies and isolation drive speciation.

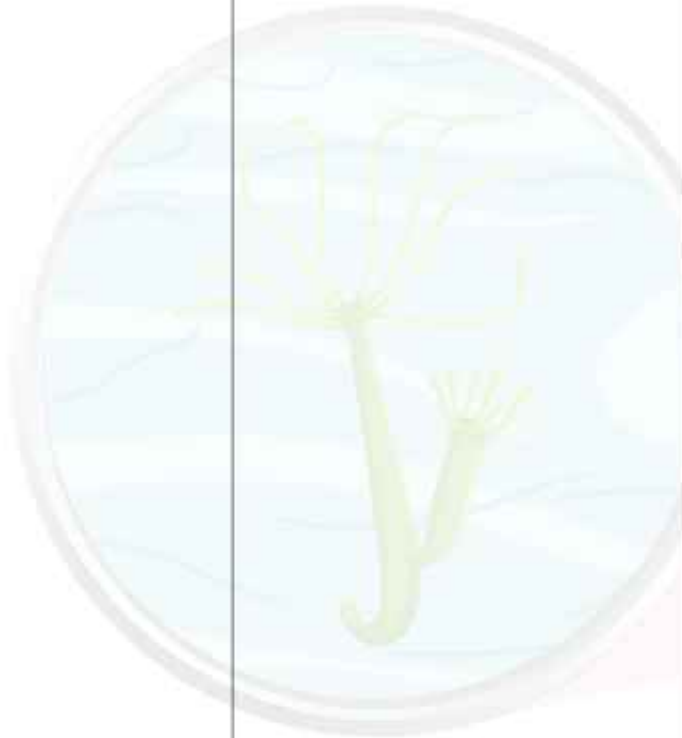
Grade 9	Grade 10	Grade 11	Grade 12
Benchmarks: 1. Describe karyotype and explain the double-helix structure of DNA and the single-stranded nature of RNA and outline the flow of genetic information from DNA to RNA to protein. 2. Apply Mendelian laws using monohybrid and dihybrid crosses. 3. Distinguish between genotypes and phenotypes and identify the effects of gene and chromosomal mutations. 4. Explain the theory of natural selection and define variation and distinguish between natural and artificial selection. 5. Describe evidences of evolution from fossil record and biogeography		Benchmarks: 1. Analyze the experimental evidence identifying DNA as hereditary material and evaluate the mechanisms of replication, transcription, and translation, while explaining the control of gene expression. 2. Explain advanced genetic concepts including incomplete dominance, epistasis, polygenic inheritance, and sex-linkage. 3. Evaluate the impact of gene linkage and crossing-over on variation. 4. Describe evolution from prokaryotes to eukaryotes and theories as well as evidences of evolution. 5. Analyze evolutionary change using the Hardy-Weinberg principle and statistical tools. 6. Evaluate the effects of genetic drift, the founder effect, and the bottleneck effect on population dynamics.	
 Inheritance [SLO: B-10-G-01] Define inheritance and outline how information in the DNA is converted to information on RNA and then into proteins. (Understanding) SLO: B-10-G-02] Briefly explain the types of RNA and outline their roles in protein synthesis (structures not required). (Understanding) [SLO: B-10-G-03] Narrate and sketch the labelled structure of		 Inheritance [SLO: B-12-G-01] Explain the law of segregation and independent assortment, using a suitable example related to the pea plants. (Understanding, Application) [SLO: B-12-G-02] Relate the Law of independent assortment to random orientation of chromosomes during Meiosis. (Application) [SLO: B-12-G-03] Express limitations of independent assortment and its usefulness. (Understanding, Application)	

Grade 9	Grade 10	Grade 11	Grade 12
	chromosomes. (Understanding, Application) [SLO: B-10-G-04] Define karyotype and explain the male and female karyotype in humans (autosomes and sex chromosomes). (Knowledge, Understanding) [SLO: B-10-G-05] Define gene, allele, genotype, phenotype, homozygous, heterozygous, dominant, and recessive. (Knowledge) [SLO: B-10-G-06] List the seven pairs of contrasting characters studied by Mendel in pea plant. (Knowledge) [SLO: B-10-G-07] Justify the pea plant as model organism for inheritance studies. (Application) [SLO: B-10-G-08] Describe Mendelian law of segregation through monohybrid cross. (Understanding, Application) [SLO: B-10-G-09] Describe Mendelian law of independent assortment through dihybrid		[SLO: B-12-G-04] Show how independent assortment leads to variation in the gametes. (Application) [SLO: B-12-G-05] Evaluate that inheritance of genes and their mixing during fertilization is based on mathematical probabilities. (Application) [SLO: B-12-G-06] Enlist the exceptions to the Mendel's laws of inheritance. (incomplete, codominance and multiple allelic system). (Understanding) [SLO: B-12-G-07] Explain incomplete dominance and exemplify it through the inheritance of flower colour in 4 o'clock plant. (Understanding) [SLO: B-12-G-08] Explain codominance through the genetics of human blood group AB. (Understanding) [SLO: B-12-G-09] Differentiate between incomplete dominance and codominance. (Understanding) [SLO: B-12-G-10] Define multiple alleles and state the alleles

Grade 9	Grade 10	Grade 11	Grade 12
	cross. (Understanding, Application) [SLO: B-10-G-10] Describe gene mutation, using the example of sickle cell anaemia. (Knowledge) [SLO: B-10-G-11] Describe chromosomal mutation, using example of Down's syndrome. (Knowledge)		responsible for the trait of ABO blood groups. (Understanding, Application) [SLO: B-12-G-11] Investigate the reasons for O-negative individual as the Universal donor and AB-positive as the Universal recipient. (Understanding, Application) [SLO: B-12-G-12] Associate the positive and negative blood groups with the presence and absence of Rh factor. (Understanding) [SLO: B-12-G-13] Justify why Rh incompatibility could be a danger to the developing foetus and mother (Erythroblastosis fetalis). (Understanding, Application) [SLO: B-12-G-14] Suggest measures to counter the problem of Erythroblastosis fetalis before it occurs. (Understanding, Application) [SLO: B-12-G-15] Define the terms polygenic inheritance and epistasis. (Knowledge) [SLO: B-12-G-16] Describe polygenic inheritance using examples from plants (grain colour

Grade 9	Grade 10	Grade 11	Grade 12
			in wheat) and animals (skin colour in man). (Understanding, Application) [SLO: B-12-G-17] List at least five polygenic traits discovered in humans. (Knowledge) [SLO: B-12-G-18] Give one example of epistasis from mammals (albinism) and one from plants (flower colour in sweet pea) and justify modified Mendelian ratios. [SLO: B-12-G-19] Describe the terms gene-linkage and crossing-over and explain how linkage can be detected. (Understanding) [SLO: B-12-G-20] Explain that gene linkage counters independent assortment and crossing-over modifies the progeny. (Understanding) [SLO: B-12-G-21] Describe the three mechanisms of sex determination in animals (XX-XY, ZZ-ZW, XX-XO). (Understanding) [SLO: B-12-G-22] Describe the concept of sex linkage. (Understanding)

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			[SLO: B-12-G-23] Explain the discovery of sex-linked inheritance (eye colour in <i>Drosophila</i>). (Understanding) [SLO: B-12-G-24] Describe the Y-linked inheritance in terms of Holandric traits in males e.g., SRY gene and hypertrichosis. (Understanding) [SLO: B-12-G-25] Describe the X-linked disorders with reference to the patterns of inheritance (X-linked recessive traits e.g., red-green color blindness, haemophilia; X-linked dominant trait e.g., vitamin D-resistant rickets). (Understanding, Application) Chromosome and DNA [SLO: B-12-G-26] Annotate the detailed structure of a chromosome. (Understanding) [SLO: B-12-G-27] Narrate the experimental work which proved that DNA is the hereditary material. (Understanding, Application) [SLO: B-12-G-28] Describe the three models proposed about the

Grade 9	Grade 10	Grade 11	Grade 12
			mechanism of DNA replication. (Understanding) [SLO: B-12-G-29] Narrate the work of Meselson and Stahl to justify the semiconservative replication as the correct method of replication. (Understanding, Application) [SLO: B-12-G-30] Describe the events of semiconservative DNA replication. (Understanding) [SLO: B-12-G-31] Define gene (as a sequence of nucleotides as part of DNA, which codes for the formation of a polypeptide.) [SLO: B-12-G-32] Explain the mechanism of transcription. (Understanding) [SLO: B-12-G-33] Explain why the length of transcribed mRNA molecule (in Eukaryotes) shortens as it enters the cytoplasm for translation. (Understanding) [SLO: B-12-G-34] Differentiate between the terms genetic code and codon. (Understanding) [SLO: B-12-G-35] Describe the characteristics of genetic code (universal, triplet, non-overlapping,

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			degenerate, has no punctuation). (Understanding) [SLO: B-12-G-36] Describe the mechanism of protein synthesis (translation). (Understanding) [SLO: B-12-G-37] State the regulation of gene expression and its importance. (Knowledge) [SLO: B-12-G-38] Describe mechanism of regulation of gene expression (positive and negative control) with example of lac operon. (Understanding, Application) [SLO: B-12-G-39] Define mutation, mutagen, mutant, mutagenesis and identify various sources of mutation. (Understanding). [SLO: B-12-G-40] Differentiate between natural and induced mutations. (Understanding) [SLO: B-12-G-41] Justify that mutations may be harmful or useful (give one example of each). (Application) [SLO: B-12-G-42] Describe the symptoms, causes and treatments of some of the gene mutations (Sickle

Grade 9	Grade 10	Grade 11	Grade 12
			cell anemia, Phenylketonuria). (Understanding, Application) [SLO: B-12-G-43] Describe the symptoms, causes and possible treatments of some of the chromosomal mutations. (Down's, Klinefelter's and Turner's syndrome). (Understanding, Application)
	Evolution [SLO: B-10-G-12] Define evolution and explain the "theory of evolution by natural selection" with example. (Understanding) [SLO: B-10-G-13] Justify the development of strains of antibiotic-resistant bacteria as an example of natural selection. (Application) [SLO: B-10-G-14] Define variation and describe its types (continuous and discontinuous) with examples. (Understanding) [SLO: B-10-G-15] Describe the sources of variation. (Understanding)		Evolution [SLO: B-12-G-44] Differentiate between concept of evolution and special creation. (Understanding) [SLO: B-12-G-45] Analyze the evolution of eukaryotes from prokaryotes according to endosymbiotic theory and membrane invagination theory. (Understanding) [SLO: B-12-G-46] Explain evolution as described by Lamarck (Theory of Inheritance of Acquired characters) and described by Darwin (Theory of Natural Selection).. (Understanding)

Grade 9	Grade 10	Grade 11	Grade 12
	[SLO: B-10-G-16] Describe evidence of evolution with reference to fossil record biogeography. (Understanding) [SLO: B-10-G-18] Describe artificial selection (selective breeding) and its significance.		[SLO: B-12-G-47] Describe modern concepts of evolution (Neo-Darwinism). (Understanding) [SLO: B-12-G-48] Discuss the evidence of evolution provided by comparative anatomy, embryology, and molecular biology. (Understanding) [SLO: B-12-G-49] Differentiate between convergent and divergent evolution on the basis of homologous and analogous structures. (Understanding) [SLO: B-12-G-50] Define allele frequency, gene pool, and evolution at the population level. (Knowledge) [SLO: B-12-G-51] Describe the T-test to compare the means of two different samples. (Application) [SLO: B-12-G-52] Explain how the following factors may affect allele frequencies in populations; - selection, - migration (emigration and immigration) - the founder effect, and

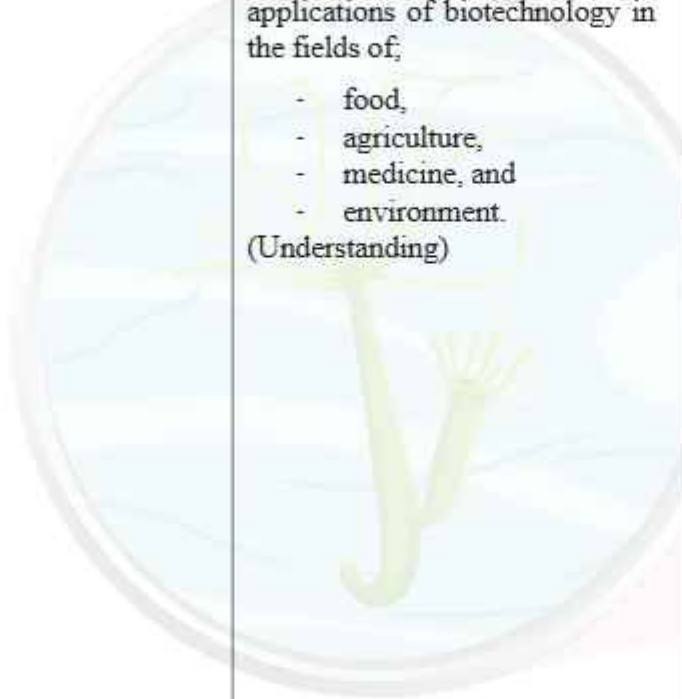
Grade 9	Grade 10	Grade 11	Grade 12
			- genetic drift, including the bottleneck effect. (Application) [SLO: B-12-G-53] Define Hardy-Weinberg principle, explain how is it used calculate allele & genotype frequencies, and mention the conditions required to maintain Hardy-Weinberg equilibrium. (Understanding, Application)

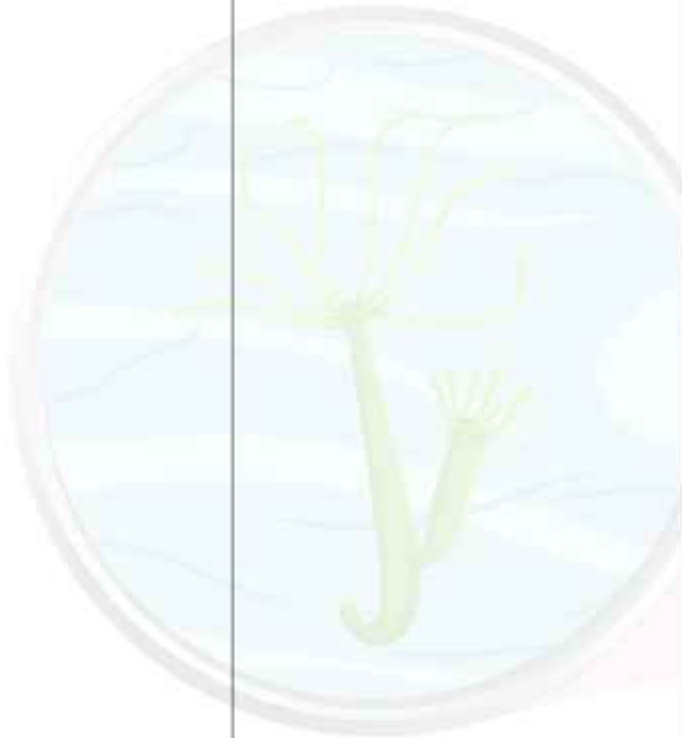
Domain H: Biotechnology

Standards:

1. Analyze the molecular tools and techniques used to manipulate genetic material in prokaryotic and eukaryotic systems.
2. Evaluate the application of biotechnology in solving global challenges through the production of recombinant proteins, the implementation of gene therapy etc.
3. Analyze the social, ethical, and environmental implications of biotechnological advancements.

Grade 9	Grade 10	Grade 11	Grade 12
Benchmarks: 1. Introduce the concept of genetic modification and describe the basic methods used to engineer organisms. 2. Justify why bacteria and yeast are essential biological tools for producing many products of interest. 3. Discuss the applications of biotechnology in food industry, medicine, and protection of environment. 4.		Benchmarks: 1. Explain gene editing as a precise form of genetic engineering. 2. Analyze the specific roles of enzymes in genetic engineering. 3. Evaluate advanced techniques including the Polymerase Chain Reaction, genome library and gel electrophoresis. 4. Synthesize the process of producing recombinant human proteins and the mechanisms of gene therapy and genetic screening. 5. Justify how biotechnology improves the quality of farmed animals and crops. 6. Discuss the potential risks of genetic modification and evaluate the social and ethical dilemmas surrounding genetic screening and gene therapy. 7. Formulate arguments regarding the use of GMOs in food production.	
 Biotechnology [SLO: B-10-H-01] Introduce biotechnology and differentiate between traditional (fermentation) and modern biotechnology (genetic engineering/modification). (Understanding/Application) [SLO: B-10-H-02] Justify the role of bacteria and yeast in biotechnology. (Understanding) [SLO: B-10-H-03] Describe the basic method of genetic engineering/genetic modification. (Understanding) [SLO: B-10-H-04] Define		 Biotechnology [SLO: B-12-H-01] Define genetic engineering. (Knowledge) [SLO: B-12-H-02] Define gene editing and justify that it is a form of genetic engineering. (Understanding) [SLO: B-12-H-03] State the roles of the following in recombinant DNA technology; - restriction endonuclease, - DNA ligase, - DNA polymerase, and - reverse transcriptase. (Knowledge)	

Grade 9	Grade 10	Grade 11	Grade 12
	genetically modified organisms. (Knowledge) [SLO: B-10-H-05] Discuss the applications of biotechnology in the fields of; - food, - agriculture, - medicine, and - environment. (Understanding) 		[SLO: B-12-H-04] Describe the characteristics essentially needed in a good vector by elaborating the example of pBR322 plasmid. (Understanding, Application) [SLO: B-12-H-05] Describe the synthesis of human insulin protein in bacteria using recombinant DNA technology. (Understanding, Application) [SLO: B-12-H-06] Explain polymerase chain reaction (PCR) enlist any three applications of PCR. (Understanding, Application) [SLO: B-12-H-07] Compare recombinant DNA technology and PCR as methods of gene cloning. (Understanding, Application) [SLO: B-12-H-08] Explain the principle of analyzing DNA (DNA Test/Fingerprinting) and explain its fundamental steps. (Understanding, Application) [SLO: B-12-H-09] Define the DNA sequencing and explain the Maxam-Gilbert Method and Sanger's method of DNA sequencing. (Understanding)

Grade 9	Grade 10	Grade 11	Grade 12
			[SLO: B-12-H-10] Describe the concept and application of genomic library. (Knowledge, Application) [SLO: B-12-H-11] Define genetic screening and state its advantages with examples. (Understanding) [SLO: B-12-H-12] Define gene therapy and describe its applications for treatment of hypercholesterolemia and Severe Combined Immunodeficiency (SCID). (Understanding, Application) [SLO: B-12-H-13] Define tissue culturing and describe plant tissue culturing techniques (meristem culture, cell suspension culture, anther culture) with their applications. (Understanding, Application) [SLO: B-12-H-14] Define bioethics and apply bioethical principles to real-world scenarios involving the development and use of biotechnological products. (Understanding, Application)

Grade 9	Grade 10	Grade 11	Grade 12
			[SLO: B-12-H-15] Discuss potential advantages and risks of genetic modification. (Application)

Domain I: Disease and immunity

Standards:

1. Evaluate the nature of infectious and non-infectious diseases, analyzing the transmission of pathogens and the efficacy of medical interventions such as antibiotics and vaccinations.
2. Explain the multi-layered defense systems of the human body, evaluating the distinction between non-specific (innate) and specific (adaptive) immunity and the cellular interactions required for effective immune responses.
3. Evaluate the molecular basis of immune-related disorders and modern clinical applications, including the role of histamines in allergies, the nature of autoimmune diseases, and the diagnostic use of monoclonal antibodies.

Benchmarks:

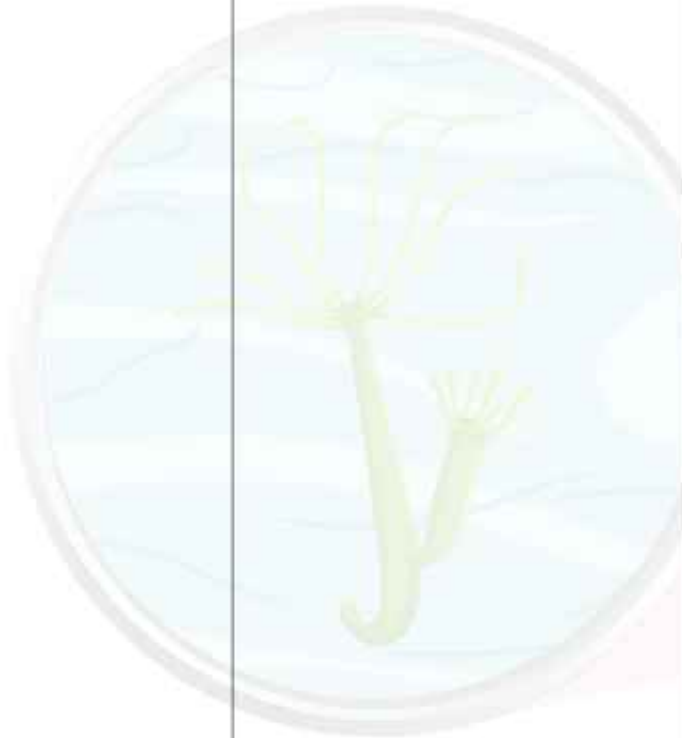
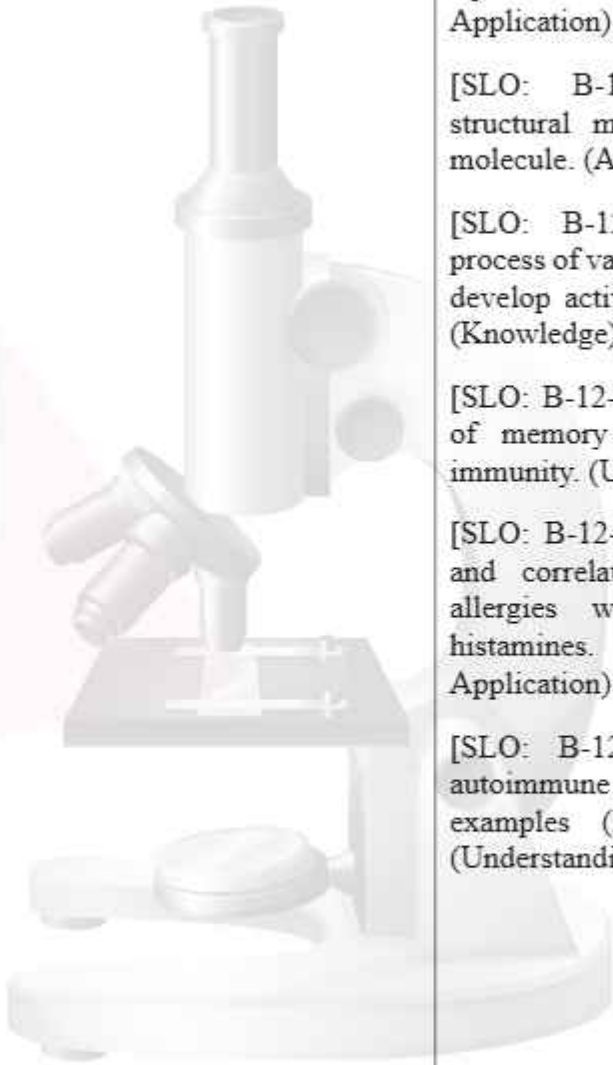
1. Classify diseases as infectious or non-infectious and describe the transmission of pathogens, including zoonotic and vector-borne diseases and allergies.
2. Explain the role of antibiotics in treating bacterial infections.
3. Describe the three lines of defense and the difference between innate and acquired immunity.
4. Identify the roles of active and passive immunity and outline the process of blood clotting.
5. Define antibodies and explain how they interact with antigens to neutralize threats.

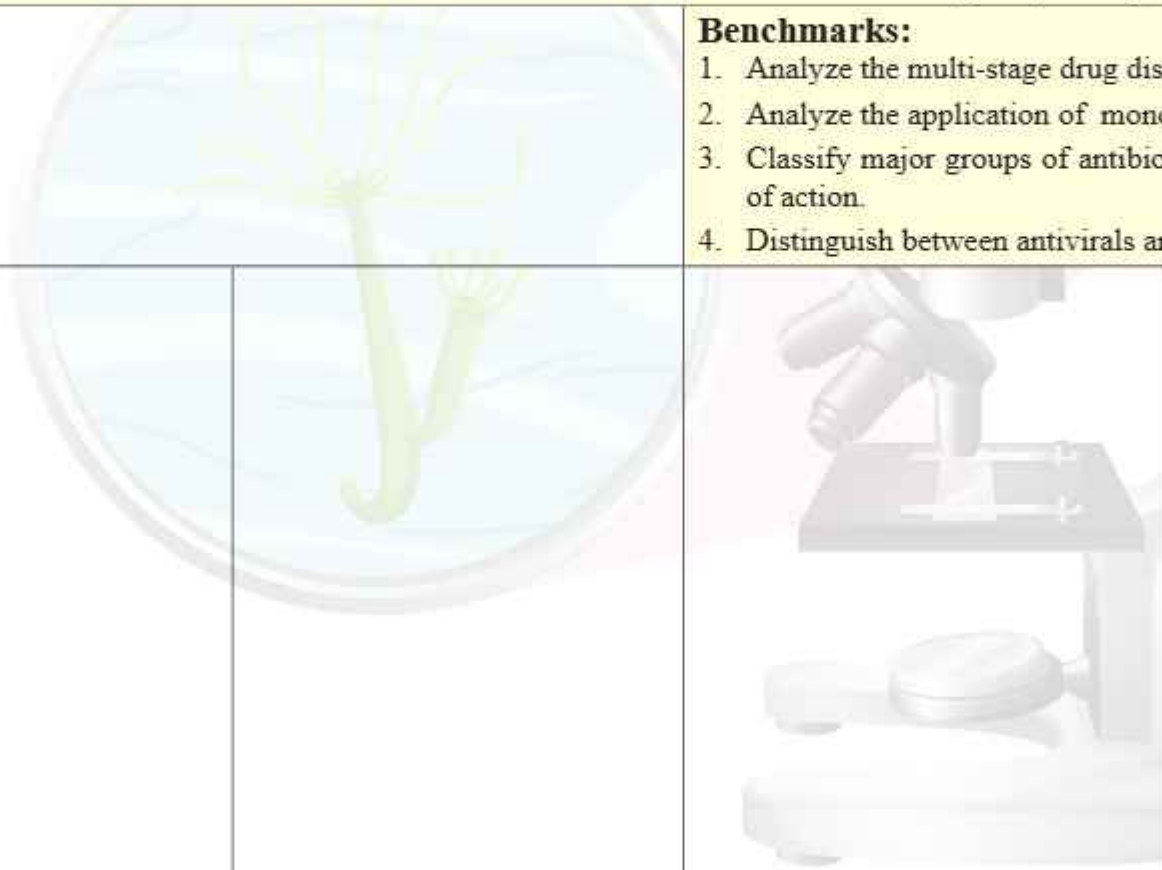
Benchmarks:

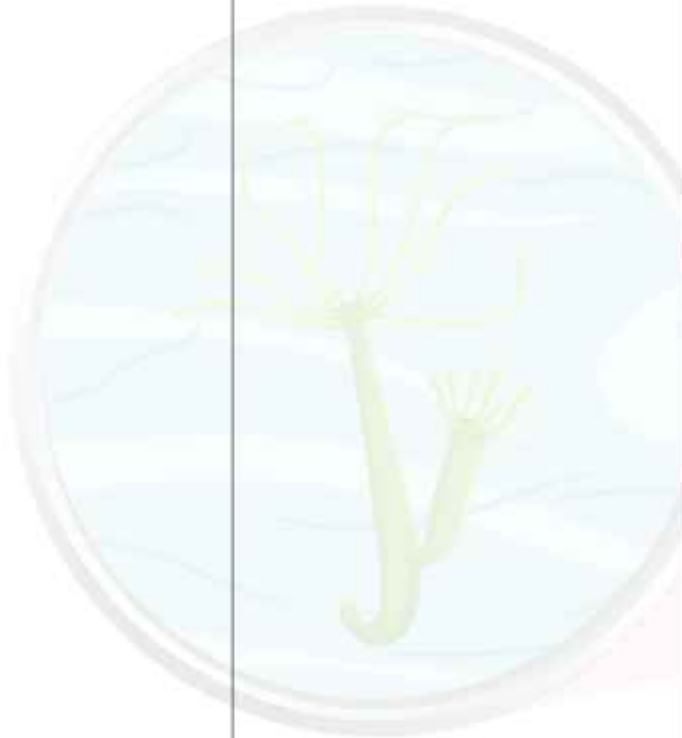
1. Evaluate the biochemical and physiological responses to infection.
2. Analyze the principles of public health strategies, such as the use of vaccines to induce long-term active acquired immunity via memory cells.
3. Analyze the specific roles of leukocytes in the second line of defense and the complement system.
4. Evaluate the 3rd line of defense, distinguishing between Cell-Mediated and Antibody-Mediated immunity.
5. Evaluate the molecular structure of antibodies and the applications of monoclonal antibodies.
6. Relate the release of histamines to allergic symptoms and analyze the failure of self-recognition in autoimmune diseases.

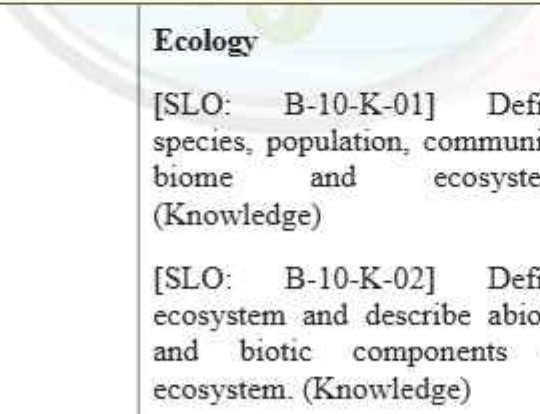
Grade 9	Grade 10	Grade 11	Grade 12
	Disease and Immunity [SLO: B-10-I-01] Define disease, illness, prevalence of disease, mortality and infestation. (Knowledge) [SLO: B-10-I-02] Define epidemiology, pandemic, endemic, and epidemic diseases. (Knowledge) [SLO: B-10-I-03] Describe infectious and non-infectious diseases with examples. (Understanding) [SLO: B-10-I-04] List the four types of pathogens (Viruses, Bacteria, Protozoans, Fungi) and name two diseases of each category (virus: AIDS, polio; bacteria: typhoid, TB; protozoans: malaria, amoebic dysentery; fungi: athlete's foot, ring worm). (Knowledge) [SLO: B-10-I-05] Define diabetes and its subtypes and describe the effects on the human body. (Knowledge) [SLO: B-10-I-06] Enlist allergies with some common types.		Immunity [SLO: B-12-I-01] State innate and acquired immunity as the two basic types of immunity. (Knowledge) [SLO: B-12-I-02] Differentiate between active (natural and artificial) and passive (natural and artificial) immunity as the two types of acquired immunity. (Understanding, Application) [SLO: B-12-I-03] Introduce the concept of three lines of defense and list the components of each. (Knowledge) [SLO: B-12-I-04] Explain the 1st line of defense provided by the skin, the acids of the digestive tract, and the epithelium of nasal cavity and the mucous of bronchi and bronchioles. (Knowledge, Understanding) [SLO: B-12-I-05] Describe the 2nd line of defense provided by macrophages, neutrophils and Natural Killer (NK) cells. (Knowledge, Understanding) [SLO: B-12-I-06] Describe the role of complement system and

Grade 9	Grade 10	Grade 11	Grade 12
	(Knowledge) [SLO: B-10-I-07] Define immunity and describe the main components of the immune system. (Knowledge) [SLO: B-10-I-08] Describe the types of immunity i.e., innate and acquired immunity and relate them with the first, second and third lines of defence. (Understanding) [SLO: B-10-I-09] State the types of acquired immunity i.e., - active immunity and - passive immunity. (Understanding) [SLO: B-10-I-10] Define antibodies and state how they attack antigens. (Understanding) [SLO: B-10-I-11] Discuss that vaccines help boost immunity with one example (polio vaccine). (Application)		interferons in second line of defense. (Understanding) [SLO: B-12-I-07] State and draw the events of the inflammatory response as a generalized, nonspecific defence. (Knowledge/Application) [SLO: B-12-I-08] Outline the release of pyrogens by microbes and their effect on the hypothalamus to boost the body's temperature. (Understanding) [SLO: B-12-I-09] List the ways that fever affects microbes. (Knowledge) [SLO: B-12-I-10] Define the 3rd line of defence in terms of specific immune system as providing specific defence. (Knowledge) [SLO: B-12-I-11] Describe the role of T-cells in cell-mediated immunity. (Understanding) [SLO: B-12-I-12] Describe the role of B-cells in antibody-mediated immunity. (Understanding) [SLO: B-12-I-13] Discuss the role of T-cells and B-cells in transplant

Grade 9	Grade 10	Grade 11	Grade 12
			rejections. (Understanding, Application) [SLO: B-12-I-14] Draw the structural model of an antibody molecule. (Application) [SLO: B-12-I-15] Identify the process of vaccination as a means to develop active acquired immunity. (Knowledge) [SLO: B-12-I-16] Explain the role of memory cells in long term immunity. (Understanding) [SLO: B-12-I-17] Define allergies and correlate the symptoms of allergies with the release of histamines. (Understanding, Application) [SLO: B-12-I-18] Describe the autoimmune diseases with examples (rheumatoid arthritis). (Understanding)

Grade 9	Grade 10	Grade 11	Grade 12
Domain J: Pharmacological Drugs			
Standards: 1. Evaluate the systematic process of pharmaceutical drug development and the clinical advantages of targeted therapies, such as monoclonal antibodies, over traditional drug classes. 2. Analyze the classification and mechanisms of action for various antimicrobial and antiviral agents, relating to their molecular structure.			
N/A		Benchmarks: 1. Analyze the multi-stage drug discovery and development process. 2. Analyze the application of monoclonal antibodies. 3. Classify major groups of antibiotics and explain their specific modes of action. 4. Distinguish between antivirals and anti-retroviral.	
			Pharmacology [SLO: B-12-J-01] Define pharmacology, pharmacokinetics, pharmacognosy and pharmaceutics. (Knowledge) [SLO: B-12-J-02] Explain the drug discovery and development process using the example of Aspirin (Acetyl salicylic acid). (Understanding, Application) [SLO: B-12-J-03] Define four classes of antibiotics on the basis of modes of action i.e., (Penicillins, Tetracyclines, Fluroquinolones and Sulfonamides). (Understanding)

Grade 9	Grade 10	Grade 11	Grade 12
			[SLO: B-12-J-04] Define antivirals and antiretrovirals with two examples of each. (Knowledge) [SLO: B-12-J-05] Evaluate the discovery of monoclonal antibodies and justify how it revolutionized modern healthcare. (Understanding, Application) [SLO: B-12-J-06] Define narcotic drugs as agents that interact with the normal nervous activity. (Knowledge) [SLO: B-12-J-07] Describe the harmful effect of narcotic drugs on the social and moral values and health conditions of drug addicts. (Application) [SLO: B-12-J-08] Explain the terms; drug addiction and drug tolerance with reference to caffeine and nicotine and their adverse effects. (Understanding, Application) [SLO: B-12-J-09] Describe the way how pain medicines can reduce or numb pain in the human body. (Understanding)

Grade 9	Grade 10	Grade 11	Grade 12
Domain K: Ecology Standards: 1. Evaluate the levels of ecological organization and analyze the factors that regulate population growth, density, and carrying capacity of ecosystem. 2. Analyze the movement of matter through biogeochemical cycles and the flow of energy within ecosystems. 3. Assess the impact of the greenhouse effect and climate change on global flora and fauna, while investigating the unique characteristics and conservation status of major regional ecosystems.			
Benchmarks: 1. Describe and explain the basic principles of ecology and its components. 2. Evaluate the impacts of human activities on ecosystems and biodiversity. 3. Explain the greenhouse effect and evaluate the impact of climate change on biodiversity 4. Evaluate the Water cycle in detail and synthesize the connection between cycle disruptions and ecosystem stability.		Benchmarks: 1. Analyze the quantitative and qualitative characteristics of populations. 2. Evaluate the sustainability of population growth in relation to resource availability. 3. Evaluate the Nitrogen cycle in detail and synthesize the connection between cycle disruptions and ecosystem stability. 4. Describe the structural and biological characteristics of the four major ecosystems of Pakistan.	
 Ecology [SLO: B-10-K-01] Define species, population, community, biome and ecosystem. (Knowledge) [SLO: B-10-K-02] Define ecosystem and describe abiotic and biotic components of ecosystem. (Knowledge) [SLO: B-10-K-03] Explain the greenhouse effect with examples			Ecology and Climate Change [SLO: B-12-K-01] Define biogeochemical cycles and locate the primary reservoirs of the chemicals in these cycles. (Understanding) [SLO: B-12-K-02] Discuss and sketch nitrogen cycle in detail. (Understanding, Application)

Grade 9	Grade 10	Grade 11	Grade 12
	of gases that exhibit this behaviour. (Understanding, Application) [SLO: B-10-K-04] Describe the harmful effects of greenhouse gases on the environment. (Understanding/Application) [SLO: B-10-K-05] Describe the water cycle in detail. (Understanding) [SLO: B-10-K-06] Define the terms aquifers and water table. (Knowledge) [SLO: B-10-K-07] Define trophic levels. (Knowledge) [SLO: B-10-K-08] Discuss the flow and loss of energy between trophic levels. (Understanding) [SLO: B-10-K-09] Interpret the pyramids of number, biomass and energy. (Understanding, Application)		[SLO: B-12-K-03] Describe characteristics of a population e.g.: - growth, - density, - distribution, - carrying capacity, and - minimum/viable size. (Understanding) [SLO: B-12-K-04] Explain the effect of growth of human population on the ecosystem. (Understanding, Application) [SLO: B-12-K-05] Describe the three important ecosystems of Pakistan (temperate deciduous forest, grassland and desert ecosystem) with important characteristics such as temperature range, average rainfall, flora, fauna, and human impact. (Understanding, Application) [SLO: B-12-K-06] Define climate change and explain the natural and human (anthropogenic) factors causing climate change. (Understanding, Application) [SLO: B-12-K-07] Describe how climate change impacts flora and

Grade 9	Grade 10	Grade 11	Grade 12
			fauna. (Understanding, Application) [SLO: B-12-K-08] Name species that have gone extinct due to climate change. (Knowledge)
Domain L: Biostatistics and Data Handling Standards: 1. Apply statistical tools to handle biological data and evaluate the significance of results through measures of central tendency, dispersion, and precision. 2. Demonstrate the ability to design scientifically valid experiments by identifying variables, establishing appropriate control groups, and ensuring the reliability of data collection. 3. Synthesize biological findings into appropriate visual formats.			
N/A		Benchmarks: 1. Calculate and interpret the mean, median, mode, range, and standard deviation for biological datasets. 2. Evaluate data distribution using percentiles and apply standard deviation. 3. Design a comprehensive experimental protocol justifying the necessity of a control group and identification of dependent, independent and controlled variables. 4. Construct technically precise bar charts, pie charts, X-Y scatter plots featuring descriptive titles, labeled axes with SI units, and legends.	
			Biostatistics and Data Handling [SLO: B-12-L-01] Define and calculate mean, median, mode, standard deviation, range,

Grade 9	Grade 10	Grade 11	Grade 12
			percentile from a given set of data. (Understanding, Application) [SLO: B-12-L-02] Sketch a bar chart and error bars (of range or standard deviation) for a given set of data. (Understanding, Application) [SLO: B-12-L-03] Evaluate the appropriate type of figure or chart for a given set of data and/or experiment e.g., - bar chart, - pie chart, - X- Y axis data figure etc. (Understanding, Application) [SLO: B-12-L-04] Make the appropriate chart with proper title, labelled axes, legend, axes units. (Application) [SLO: B-12-L-05] Design an appropriate experiment with a control group and dependent, independent and control variables. (Understanding, Application)

Grade 9	Grade 10	Grade 11	Grade 12
Domain M: Experimentation Skills			
Standards:			
1. Master the preparation and analysis of biological specimens, utilizing specialized staining and micrometric tools to quantify cellular structures. 2. Design and execute controlled experiments to investigate metabolic processes, enzyme kinetics, and physiological responses. 3. Use specimens, virtual simulations, and physical models to identify diagnostic features of living organisms and analyze the structural-functional relationships of major organ systems. 4. Demonstrate the ability to organize, analyze, and validate experimental data using statistical tools and graphical representations. 5. Demonstrate knowledge of common experimental terminology and how to select and safely use techniques, apparatus and materials.			
Benchmarks:		Benchmarks:	
1. Apply basic slide preparation and staining techniques to observe and sketch plant and animal cells. 2. Calculate magnification and identify specialized tissues and stages of mitosis/meiosis in permanent slides. 3. Identify diagnostic morphological features for classification and utilize physical models to explore the gross anatomy of organ systems. 4. Perform standard food tests and investigate the effects of different factors on enzyme activity. 5. Demonstrate the requirements for photosynthesis and respiration. 6. Organize observational data into structured tables and translate findings into basic graphical formats. 7. Identify independent and dependent variables within a simple investigative context.		1. Master differential staining and the use of stage micrometers and eyepiece graticules to measure cell wall thickness and stomatal dimensions. 2. Analyze the ultrastructure of different tissues from prepared slides. 3. Execute advanced biochemical techniques, including paper chromatography and potato osmometers. 4. Evaluate structural-functional relationships through comparative anatomical study. 5. Perform experiments to investigate different phenomena in plants and humans. 6. Apply rigorous statistical tests to determine the significance of results.	

Grade 9	Grade 10	Grade 11	Grade 12
[SLO: B-09-M-01] Use of microscope to measure the sizes of various types of cells. [SLO: B-09-M-02] Calculation of the magnification of biological specimens. [SLO: B-09-M-03] Observation of various stages of mitosis by slides, model and charts. [SLO: B-09-M-04] Observation of various stages of meiosis by slides, model and charts. [SLO: B-09-M-05] Preparation of slides of animal cells (e.g., cheek cells) and examining them under the microscope using a staining techniques, such as iodine or methylene blue. [SLO: B-09-M-06] Preparation of slides of plant cells (e.g., from onion epidermis) and examining them under the microscope using a staining techniques, such as iodine or methylene blue.	[SLO: B-10-M-01] Comparing the content of inhaled and exhaled air using limewater or hydrogen-carbonate indicator. [SLO: B-10-M-02] Comparing the breathing rate at rest and after exercise. [SLO: B-10-M-03] Investigation of the effect of physical activity on pulse rate. [SLO: B-10-M-04] Examination of the structure of kidney (sheep kidney / model). [SLO: B-10-M-05] Observation of the contraction in the shin muscle of frog in a Petri dish filled with methylene blue and using 12 V DC current. [SLO: B-10-M-06] Recording the heights of class-fellows to predict which kind of variation is it and presentation of the data of class fellows' heights in graphical form (either histogram or barchart). [SLO: B-10-M-07] Identify and explain the functions and proper uses of different laboratory	[SLO: B-11-M-01] Setting up a light microscope and measuring the size of a tissue or cell using eye piece graticule or ocular micrometer and stage micrometer. [SLO: B-11-M-02] Measuring the actual size, image size and magnification of a tissue or cell from photomicrographs using scale bar or millimeter ruler. [SLO: B-11-M-03] Finding and drawing particular plant tissues from the permanent slides of: - Transverse Section (TS) Monocot root, - TS of Dicot root, - TS of Monocot stem, - TS of Dicot stem, and - TS of Bifacial leaf. [SLO: B-11-M-04] Finding and drawing particular animal specimens from permanent slides of: - TS of seminiferous tubules in human testes, - TS of Graafian follicle in human ovary,	[SLO: B-12-M-01] Extraction of the leaf pigments and their separation by paper chromatography. [SLO: B-12-M-02] Measuring variability in leaf surface area by graph paper method using different plant species. [SLO: B-12-M-03] Demonstration of the evolution of CO₂ from leaf discs placed in dark and light, with the help of indicator (hydrogen carbonate). [SLO: B-12-M-04] Study of plasmolysis in epidermal peels (e.g., lily leaves or flashy scale leaves of onion bulb). [SLO: B-12-M-05] Study of distribution of stomata on the upper and lower surfaces of leaves. [SLO: B-12-M-06] Comparative study of the rates of transpiration in the upper and lower surfaces of leaves. [SLO: B-12-M-07] Correlating the lub-dub sounds of the

Grade 9	Grade 10	Grade 11	Grade 12
[SLO: B-09-M-07] Investigation of the effects of temperature on enzyme activity e.g., pepsin working on meat in test tube or working of amylase on starch. [SLO: B-09-M-08] Demonstration of the process of photosynthesis using an aquatic plant, like <i>Hydrilla</i>. [SLO: B-09-M-09] Investigation of the necessity of chlorophyll for photosynthesis. [SLO: B-09-M-10] Investigation of the necessity of light for photosynthesis. [SLO: B-09-M-11] Investigation of the necessity of carbon dioxide for photosynthesis. [SLO: B-09-M-12] Investigation of the effect of light on net gas exchange from a leaf, using hydrogen-carbonate indicator. [SLO: B-09-M-13] Investigation of the release of carbon dioxide and heat during	apparatus, and apply laboratory safety rules and procedures while conducting experiments. 	c. TS of artery, vein and capillary, and d. TS of pancreas (Islets of Langerhans). [SLO: B-11-M-05] Preparation of temporary slides of animal cells using differential staining and their identification under light microscope: - Squamous epithelium (skin) of frog or blood cells from human blood smear, - Epithelial cells of human oral cavity (cheek cells). [SLO: B-11-M-06] Preparation of temporary slides of plant cells using differential staining and their identification under light microscope: - Leaf epidermis (stomata, guard cells and epidermal cells), - Onion epidermal cells. [SLO: B-11-M-07] Observation of specimens/slides/models and identification with reasons - kingdom Protista (Protozoa,	closing of heart valves with the monitoring of the heartbeat. [SLO: B-12-M-08] Determination of human height or weight variability among students of same age group. [SLO: B-12-M-09] Data collection from class to see how many individuals have AB blood group and construction of pie chart and histogram for the collected data. [SLO: B-12-M-10] Testing of blood group using antisera and performing agglutination reaction for Rh factor. [SLO: B-12-M-11] Observation of human skeleton and different types of joints with the help of virtual images/models only. [SLO: B-12-M-12] To investigate how much a bacterial pathogen shows sensitivity or resistance to a particular antibiotic by Disc Diffusion Method (Kirby-Bauer test)

Grade 9	Grade 10	Grade 11	Grade 12
aerobic respiration in germinating seeds. [SLO: B-09-M-14] Food tests: Benedict's test for reducing sugar. [SLO: B-09-M-15] Food tests: iodine test for starch. [SLO: B-09-M-16] Food tests: spot test and emulsion test for fat. [SLO: B-09-M-17] Food tests: Biuret test for protein. [SLO: B-09-M-18] Measurement of differences in length/weight of raw potato strips in concentrated salt solution and water. [SLO: B-09-M-19] Investigation of transpiration in potted plant under a bell jar. [SLO: B-09-M-20] Investigation of the effects of wind speed on transpiration rate. [SLO: B-09-M-21] Investigation of the effects of light intensity on transpiration		algae, Myxomycota and Oomycota). [SLO: B-11-M-08] Identification and drawing of different parts of sporophyte and gametophyte generations of a fern (<i>Adiantum</i>) through specimen and prepared slides. [SLO: B-11-M-09] Study of the structure of flower and floral characteristics of a Monocot (<i>Avena sativa</i>) and one Dicot (<i>Brassica campestris</i> or <i>Rosa indica</i>). [SLO: B-11-M-10] Observation of specimens/slides/models and identification of Amoeba, Hydra, liver fluke, and Ascaris. [SLO: B-11-M-11] Observation of specimens/slides/models and identification of - leech, earthworm, prawn, silkworm, honey bee, snail, starfish, shark, rohu, frog, lizard, pigeon and rabbit. [SLO: B-11-M-12] Observing mitosis in onion root tip cells	[SLO: B-12-M-13] Study of following biostatistical parameters from Grade 11 (Experiment No. 13 to 17) and Grade 12 (Experiment No. 2 to 5 and 17 to 19) OR given data from medical or agriculture fields. - Identification of independent (continuous, discontinuous), dependent & controlled variables. - Planning of control and experimental groups. - Data presentation in the form of tables, bar chart, histogram, line graph, pie chart. - Calculation of mean, median, mode, range, standard deviation. [SLO: B-12-M-14] Identify and explain the functions and proper uses of different laboratory apparatus, and apply laboratory safety rules and procedures while conducting experiments.

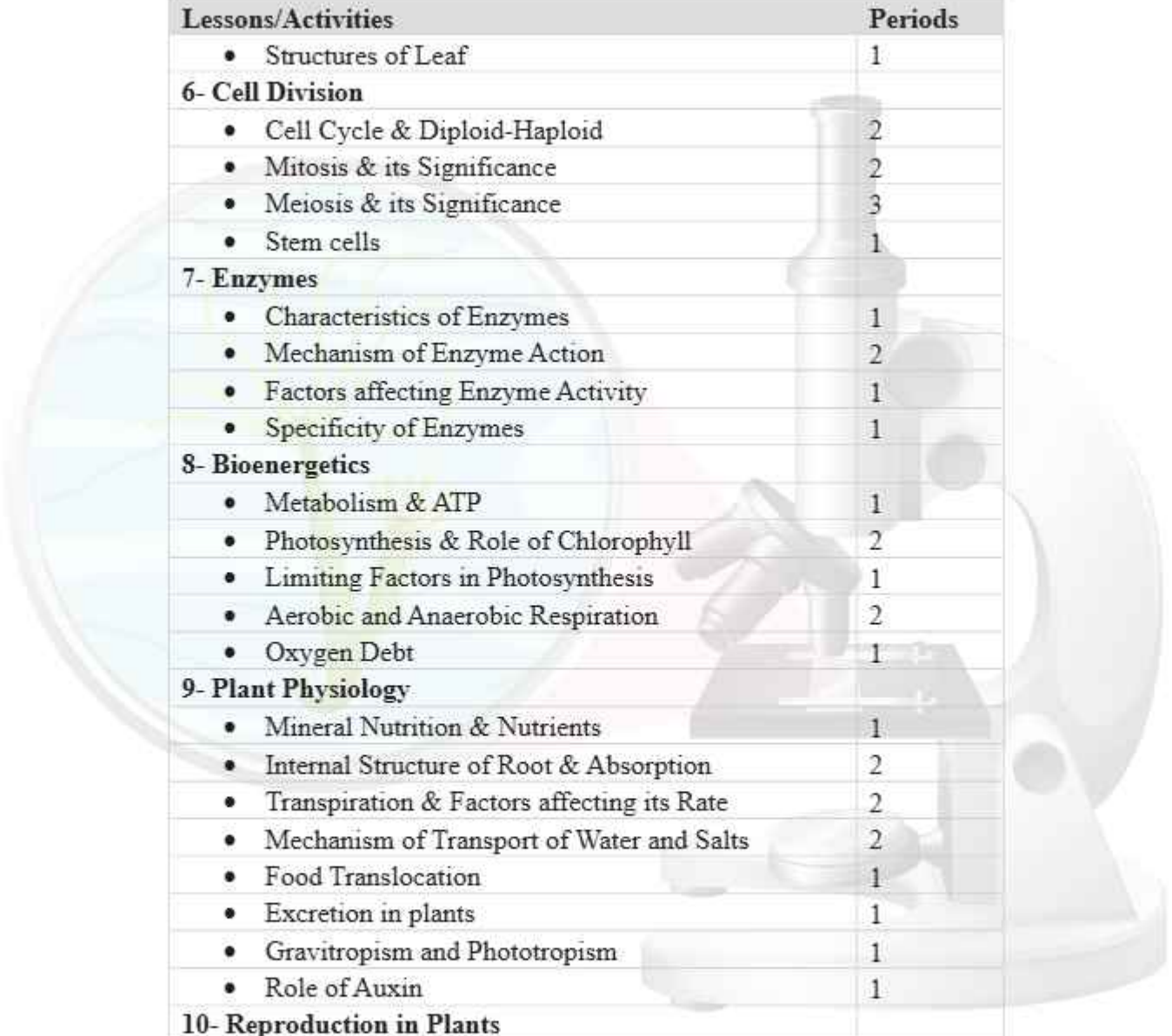
Grade 9	Grade 10	Grade 11	Grade 12
rate. [SLO: B-09-M-22] Investigation of the effects of temperature variation on transpiration rate. [SLO: B-09-M-23] Identification of xylem and phloem tissues in the prepared slides of stem, root and leaf. [SLO: B-09-M-24] Investigation of the conditions (temperature, availability of oxygen, and availability of water) for seed germination. [SLO: B-09-M-25] Demonstration of anaerobic respiration in yeast in different conditions (e.g., temperature, concentration of glucose). [SLO: B-09-M-26] Identify and explain the functions and proper uses of different laboratory apparatus, and apply laboratory safety rules and procedures while conducting experiments.		and animal's cells (grasshopper) from permanent slides. [SLO: B-11-M-13] Performing Benedict's test for reducing sugars and confirmation of the presence of starch through Iodine test. [SLO: B-11-M-14] Confirmation of the presence of proteins through Biuret test [SLO: B-11-M-15] Confirmation of the presence of lipids through Emulsion test. [SLO: B-11-M-16] Performing chemical test to demonstrate that enzymes are proteins. [SLO: B-11-M-17] Performing amylase test on starch with boiled amylase and un-boiled amylase in separate test tubes and confirmation through iodine test. [SLO: B-11-M-18] Identify and explain the functions and proper uses of different laboratory apparatus, and apply laboratory safety rules and procedures while conducting experiments.	

Time Allocations (in Terms of Number of Periods)

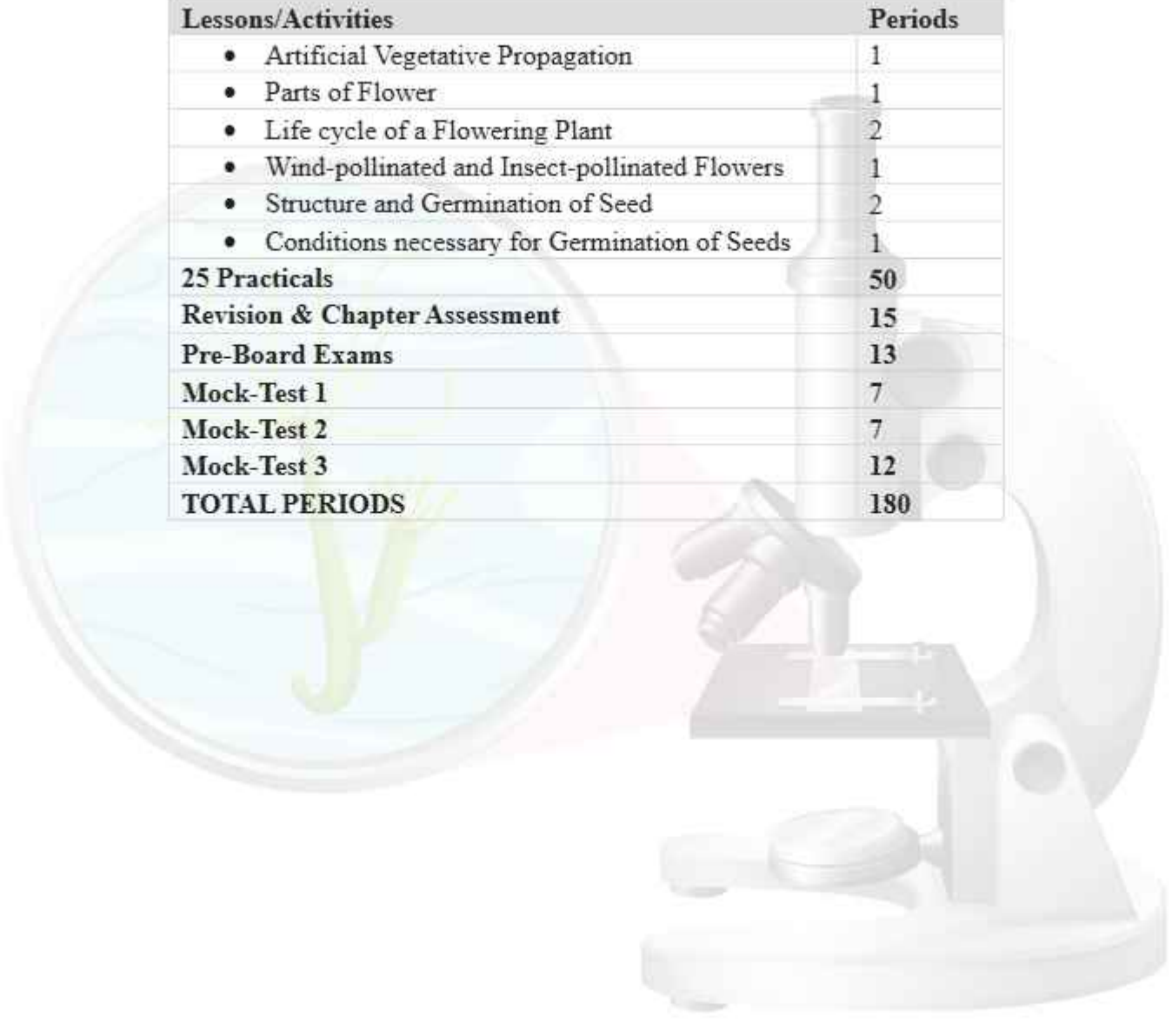
Tentative Time Allocations for Grade 9



Lessons/Activities	Periods
1- Introduction to Biology	
• Bio Into & Branches	1
• Scientific Method	3
• Biostatistics	3
2- Classification	
• Classification & Three Domain	1
• Five Kingdoms	2
• Taxonomic Ranks & Status of Virus	1
• Binomial Nomenclature	1
3- Biological Molecules	
• Proteins	1
• Lipids	1
• Carbohydrates	2
• Nucleic Acids	2
• Chemical Tests	2
4- Cells	
• Structure of Cell	3
• Prokaryotic and Eukaryotic Cells	1
• Types of Cells	1
• Role of Cell Membrane	1
• Movements of Material	2
• Turgor	1
5- Levels of Organization	
• Cell Specialization & Levels of Organization	1
• Major Animal Tissues	1
• Major Plant Tissues	2

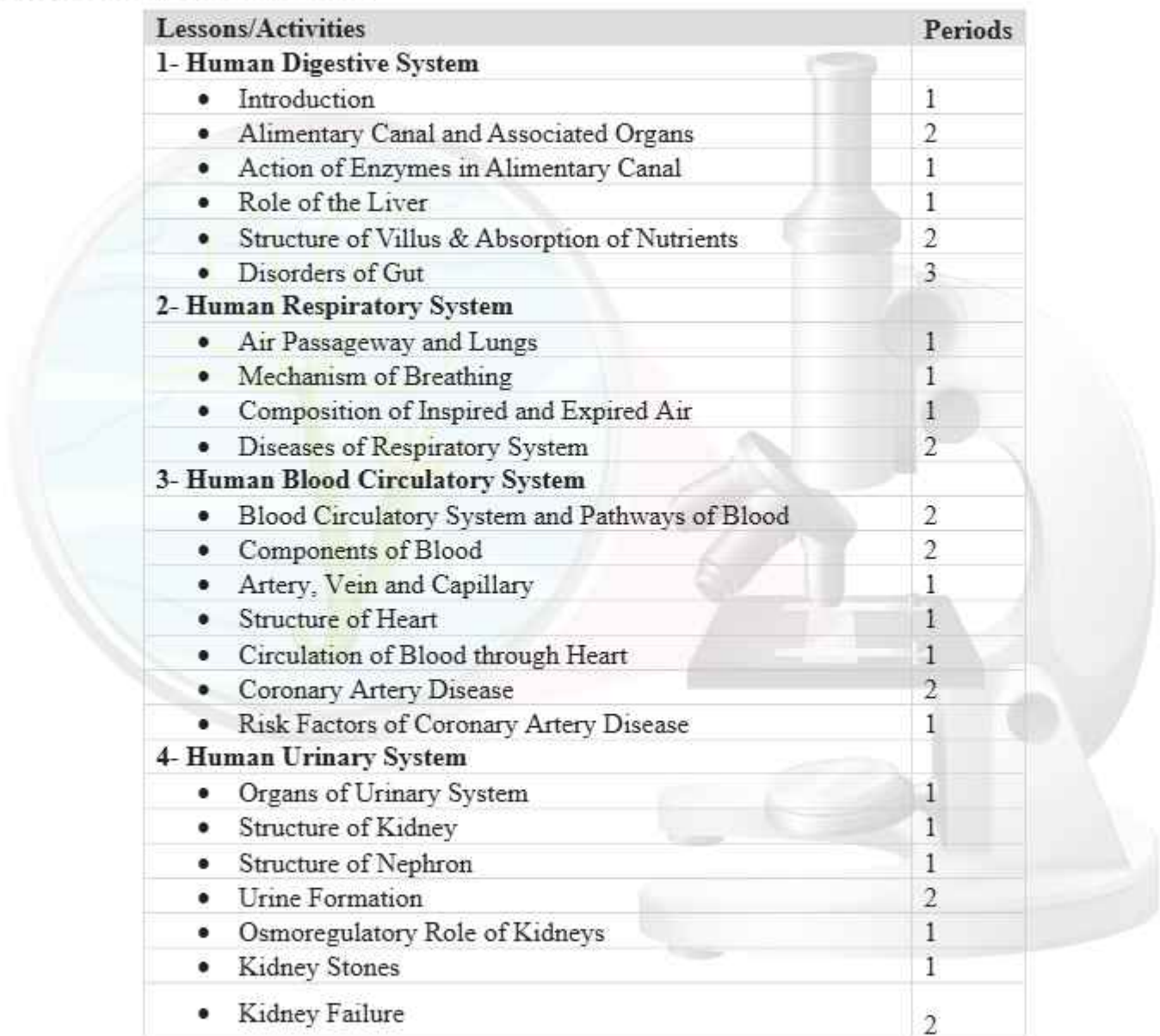


Lessons/Activities	Periods
• Structures of Leaf	1
6- Cell Division	
• Cell Cycle & Diploid-Haploid	2
• Mitosis & its Significance	2
• Meiosis & its Significance	3
• Stem cells	1
7- Enzymes	
• Characteristics of Enzymes	1
• Mechanism of Enzyme Action	2
• Factors affecting Enzyme Activity	1
• Specificity of Enzymes	1
8- Bioenergetics	
• Metabolism & ATP	1
• Photosynthesis & Role of Chlorophyll	2
• Limiting Factors in Photosynthesis	1
• Aerobic and Anaerobic Respiration	2
• Oxygen Debt	1
9- Plant Physiology	
• Mineral Nutrition & Nutrients	1
• Internal Structure of Root & Absorption	2
• Transpiration & Factors affecting its Rate	2
• Mechanism of Transport of Water and Salts	2
• Food Translocation	1
• Excretion in plants	1
• Gravitropism and Phototropism	1
• Role of Auxin	1
10- Reproduction in Plants	
• Asexual and Sexual reproduction	1
• Vegetative Propagation	2

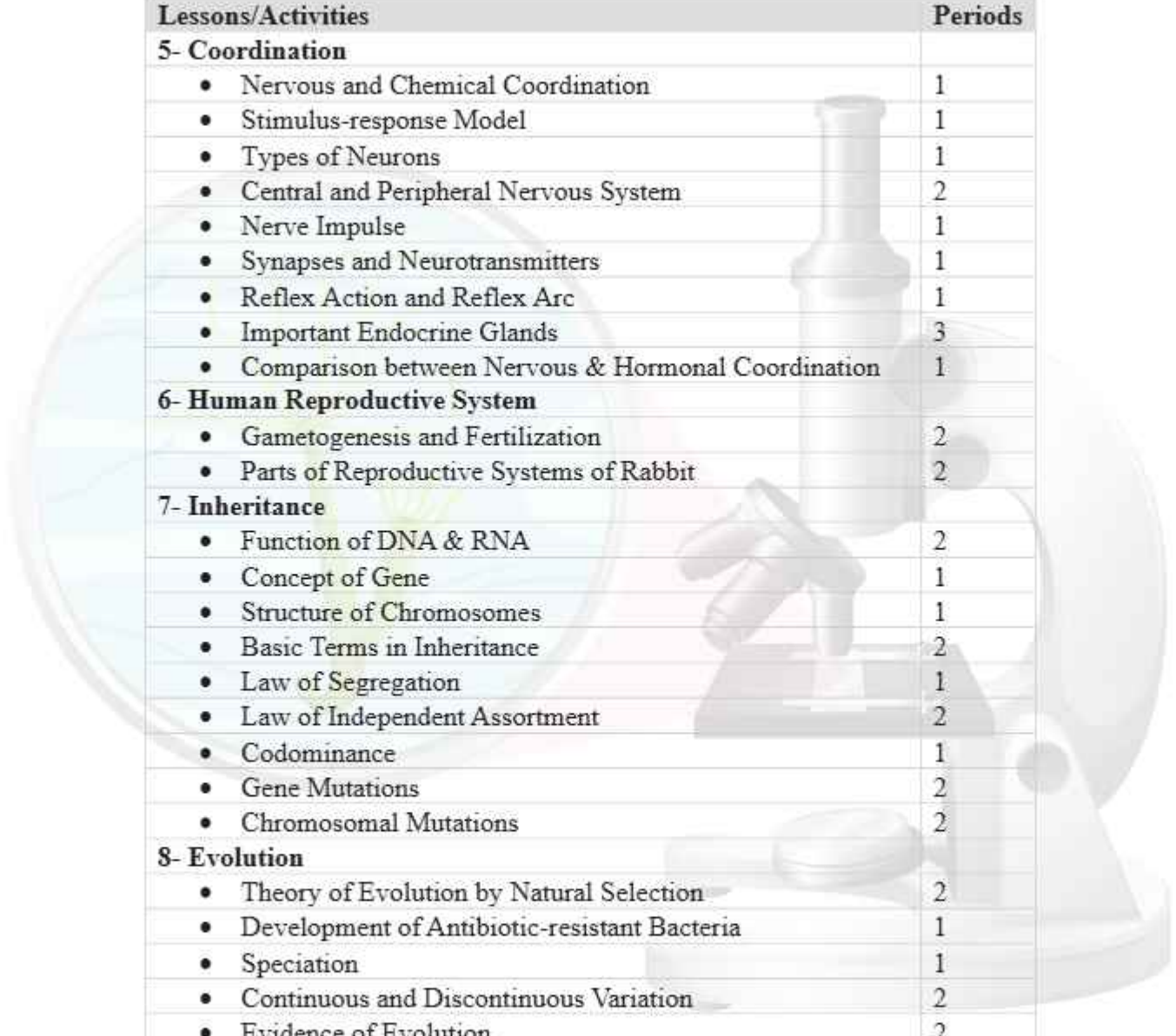


Lessons/Activities	Periods
• Artificial Vegetative Propagation	1
• Parts of Flower	1
• Life cycle of a Flowering Plant	2
• Wind-pollinated and Insect-pollinated Flowers	1
• Structure and Germination of Seed	2
• Conditions necessary for Germination of Seeds	1
25 Practicals	50
Revision & Chapter Assessment	15
Pre-Board Exams	13
Mock-Test 1	7
Mock-Test 2	7
Mock-Test 3	12
TOTAL PERIODS	180

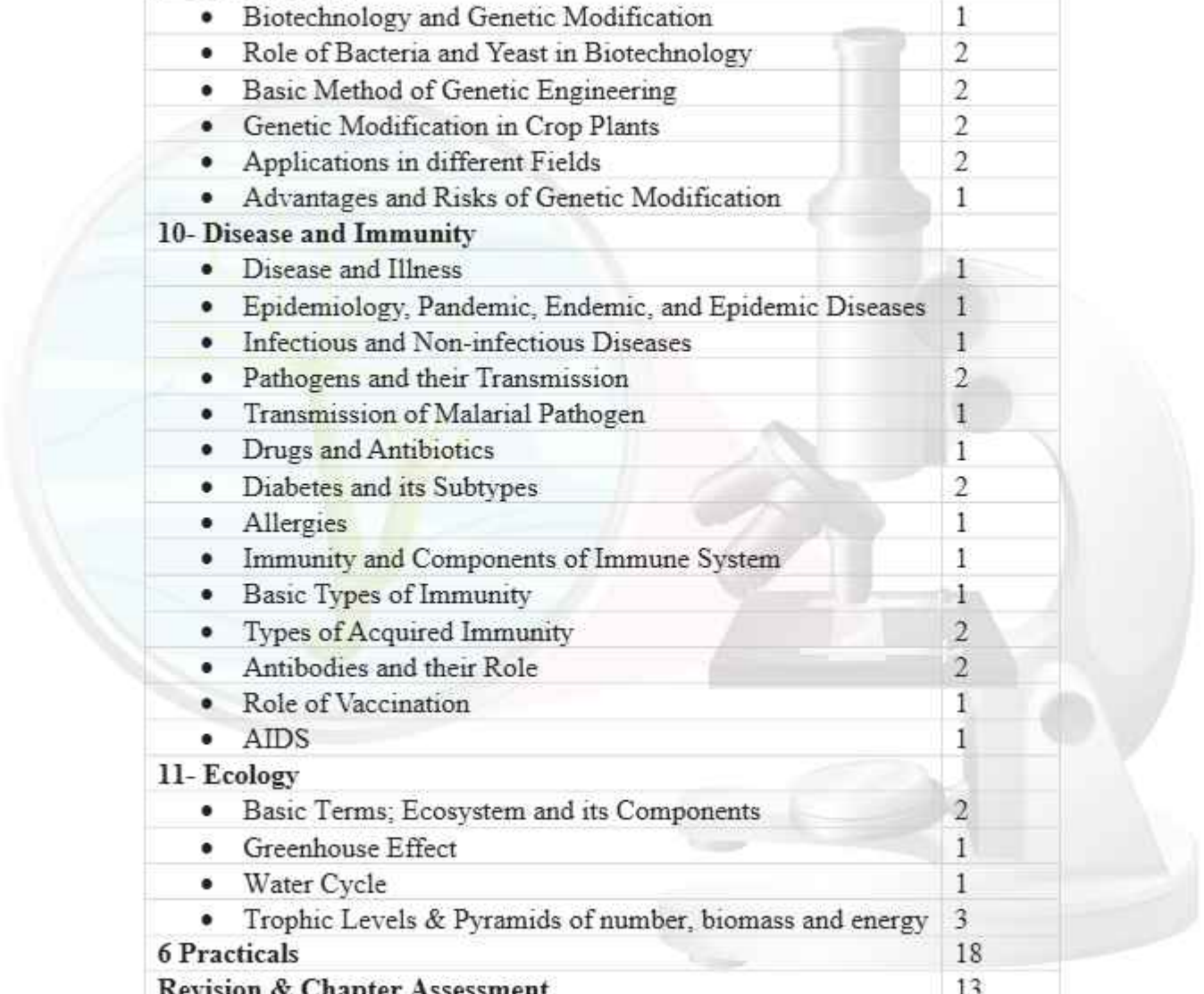
Tentative Time Allocations for Grade 10



Lessons/Activities	Periods
1- Human Digestive System	
• Introduction	1
• Alimentary Canal and Associated Organs	2
• Action of Enzymes in Alimentary Canal	1
• Role of the Liver	1
• Structure of Villus & Absorption of Nutrients	2
• Disorders of Gut	3
2- Human Respiratory System	
• Air Passageway and Lungs	1
• Mechanism of Breathing	1
• Composition of Inspired and Expired Air	1
• Diseases of Respiratory System	2
3- Human Blood Circulatory System	
• Blood Circulatory System and Pathways of Blood	2
• Components of Blood	2
• Artery, Vein and Capillary	1
• Structure of Heart	1
• Circulation of Blood through Heart	1
• Coronary Artery Disease	2
• Risk Factors of Coronary Artery Disease	1
4- Human Urinary System	
• Organs of Urinary System	1
• Structure of Kidney	1
• Structure of Nephron	1
• Urine Formation	2
• Osmoregulatory Role of Kidneys	1
• Kidney Stones	1
• Kidney Failure	2

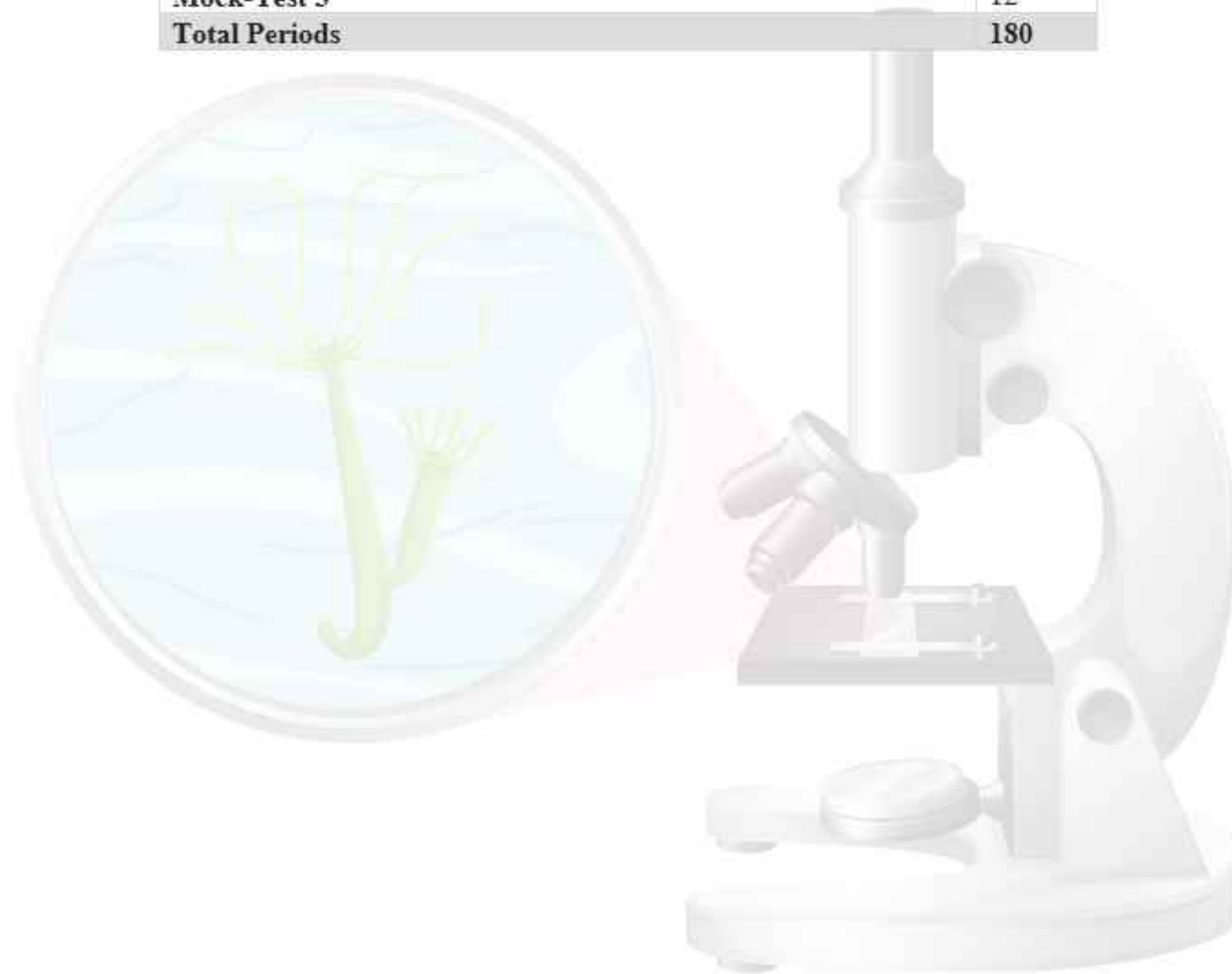


Lessons/Activities	Periods
5- Coordination	
• Nervous and Chemical Coordination	1
• Stimulus-response Model	1
• Types of Neurons	1
• Central and Peripheral Nervous System	2
• Nerve Impulse	1
• Synapses and Neurotransmitters	1
• Reflex Action and Reflex Arc	1
• Important Endocrine Glands	3
• Comparison between Nervous & Hormonal Coordination	1
6- Human Reproductive System	
• Gametogenesis and Fertilization	2
• Parts of Reproductive Systems of Rabbit	2
7- Inheritance	
• Function of DNA & RNA	2
• Concept of Gene	1
• Structure of Chromosomes	1
• Basic Terms in Inheritance	2
• Law of Segregation	1
• Law of Independent Assortment	2
• Codominance	1
• Gene Mutations	2
• Chromosomal Mutations	2
8- Evolution	
• Theory of Evolution by Natural Selection	2
• Development of Antibiotic-resistant Bacteria	1
• Speciation	1
• Continuous and Discontinuous Variation	2
• Evidence of Evolution	2
• Artificial Selection	1



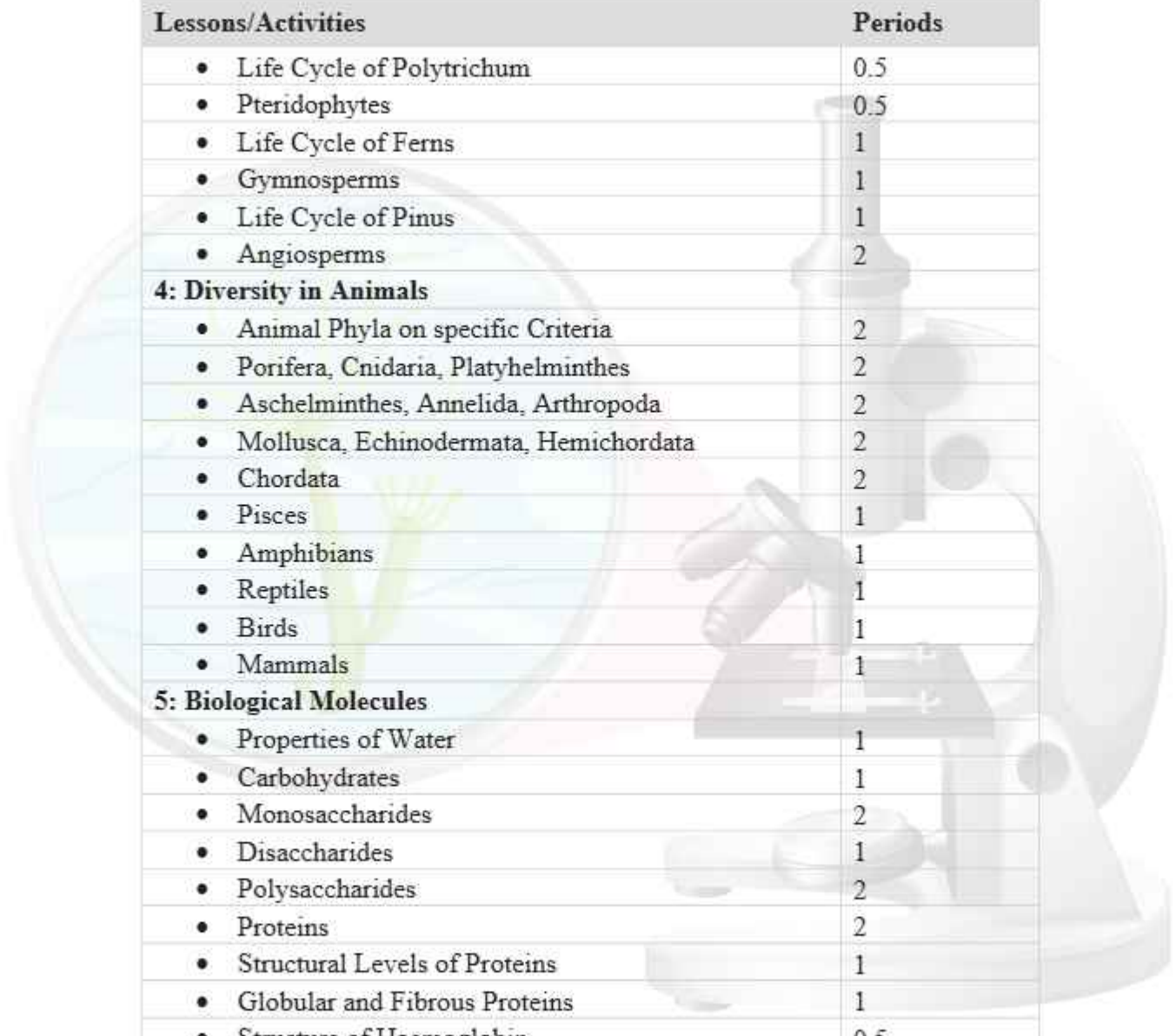
Lessons/Activities	Periods
9- Biotechnology	
• Biotechnology and Genetic Modification	1
• Role of Bacteria and Yeast in Biotechnology	2
• Basic Method of Genetic Engineering	2
• Genetic Modification in Crop Plants	2
• Applications in different Fields	2
• Advantages and Risks of Genetic Modification	1
10- Disease and Immunity	
• Disease and Illness	1
• Epidemiology, Pandemic, Endemic, and Epidemic Diseases	1
• Infectious and Non-infectious Diseases	1
• Pathogens and their Transmission	2
• Transmission of Malarial Pathogen	1
• Drugs and Antibiotics	1
• Diabetes and its Subtypes	2
• Allergies	1
• Immunity and Components of Immune System	1
• Basic Types of Immunity	1
• Types of Acquired Immunity	2
• Antibodies and their Role	2
• Role of Vaccination	1
• AIDS	1
11- Ecology	
• Basic Terms; Ecosystem and its Components	2
• Greenhouse Effect	1
• Water Cycle	1
• Trophic Levels & Pyramids of number, biomass and energy	3
6 Practicals	18
Revision & Chapter Assessment	13
Pre-Board Exams	13
Mock-Test 1	7

Lessons/Activities	Periods
Mock-Test 2	7
Mock-Test 3	12
Total Periods	180

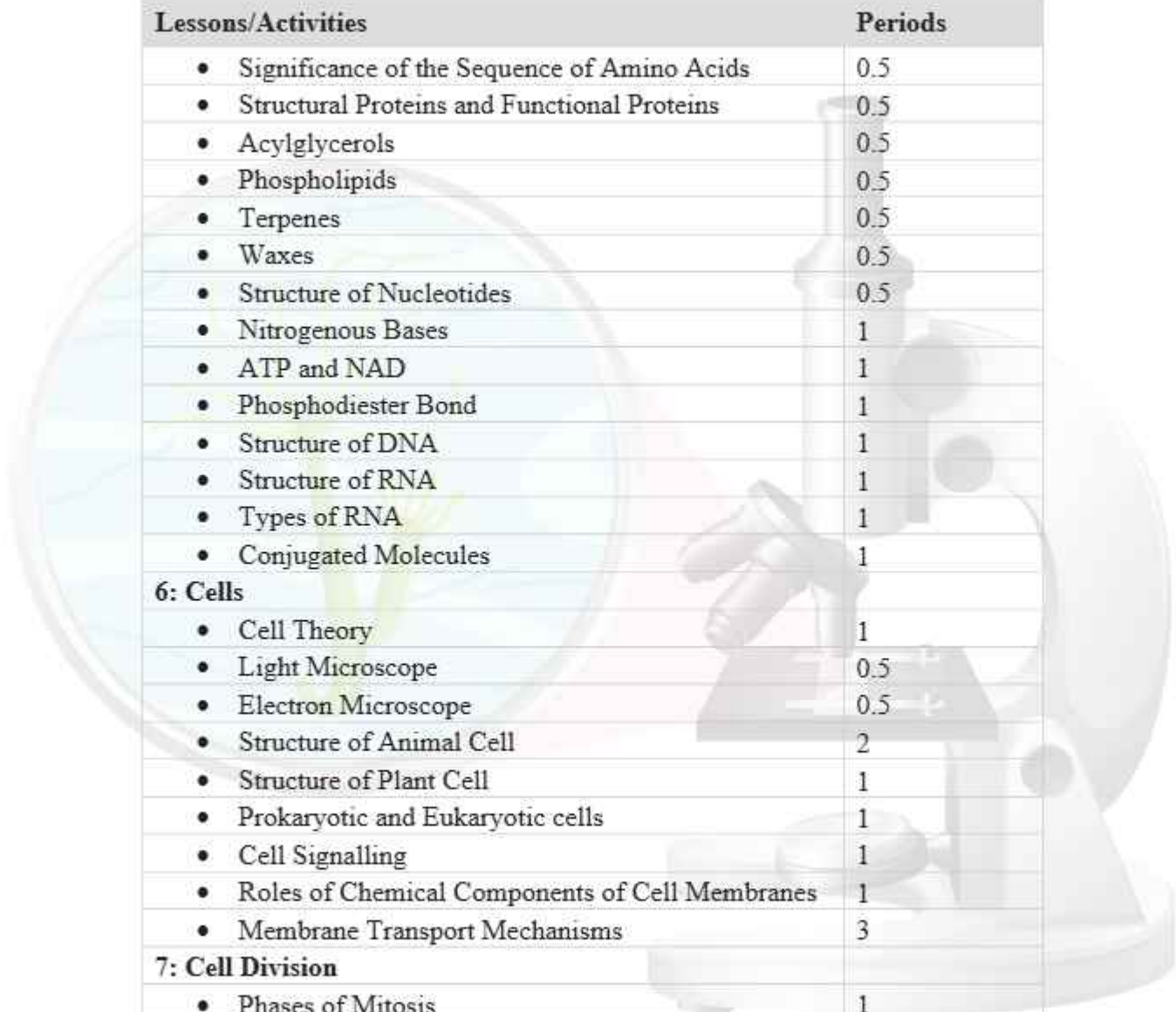


Tentative Time Allocations for Grade 11

Lessons/Activities	Periods
1: Acellular Life and Prokaryotes	
• Acellular Life	1
• Classification of Viruses	1
• Structure of Bacteriophage and HIV	1
• Lytic and Lysogenic life cycles of Virus	1
• Life Cycle of HIV	0.5
• AIDS	0.5
• Useful Aspects of Viruses	0.5
• Prions and Viroids and Diseases caused by them	0.5
• Three Domains	0.5
• Taxonomy of Prokaryotes	1
• Structure of Prokaryotic Cell	1
• Cyanobacteria	1
• Bacterial Cell Wall; Gram-Positive & Gram-negative Bacteria	1
• Endospore Formation	0.5
• Flagellum of Bacteria; Motility in Bacteria	1
• Genetic Recombination in Bacteria	1
• Classification of Bacteria	1
2: Protists and Fungi	
• Major Groups of Protists	1
• Importance of Protists	1
• Major Groups of Fungi	1
• Life Cycle of Mushroom	1
3: Diversity in Plants	
• Divisions of Plant Kingdom	1
• Bryophytes	0.5



Lessons/Activities	Periods
• Life Cycle of Polytrichum	0.5
• Pteridophytes	0.5
• Life Cycle of Ferns	1
• Gymnosperms	1
• Life Cycle of Pinus	1
• Angiosperms	2
4: Diversity in Animals	
• Animal Phyla on specific Criteria	2
• Porifera, Cnidaria, Platyhelminthes	2
• Aschelminthes, Annelida, Arthropoda	2
• Mollusca, Echinodermata, Hemichordata	2
• Chordata	2
• Pisces	1
• Amphibians	1
• Reptiles	1
• Birds	1
• Mammals	1
5: Biological Molecules	
• Properties of Water	1
• Carbohydrates	1
• Monosaccharides	2
• Disaccharides	1
• Polysaccharides	2
• Proteins	2
• Structural Levels of Proteins	1
• Globular and Fibrous Proteins	1
• Structure of Haemoglobin	0.5
• Structure of Collagen	0.5



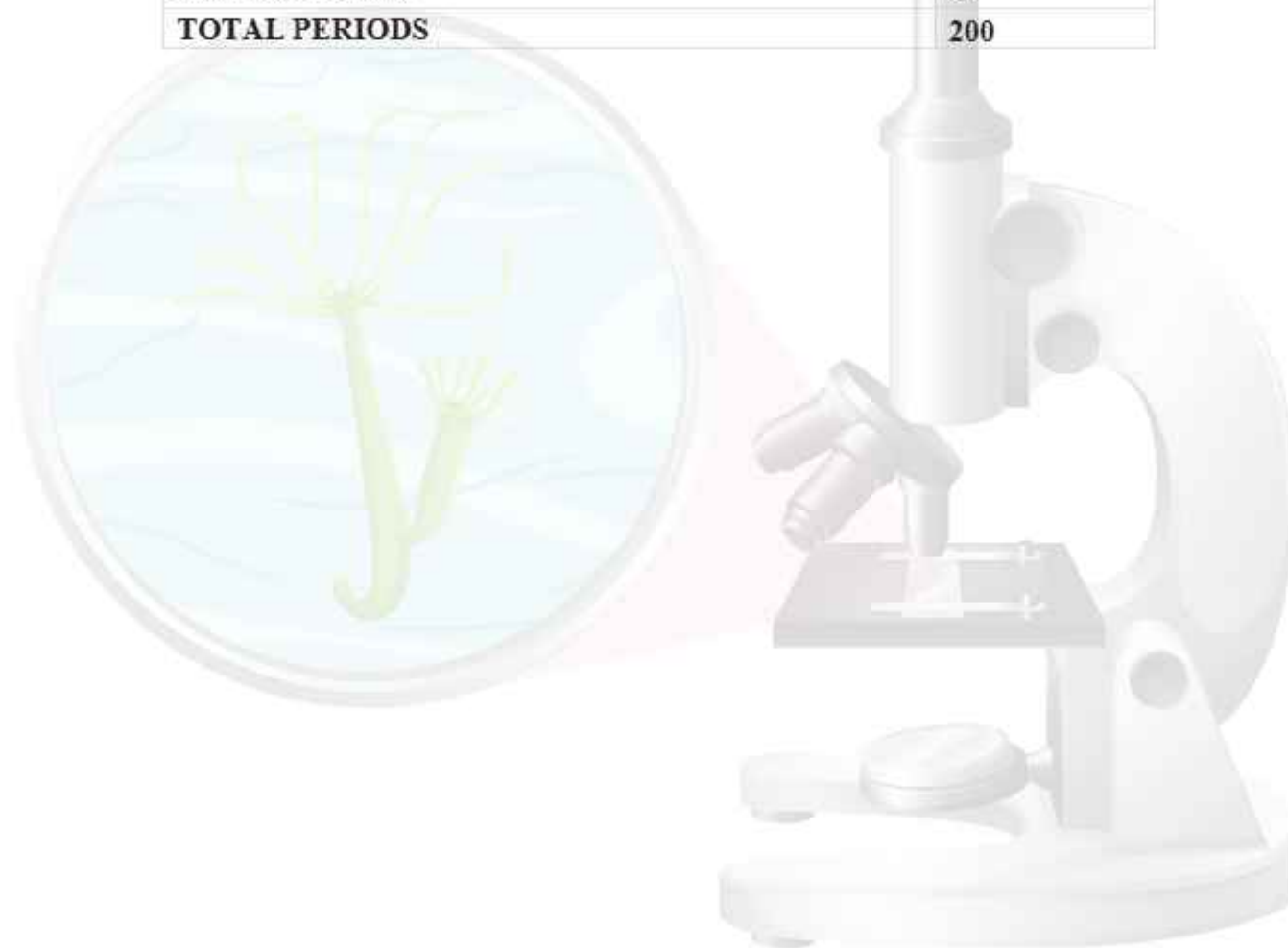
Lessons/Activities	Periods
• Significance of the Sequence of Amino Acids	0.5
• Structural Proteins and Functional Proteins	0.5
• Acylglycerols	0.5
• Phospholipids	0.5
• Terpenes	0.5
• Waxes	0.5
• Structure of Nucleotides	0.5
• Nitrogenous Bases	1
• ATP and NAD	1
• Phosphodiester Bond	1
• Structure of DNA	1
• Structure of RNA	1
• Types of RNA	1
• Conjugated Molecules	1
6: Cells	
• Cell Theory	1
• Light Microscope	0.5
• Electron Microscope	0.5
• Structure of Animal Cell	2
• Structure of Plant Cell	1
• Prokaryotic and Eukaryotic cells	1
• Cell Signalling	1
• Roles of Chemical Components of Cell Membranes	1
• Membrane Transport Mechanisms	3
7: Cell Division	
• Phases of Mitosis	1
• Importance of Meiosis	0.5
• Phases of Meiosis (I and II)	1

Lessons/Activities	Periods
• Importance of Mitosis	1
• Stem Cells	1
8: Enzymes	
• Intracellular and Extracellular Enzymes	0.5
• Enzymes' Mode of Action	1
• Enzyme Cofactors	1
• Enzymatic Inhibition	1
• Effect of Environmental Factors on the Rate of Enzyme Action	2
• Enzymes' Classification on the Basis of Reactions	1
• Enzymes' Classification on the Basis of Substrates	0.5
9: Bioenergetics	
• Photosynthesis- Role of Light, CO ₂ and Water	1
• Role of Photosynthetic Pigments	1
• Absorption Spectra and Action Spectra	1
• Photosystem-I and II	1
• Photophosphorylation	1
• Calvin Cycle	1
• Aerobic Respiration	0.5
• Glycolysis and Link Reaction	1
• Krebs cycle	1
• Electron Transport Chain	0.5
• ATP as the Universal Energy Currency	0.5
• Chemiosmosis	0.5
• Substrate Level Phosphorylation	0.5
• Energy Values of Carbohydrates, Lipids & Proteins	0.5
• Anaerobic Respiration	1
• Linkage of Fats & Proteins with respiratory process	1
• Photorespiration	1

Lessons/Activities	Periods
10: Plant Physiology	
• Water Potential	1
• Exchange of Gasses in Plants	1
• Opening and Closing of Stomata	1
• Transpiration	1
• Structure of Xylem and Phloem	1
• Movement of Water through Roots	1
• TACT mechanism	1
• Transport of Sugars in Plants	1
• Osmotic Adjustments in Plants	1
• Coping with Low and High Temperatures	1
• Turgor Pressure and its Significance	1
• Structure of Supporting Tissues in Plants	1
• Primary and Secondary Growth in Plants	1
• Influence of Apical Meristem	0.5
• Plant Growth Regulators	1
• Movement in Plants	1
• Photoperiodism	1
• Vernalization	0.5
11: Human Digestive System	
• Alimentary Canal; Oral Cavity; Stomach	1
• Stomach	1
• Role of the Nervous System and Gastrin Hormone	0.5
• Small Intestine; Absorption from Small intestine	1
• Large Intestine	0.5
• Structure of Pancreas	0.5
• Roles of Liver and Pancreas	0.5
12: Human Respiratory System	

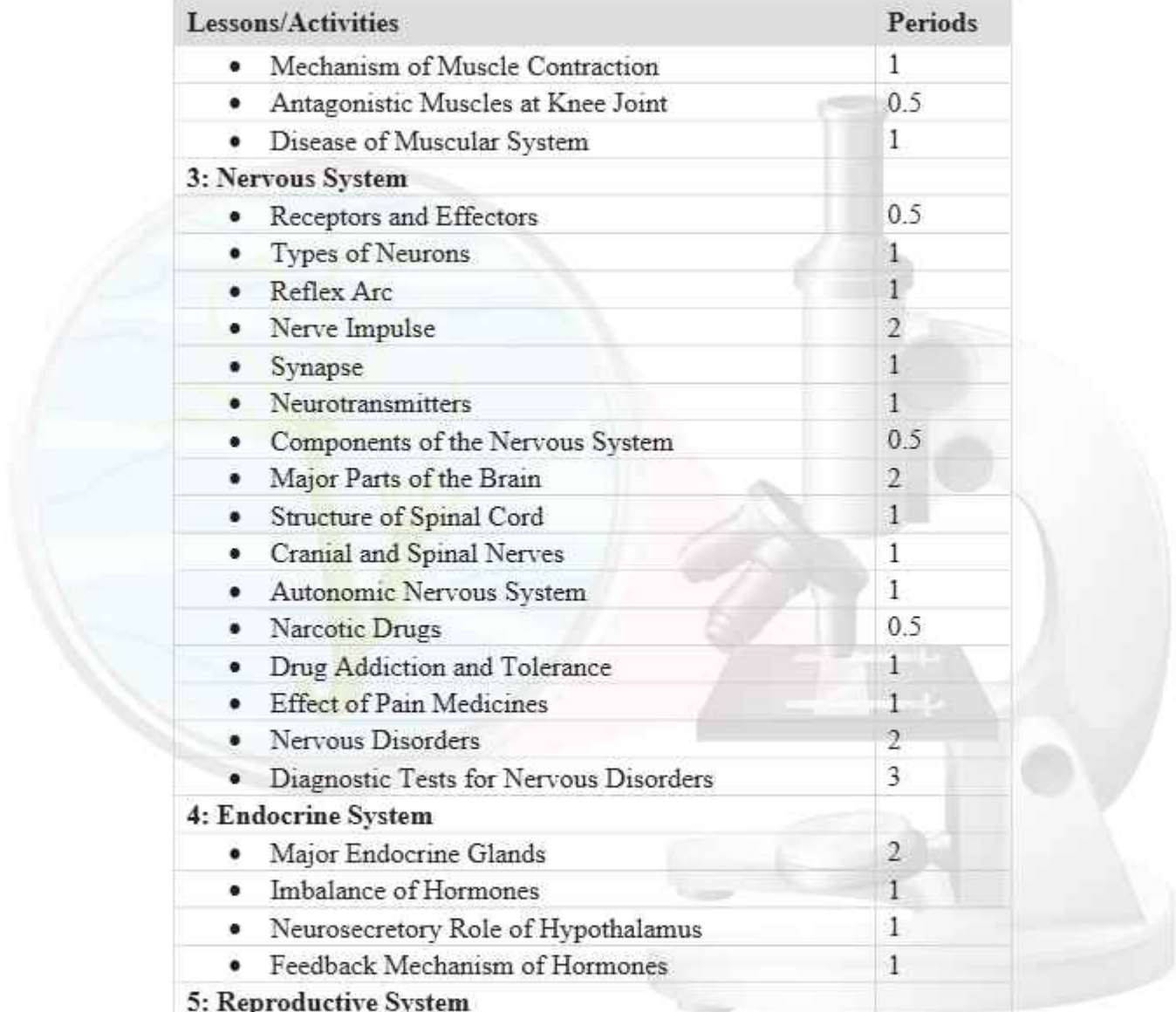
Lessons/Activities	Periods
• Properties of a Respiratory Surface	0.5
• Components of Human Respiratory System	0.5
• Ventilation Mechanism in Humans	1
• Transport of Oxygen and Carbon dioxide	2
• Respiratory Diseases-I	1
• Respiratory Diseases-II	1
• Effects of Smoking on Respiratory System	0.5
13: Transport Systems in Humans	
• Components of Human Circulatory System	0.5
• Structure of the Heart	1
• Flow of Blood through the Heart	1
• Heartbeat	0.5
• Control of Heartbeat	0.5
• Electrocardiogram	0.5
• Arteries, Veins and Capillaries	1
• Vasoconstriction and Vasodilation	0.5
• Pulmonary and Systemic Circulation	1
• Rate of Blood Flow through different Blood Vessels	0.5
• Blood Pressure	1
• Thrombus and Embolus	0.5
• Atherosclerosis and Arteriosclerosis	0.5
• Cardiovascular Diseases	1
• Malfunctioning of Cardiac Valves	1
• Angiography	0.5
• Treatments of Cardiovascular Diseases	1
• Hypertension and Hypotension	0.5
• Intercellular Fluid and Lymph	1
• Parts of Lymphatic System	0.5

Lessons/Activities	Periods
17 Practicals	32
Revision & Chapter Assessment	13
Pre-Board Exams	13
TOTAL PERIODS	200

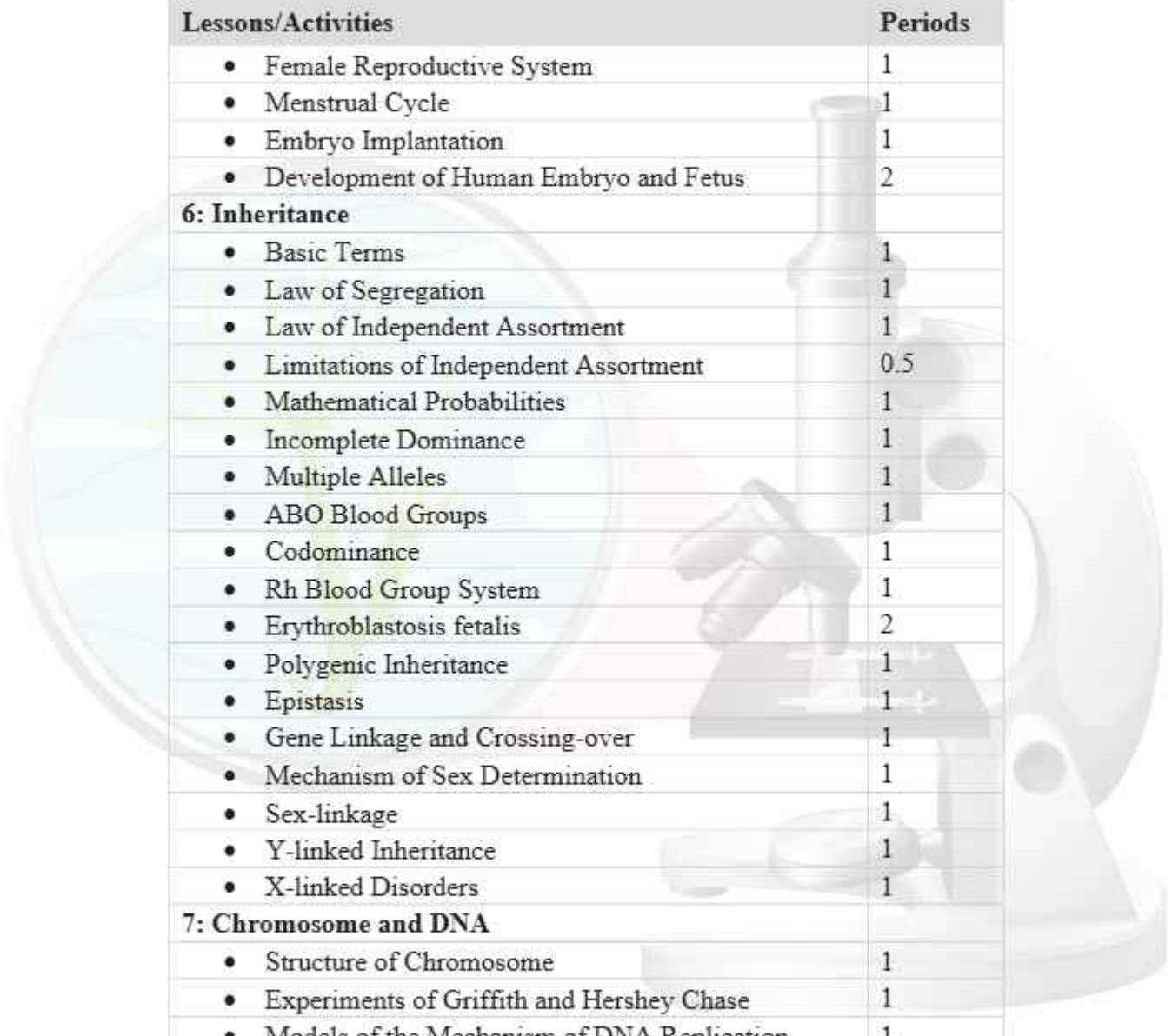


Tentative Time Allocations for Grade 12

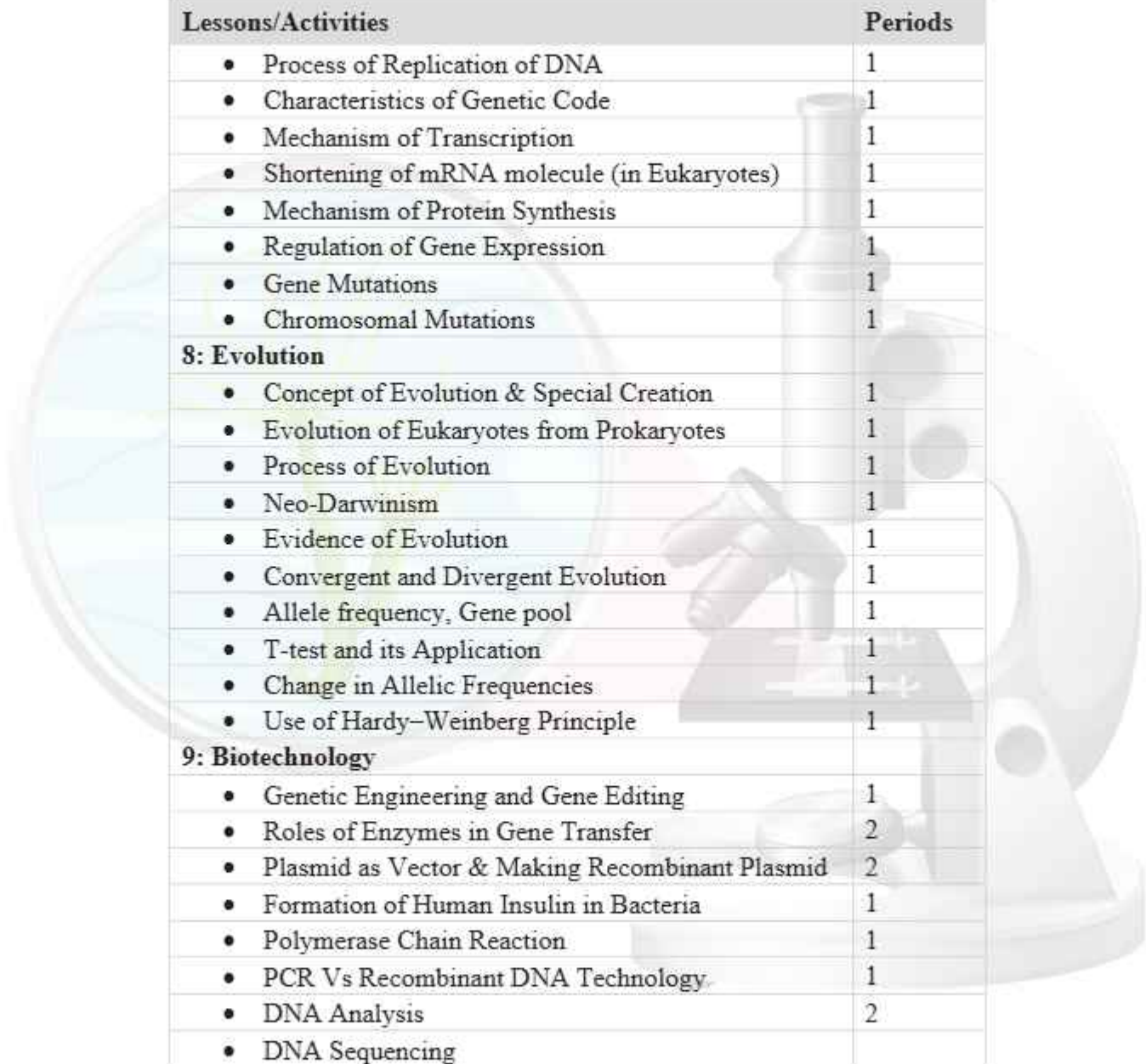
Lessons/Activities	Periods
1: Homeostasis	
• Elements of Homeostasis	0.5
• Negative and Positive Feedback Systems	0.5
• Osmoconformers and Osmoregulators	0.5
• Osmoregulation in Animals	1
• Nitrogenous Wastes	0.5
• Organs of Urinary System	0.5
• Structure of Kidney	1
• Structure of Nephron	1
• Process of Urine Formation	1
• Regulation of Urine Concentration	1
• Kidney's Role in Osmoregulation	0.5
• Capillary Beds in Kidneys	0.5
• Kidney Stones	1
• Kidney Failure	1
• Dialysis and Kidney Transplant	2
• Ectotherms and Endotherms	0.5
• Poikilotherms and Homeotherms	0.5
• Thermoregulation in Humans	0.5
2: Musculoskeletal System	
• Structure of Bone and Cartilage	1
• Appendicular and Axial Skeleton	1
• Types of Joints	2
• Disease of Skeletal System	1
• Fractures and their Repair	1
• Types of Muscles	0.5
• Structure of Skeletal Muscle	1



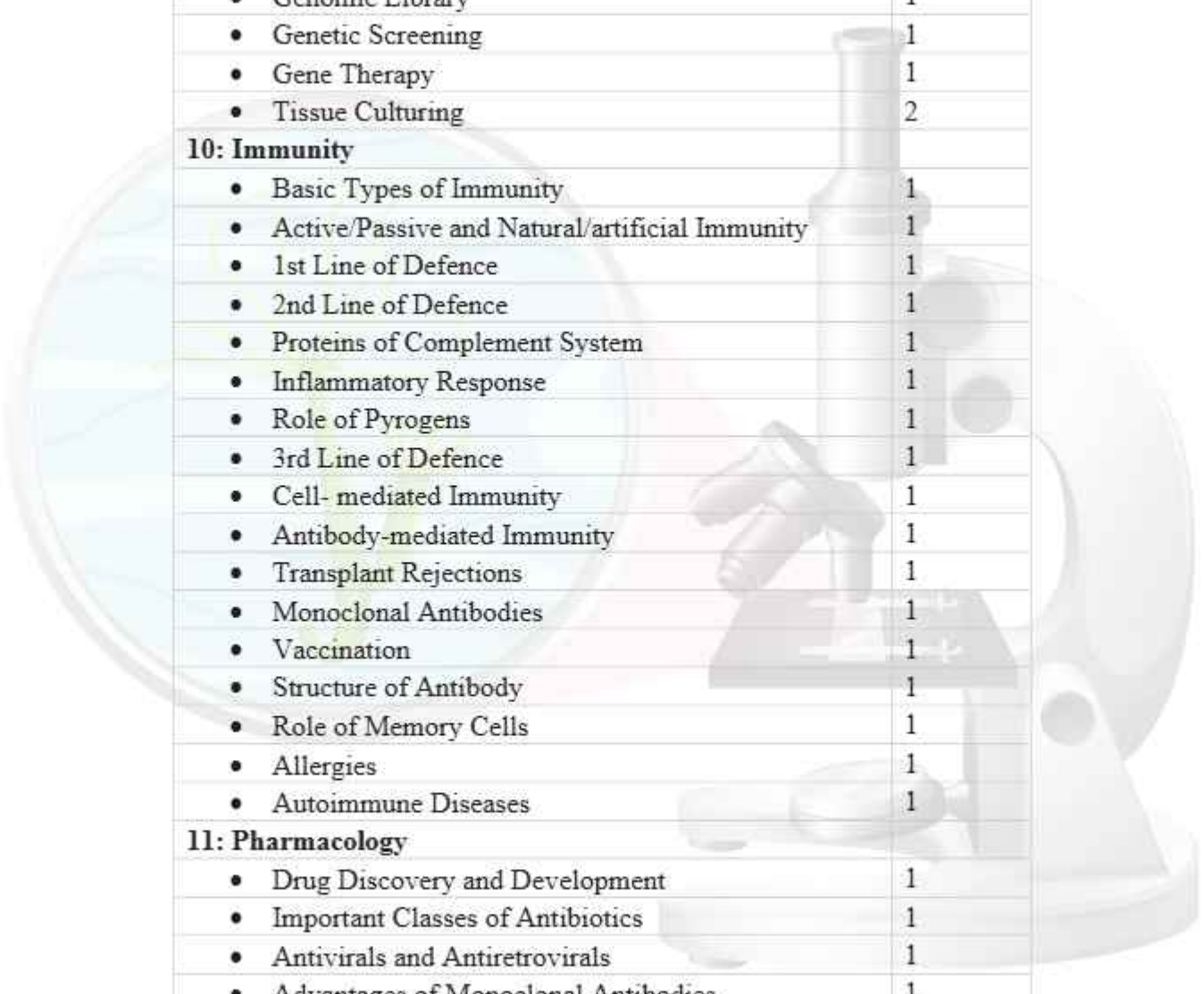
Lessons/Activities	Periods
• Mechanism of Muscle Contraction	1
• Antagonistic Muscles at Knee Joint	0.5
• Disease of Muscular System	1
3: Nervous System	
• Receptors and Effectors	0.5
• Types of Neurons	1
• Reflex Arc	1
• Nerve Impulse	2
• Synapse	1
• Neurotransmitters	1
• Components of the Nervous System	0.5
• Major Parts of the Brain	2
• Structure of Spinal Cord	1
• Cranial and Spinal Nerves	1
• Autonomic Nervous System	1
• Narcotic Drugs	0.5
• Drug Addiction and Tolerance	1
• Effect of Pain Medicines	1
• Nervous Disorders	2
• Diagnostic Tests for Nervous Disorders	3
4: Endocrine System	
• Major Endocrine Glands	2
• Imbalance of Hormones	1
• Neurosecretory Role of Hypothalamus	1
• Feedback Mechanism of Hormones	1
5: Reproductive System	
• Male Reproductive System	1
• Male Reproductive Hormones	1



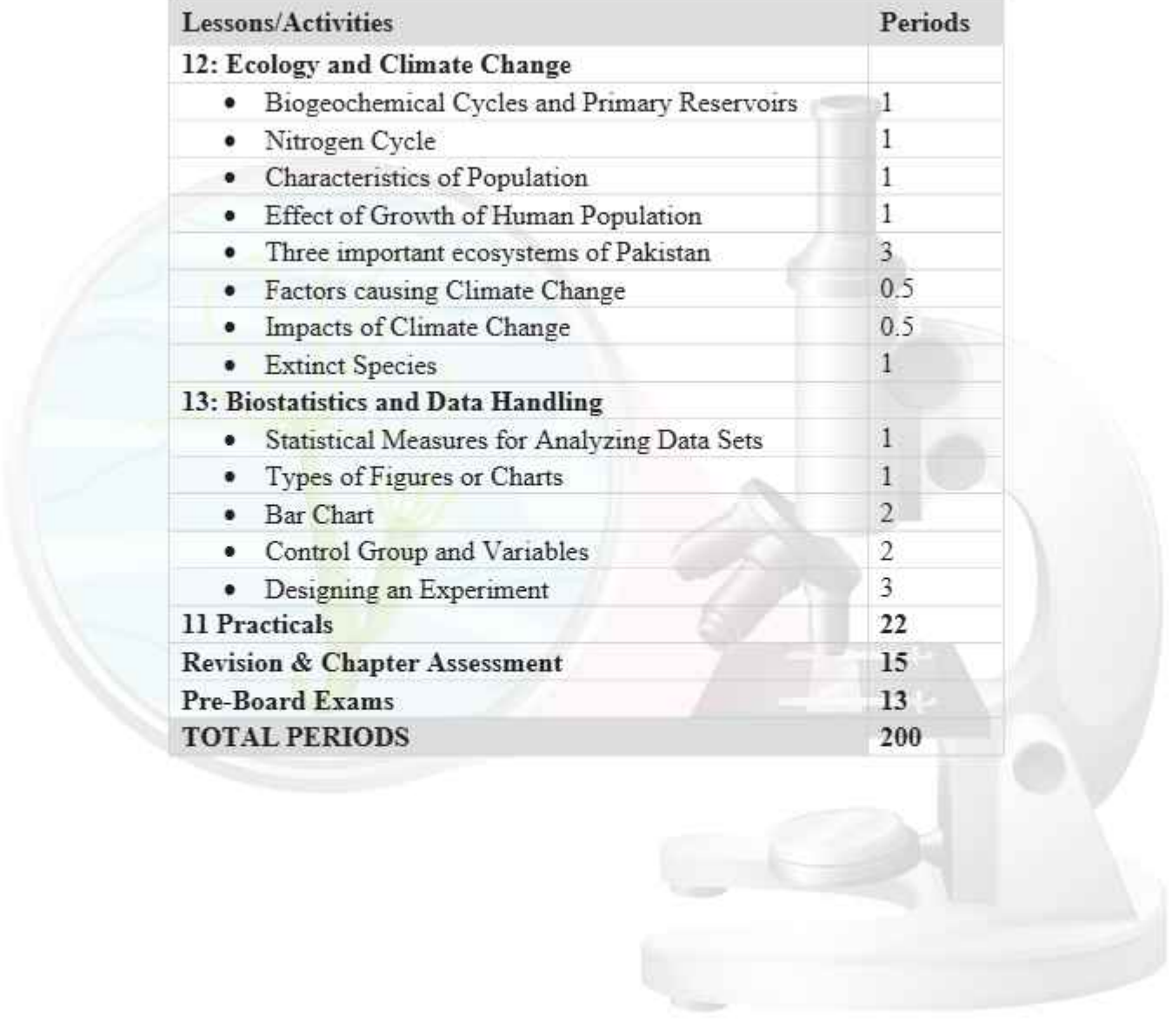
Lessons/Activities	Periods
• Female Reproductive System	1
• Menstrual Cycle	1
• Embryo Implantation	1
• Development of Human Embryo and Fetus	2
6: Inheritance	
• Basic Terms	1
• Law of Segregation	1
• Law of Independent Assortment	1
• Limitations of Independent Assortment	0.5
• Mathematical Probabilities	1
• Incomplete Dominance	1
• Multiple Alleles	1
• ABO Blood Groups	1
• Codominance	1
• Rh Blood Group System	1
• Erythroblastosis fetalis	2
• Polygenic Inheritance	1
• Epistasis	1
• Gene Linkage and Crossing-over	1
• Mechanism of Sex Determination	1
• Sex-linkage	1
• Y-linked Inheritance	1
• X-linked Disorders	1
7: Chromosome and DNA	
• Structure of Chromosome	1
• Experiments of Griffith and Hershey Chase	1
• Models of the Mechanism of DNA Replication	1
• Work of Meselson and Stahl	1



Lessons/Activities	Periods
• Process of Replication of DNA	1
• Characteristics of Genetic Code	1
• Mechanism of Transcription	1
• Shortening of mRNA molecule (in Eukaryotes)	1
• Mechanism of Protein Synthesis	1
• Regulation of Gene Expression	1
• Gene Mutations	1
• Chromosomal Mutations	1
8: Evolution	
• Concept of Evolution & Special Creation	1
• Evolution of Eukaryotes from Prokaryotes	1
• Process of Evolution	1
• Neo-Darwinism	1
• Evidence of Evolution	1
• Convergent and Divergent Evolution	1
• Allele frequency, Gene pool	1
• T-test and its Application	1
• Change in Allelic Frequencies	1
• Use of Hardy–Weinberg Principle	1
9: Biotechnology	
• Genetic Engineering and Gene Editing	1
• Roles of Enzymes in Gene Transfer	2
• Plasmid as Vector & Making Recombinant Plasmid	2
• Formation of Human Insulin in Bacteria	1
• Polymerase Chain Reaction	1
• PCR Vs Recombinant DNA Technology	1
• DNA Analysis	2
• DNA Sequencing	



Lessons/Activities	Periods
• Genomic Library	1
• Genetic Screening	1
• Gene Therapy	1
• Tissue Culturing	2
10: Immunity	
• Basic Types of Immunity	1
• Active/Passive and Natural/artificial Immunity	1
• 1st Line of Defence	1
• 2nd Line of Defence	1
• Proteins of Complement System	1
• Inflammatory Response	1
• Role of Pyrogens	1
• 3rd Line of Defence	1
• Cell-mediated Immunity	1
• Antibody-mediated Immunity	1
• Transplant Rejections	1
• Monoclonal Antibodies	1
• Vaccination	1
• Structure of Antibody	1
• Role of Memory Cells	1
• Allergies	1
• Autoimmune Diseases	1
11: Pharmacology	
• Drug Discovery and Development	1
• Important Classes of Antibiotics	1
• Antivirals and Antiretrovirals	1
• Advantages of Monoclonal Antibodies	1



Lessons/Activities	Periods
12: Ecology and Climate Change	
• Biogeochemical Cycles and Primary Reservoirs	1
• Nitrogen Cycle	1
• Characteristics of Population	1
• Effect of Growth of Human Population	1
• Three important ecosystems of Pakistan	3
• Factors causing Climate Change	0.5
• Impacts of Climate Change	0.5
• Extinct Species	1
13: Biostatistics and Data Handling	
• Statistical Measures for Analyzing Data Sets	1
• Types of Figures or Charts	1
• Bar Chart	2
• Control Group and Variables	2
• Designing an Experiment	3
11 Practicals	22
Revision & Chapter Assessment	15
Pre-Board Exams	13
TOTAL PERIODS	200

Guidelines for Assessment and Evaluation

I. Strategic Shift in Assessment Focus

To modernize the evaluation of Biology, examiners and teachers should apply the following shifts in emphasis:

- **Cognitive Depth:** Rich, well-structured knowledge and scientific reasoning should be prioritized over discrete isolated facts.
- **Positive Reinforcement:** What students *do* understand should be aimed to discover rather than searching for what they do not know.
- **Collaborative Evaluation:** Students should be engaged in the ongoing assessment of their own work and the work of their peers.
- **Teacher Agency:** Classroom teachers should be involved in the development of external assessments rather than relying solely on external experts.

II. Formative Assessment Guidelines (*Assessment for Learning*)

Formative assessment must be a continuous part of classroom learning to provide immediate feedback to both students and teachers.

Classroom-Based Instruments

- **Classroom Tests and Quizzes:** Regular, short-duration evaluations to check for conceptual retention.
- **Objective Enhancement Worksheets:** Structured tasks designed to reinforce specific SLOs.
- **Observation and Discussion:** Using active classroom dialogue to diagnose misconceptions in real-time.
- **Lab Completion and Observation:** Tracking the student's ability to follow the scientific method during experiments.
- **Identification and Diagram Completion:** Assessing the ability to recognize biological structures and their relationships.

III. Summative Assessment Guidelines (*Assessment of Learning*)

Summative evaluation measures the total attainment of curriculum objectives through an external examination at the end of the course.

- **Curriculum-Led Design:** The question paper must be based strictly on the curriculum SLOs, not on a specific textbook.
- **Domain Weightage Authority:** The specific weightage for cognitive learning domains—including Knowledge, Understanding, Analysis, Evaluation, Synthesis, and Application—shall be determined and assigned by the respective **Examination Boards** based on their specific assessment policies and procedures.

- **Contextual Application:** Questions should involve unfamiliar contexts or daily-life experiences to assess problem-solving and higher-order thinking.
- **Information Scaffolding:** For questions involving new scenarios, sufficient background information must be provided so candidates can apply their curriculum-based knowledge.

IV. General Instructions for Evaluators

- **Cumulative Nature:** Assessment must be comprehensive and cover the full range of objectives defined in the curriculum.
- **Grading Consistency:** Use assessment instruments that align precisely with the expectations and commanding verbs defined in the curriculum objectives.
- **Policy Compliance:** Ensure the assessment pattern follows the specific requirements and procedures of the relevant Examination Boards.

V. Practical-Based Assessment (PBA)

The PBA paper should be conceptual and skill-oriented. It should be set in a manner that the students who attend the laboratory sessions regularly and perform practical work in the laboratory are capable of attempting the paper. PBA questions must include experimental objectives, use of apparatus, observation, interpretation of data, good laboratory safety practices and problems that require solution in an experimental setting. The paper must avoid assessing rote learning of practical manuals or the long reproduction of procedures.

Guidelines for Textbook Development

1. Authorship and Editorial Strategy

- **Narrative Coherence:** The core text must be authored by a small, integrated team of **two to three experts**. This ensures a consistent pedagogical voice and a logical "storyline" for the biological sciences.
- **Curriculum-Alignment Synergy:** Preference should be given to authors who contributed to the "SLO" rationalization phase of the curriculum to ensure the original instructional intent is preserved.
- **Capacity Building:** Before the writing phase, the textbook boards must conduct a "**Modern Instructional Design**" workshop for authors and editors, focusing on active learning strategies and cognitive load theory.

2. The Digital & Multimedia Ecosystem

- **Dynamic Resources:** QR-code-enabled Dynamic Resources should be provided in the textbook. These should link to 3D molecular simulations and curated "Open Educational Resources" (OER) that stay updated.
- **Interactive Teacher Support:** Digital interactive suites should be advised which feature "Layered Illustrations" (where teachers can toggle labels on/off) and high-definition video case studies.
- **Assessment Portals:** A cloud-based **Test Item Bank** should be developed. This should include not just MCQs, but "Problem-Based Tasks" and "Data Analysis" questions that prepare students for international standards.

3. Structural Components of a Chapter

- **The 5E Instructional Model:** Chapters should follow the **Engage, Explore, Explain, Elaborate, and Evaluate** cycle rather than simple lecturing text.
- **Prior Knowledge Activation:** Every chapter must begin with a "**Retrieval Practice**" section—brief prompts that help students recall relevant concepts from previous grades or chapters.
- **Systematic Navigation:** A rigorous, consistent **Decimal Numbering System** (1.1, 1.1.1) should be adopted for easy referencing.
- **Concept Mapping:** Conclude each chapter with a **Hierarchical Concept Map**.

4. Content Philosophy and Pedagogical Features

- **Contextualized Learning:** Abstract biology should be connected to real-world and local issues. Examples must be culturally and geographically relevant to the student's environment.

- **Heritage and Ethics:**
 - **Scientific Contributions:** The history of science should be seamlessly integrated, highlighting the foundational work of **Muslim scientists** and global pioneers to show science as a collective human endeavour.
 - **Ethical Frameworks:** Ethical sidebars should be included where relevant to foster reflection on the stewardship of nature and the morality (e.g., gene editing).
- **"Bio-Insights" (Tidbits):** These should be used for **"Science-at-the-Frontier"**—brief, exciting mentions of current breakthroughs (like mRNA vaccines) to show that biology is a living, evolving field.
- **Inquiry-Based Lab Manuals:** The laboratory component must be a **"Discovery Guide."** Instead of confirming known facts, it should guide students through the **Scientific Method**, emphasizing hypothesis testing, error analysis, and cladistic modelling.

5. Visual Design and Accessibility

- **Cognitive Load Management:** High-quality **Infographics** should be used effectively. Diagrams should not just be "attractive"; they must be functional tools that simplify complex pathways (like the Krebs Cycle or Signal Transduction).
- **Inclusion:** It must be ensured that the language is gender-neutral and accessible to students with diverse learning needs.

6. Exercises

- Exercises at the end of each chapter should be clearly **aligned to relevant SLOs** and their cognitive levels. An appropriate balance of the following components should be ensured:
 - Objective-type questions (MCQs)
 - Structured questions (Both short response and extended response questions)
- **Repetition** of similar questions across chapters is not encouraged. Questions should address all cognitive levels of the SLOs in same proportion as mentioned in the chapters.

Criteria for the Selection of Learning Material

I. SLO Alignment & Content Volume (Primary Criteria)

- Does the material strictly align with the SLOs? Every sentence and paragraph should directly support a defined SLO.
- Is the depth of the text determined by the "Commanding Verb"? (e.g., If the SLO asks to "Identify," does the book avoid unnecessary, complex *explanations* that overload the student?)
- Is the material free from content overload? The book should only include what is required by the curriculum, avoiding "extra" information that exhausts the allotted teaching periods.
- Are end-of-chapter exercises mapped to specific SLOs? Each question should be a direct test of a competency defined in the curriculum.

II. Language & Linguistic Accessibility

- Is the language "Reader-Friendly" for ESL (English as a Second Language) learners? The text must be written in simple, direct English to accommodate students for whom English is not a first language.
- Has "International Content" been localized? If material is adapted from international sources, has the sentence structure been simplified and complex idioms removed?
- Is the vocabulary appropriate? Does the text explain technical biological terms clearly without using unnecessary "flowery" or academic jargon in the prose?
- Are sentences short and concise? Long, compound sentences should be broken down to improve readability and comprehension.

III. Pedagogical Design & Scaffolding

- Does the material follow the 5E Instructional Model? Is there a clear path from *Engage* (introductory phenomenon) to *Evaluate* (assessment)?
- Does the chapter start with a "Prior Knowledge" bridge? Does it help the student recall what they learned in previous grades before starting new topics?
- Is there a consistent numbering system? Does the book use a clear decimal system (e.g., 1.1, 1.1.1) to help students navigate the hierarchy of concepts?

IV. Visuals & Digital Integration

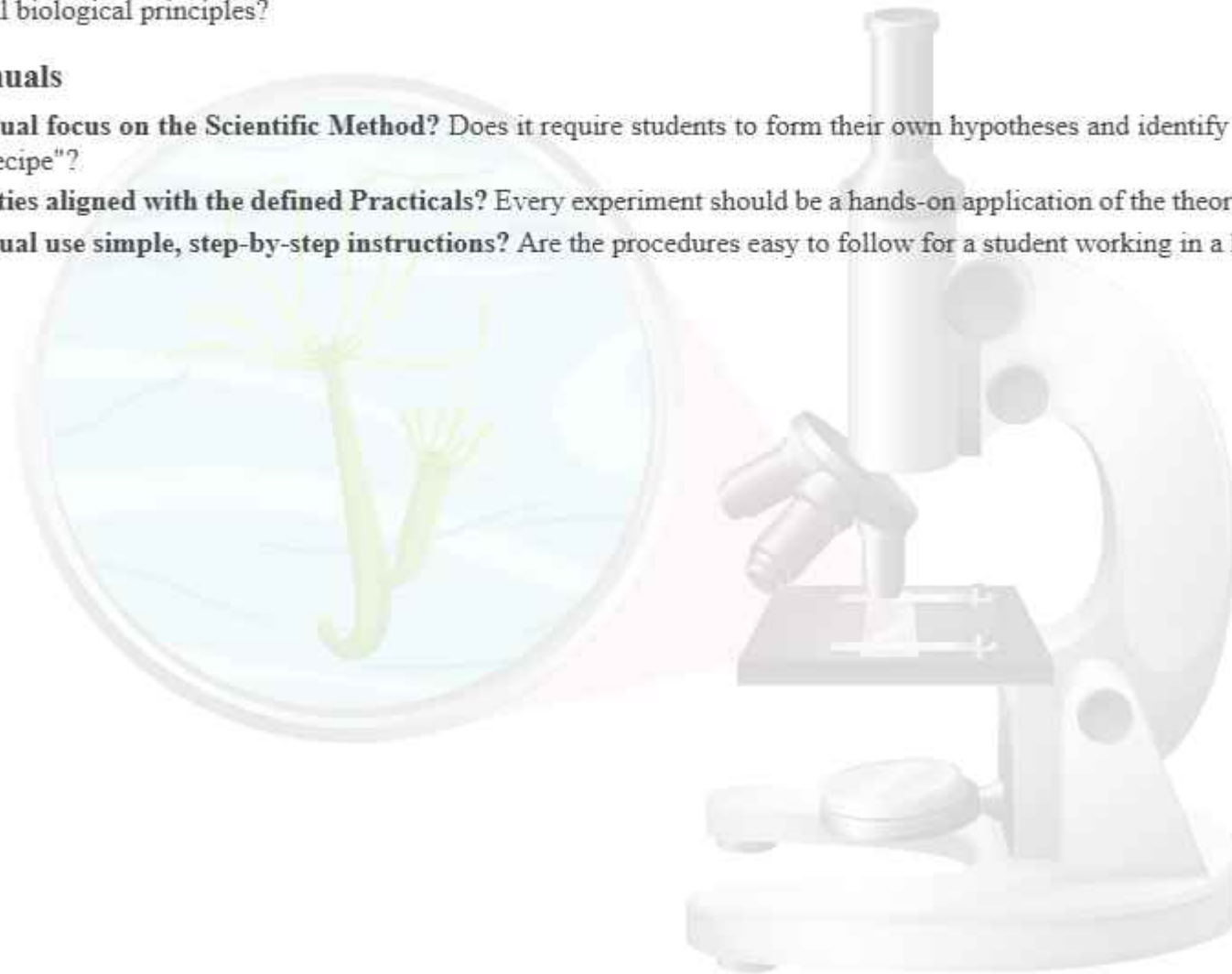
- Are the illustrations functional? Do the diagrams help explain the relevant contents, or are they just decorative?
- Does the material include QR codes for digital support? Do these codes link to simple animations or simulations that clarify difficult concepts?
- Is the layout clean? Is there enough "white space" to prevent the pages from looking crowded and intimidating to the reader?

V. Context

- **Are local examples used?** Does the book use indigenous flora, fauna, and local health issues (e.g., local ecosystems or regional diseases) to explain general biological principles?

VI. Practical Manuals

- **Does the manual focus on the Scientific Method?** Does it require students to form their own hypotheses and identify variables instead of just following a "recipe"?
- **Are the activities aligned with the defined Practicals?** Every experiment should be a hands-on application of the theory taught in the textbook.
- **Does the manual use simple, step-by-step instructions?** Are the procedures easy to follow for a student working in a local lab setting?



Glossary of Command Verbs

This glossary provides a concise definition of the **Command Verbs** used in the rationalized SLOs. These verbs are organized into three primary categories i.e., Knowledge, Understanding and Application.

1. Knowledge (Recall of Information)

- **Define:** State the exact meaning of a term, concept, or physical quantity.
- **List:** Provide a series of items, names, or points without further explanation.
- **State:** Give a specific name, value, or brief answer without supporting details.
- **Identify:** Recognize and name a specific factor, object, or biological component.
- **Label:** Add names or specific terms to a provided diagram or illustration.

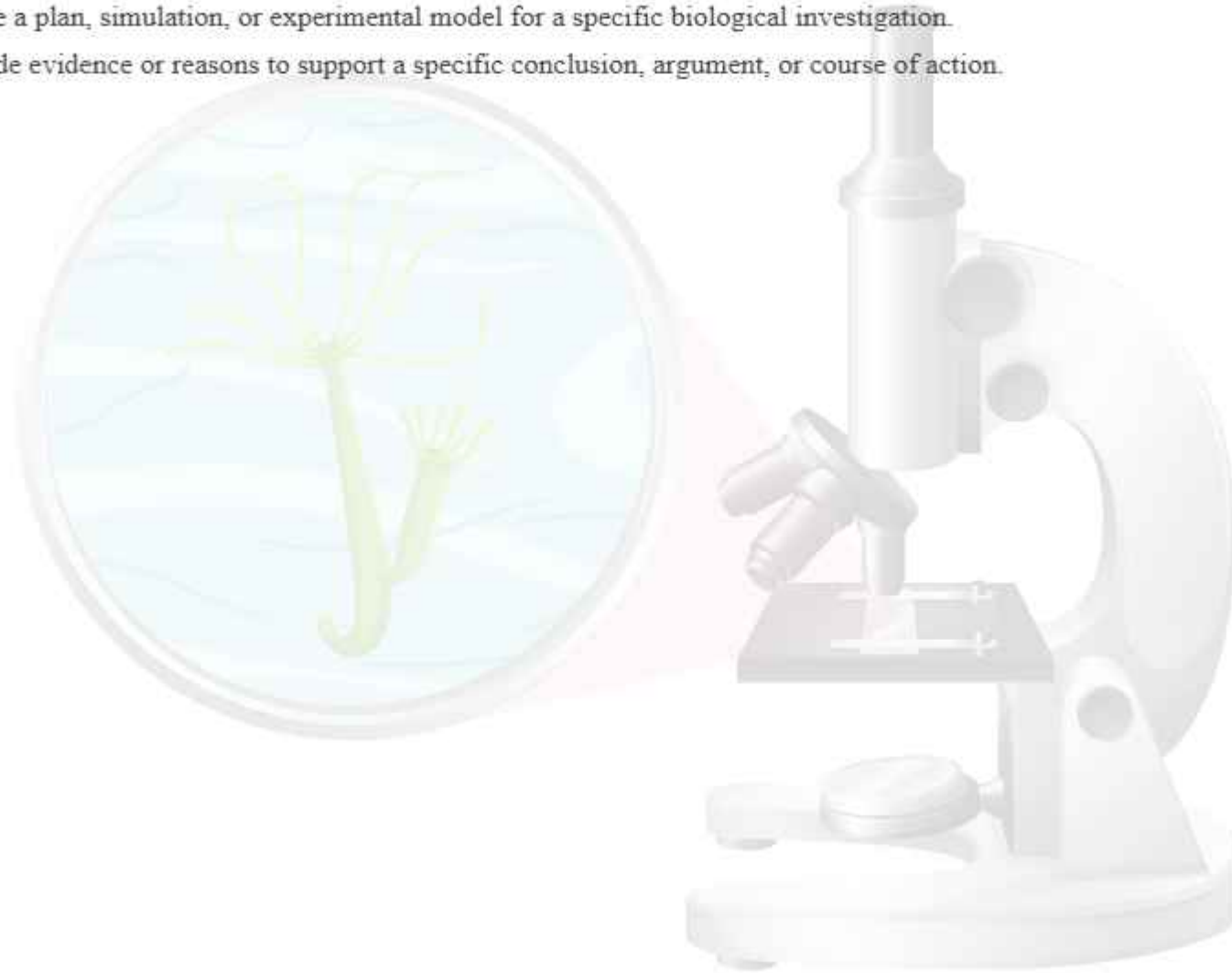
2. Understanding (Comprehension & Analysis)

- **Describe:** Give a detailed account or provide the characteristics of a structure or process.
- **Explain:** Give reasons or causes to make a phenomenon or relationship clear.
- **Illustrate:** Use examples or diagrams to clarify a point.
- **Compare:** Identify similarities between two or more items or processes.
- **Contrast:** Identify differences between two or more items or processes.
- **Differentiate:** Highlight specific characteristics that distinguish one entity from another.
- **Analyze:** Break down information into parts to explore relationships, patterns, or evidence.
- **Summarize:** Provide a brief statement of the main points or general ideas.

3. Application (Usage, Synthesis & Evaluation)

- **Apply:** Use biological principles or knowledge to solve problems in new or familiar situations.
- **Calculate:** Determine a numerical value using mathematical procedures or formulas.
- **Predict:** Deduce a likely future outcome based on given information or observed trends.
- **Show:** Demonstrate a particular fact or process through evidence or logical steps.

- **Synthesize:** Combine different ideas, data, or elements to form a new, coherent conclusion or model.
- **Evaluate:** Make a judgment based on criteria to determine the value, impact, or effectiveness of a biological concept.
- **Design:** Create a plan, simulation, or experimental model for a specific biological investigation.
- **Justify:** Provide evidence or reasons to support a specific conclusion, argument, or course of action.



Conclusion

The revision of the National Curriculum of Pakistan for Biology (Grades 9–12) has been carried out as a strategic policy initiative to enhance curriculum relevance, coherence, and alignment with national educational goals and internationally recognized standards. A comprehensive review revealed that the existing curriculum content was overburden, exhibited improper vertical progression of Student Learning Outcomes (SLOs), and, in several instances, SLOs are beyond the expectations of the cognitive level of students at the respective grades.

Furthermore, the presence of overlapping and repetitive SLOs across allied subjects, particularly Chemistry and Physics, resulted in unnecessary academic burden and dilution of subject focus. To address these challenges, redundant and misaligned SLOs were rationalized or removed, ensuring that Biology retains its disciplinary integrity while avoiding duplication of learning objectives already addressed in other subjects.

As part of the reform process, selected SLOs were reallocated across grade levels to establish a logical, gradual progression from foundational concepts in Grade 9 to advanced understanding in Grade 12. In addition, certain SLOs were shifted across learning domains to ensure alignment among curriculum intent, instructional practices, and assessment frameworks.

The development of clear implementation guidelines for teachers, textbook authors, and paper setters is a key policy measure to ensure uniform and effective execution of the rationalized curriculum of Biology. These guidelines promote outcome-based instruction, conceptual clarity, real life relevance, and assessment practices aligned with defined cognitive levels, while explicitly discouraging unwarranted theoretical depth and advanced derivations not required at this stage.

The following table depicts the comparative analysis of the rationalization and optimization.

Drawbacks in the NCP 2022-23	Rectifications in the Rationalized Curriculum
Lack of Definitions of Domain, Standard, and Benchmark	Proper definitions added at relevant places.
Poor Sequencing of Domains	Reorganized the domains to follow a logical progression from foundational to complex systems.
Poor Alignment of Concepts & Domains	Ensured that concepts are housed within relevant domains.

Drawbacks in the NCP 2022-23	Rectifications in the Rationalized Curriculum
No Categorization of SLOs	Categorized SLOs into three cognitive levels: Knowledge, Understanding, and Application .
Cognitively Overloaded SLOs	Refined SLOs to focus on core competencies.
Focus on Breadth over Depth	Shifted the focus to deep understanding over the superficial coverage of numerous topics.
No Specification of Practical Work	Separate lists of practicals added for Grade 9 through Grade 12.
Improperly Created Standards and Benchmarks	Standards and Benchmarks developed afresh, aligning with the SLOs and with the checking points at Grades 10 and 12.
No Time Allotment for Lessons	Proper time (number of classroom periods) given for each lesson.
Lack of Assessment Guidelines	Developed comprehensive Guidelines for Formative and Summative Assessments .
No Instructions for Textbook Development	Drafted Instructions for Textbook Writing , focusing on SLOs-alignment, authorship coherence, and digital integration; Established a specific selection criteria for textbooks and lab manuals.
Absence of Command Verbs Glossary	Provided a structured Glossary of Command Verbs to standardize the interpretation of SLOs.

◦ Internal Curriculum Review Committee

	Name & Designation	Role in Committee
1	Dr. Tabassum Naz, Director, National Curriculum Council, Islamabad	Chairperson
2	Abdul Hanan, Deputy Educational Advisor, National Curriculum Council, Islamabad	Member
3	Muhammad Nadeem Asghar, Associate Professor, Higher Education Department, Punjab, Lahore	Member/Focal Person
4	Javed Mohsin Malik, Author, National Book Foundation, Islamabad	Member
5	Dr. Kashif Ali, Associate Professor, Islamabad Model College for Boys, F-7/3, Islamabad	Member
6	Dr. Abid Ali Mughal, Assistant Professor, Islamabad Model College for Boys, H-9, Islamabad	Member
7	Johnson James, Senior Science Teacher, Federal Government Educational Institutions, Islamabad	Member
8	Nasreen Anjum, Assistant Professor, Federal Government Educational Institutions, Islamabad	Member
9	Dr. Muhammad Ishaque, , Islamabad Model College for Boys, F-8/4, Islamabad	Member
10	Sheeba Makhdoom, Assistant Professor, Islamabad Model College for Girls, F-10/2, Islamabad	Member
11	Sabeen Narjis, Fazaia Inter College, Rawalpindi	Member
12	Abdul Rauf, Elementary School Teacher, Federal Government Educational Institutions, Islamabad	Member
13	Mr. Imran Ahmad Khan, Assistant Educational Advisor, National Curriculum Council, Islamabad	Member/Secretary

o **Inter-Provincial Curriculum Review Committee**

	Name & Designation	Province / Region	Role in Committee
1	Dr. Irum Naz, Subject Specialist	Khyber Pakhtunkhwa	Member
2	Munazza Nawab, Senior Research Officer	Balochistan	Member
3	Abdul Ghani, Elementary School Teacher	Gilgit Baltistan	Member
4	Muhammad Sabir Mir, Subject Specialist	Azad Jammu & Kashmir	Member
5	Dr. Robeela Shabbir, Subject Specialist	Punjab	Member
6	Tariq Mahmood, Assistant Professor	South Punjab	Member
7	Gul Muhammad Keerio, Deputy Director	Sindh	Member
8	Muhammad Nadeem Asghar, Associate Professor	Islamabad (Curriculum Review Committee)	Member/Focal Person
9	Dr. Abid Ali Mughal, Assistant Professor	Islamabad (Curriculum Review Committee)	Member
10	Dr. Kashif Ali, Associate Professor	Islamabad (Curriculum Review Committee)	Member
11	Mr. Imran Ahmad Khan, Assistant Educational Advisor	National Curriculum Council, Islamabad	Member/Secretary



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GOVERNMENT OF PAKISTAN