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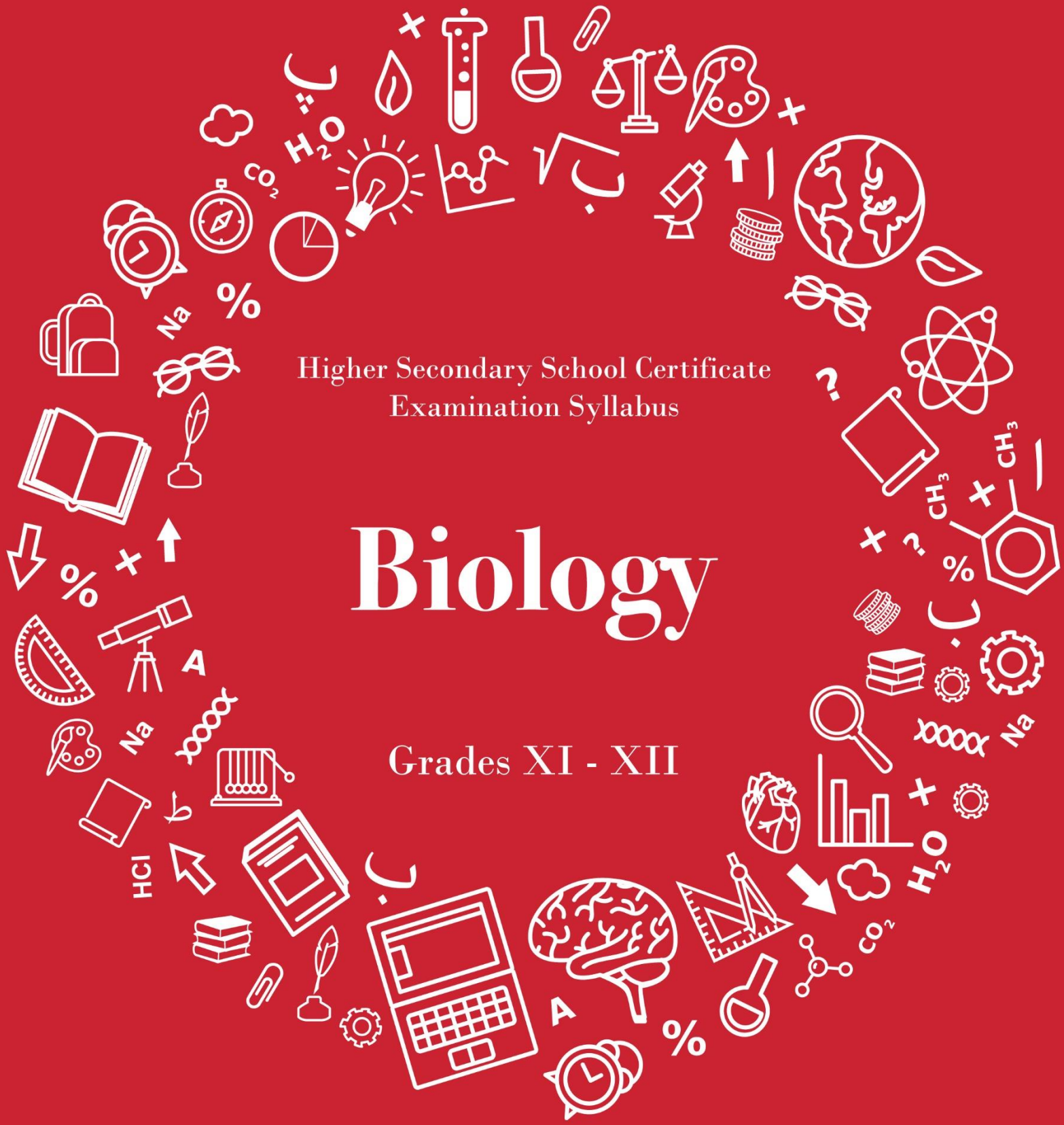

Higher Secondary School Certificate
Examination Syllabus

Biology

Grades XI - XII

(Based on New National Curriculum 2022-2023)

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Higher Secondary School Certificate Examination Syllabus

BIOLOGY

GRADES XI-XII

This syllabus will be examined in both Annual and September Examination sessions from Annual Examinations 2026 for Grade XI and Annual Examination 2027 for Grade XII

For queries and feedback

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Preface

Established in 2002 through the Pakistan government's ordinance, the Aga Khan University Examination Board (AKU-EB) is country's first private autonomous qualification awarding body for Secondary School Certificate (SSC) and Higher Secondary School Certificate (HSSC). Its vision is to be a model of excellence and innovation in education in Pakistan and the developing world.

AKU-EB achieves its vision by developing examination syllabi which inculcate conceptual thinking and higher order learning and is aligned with the National Curriculum and mapped with provincial curricula and international standards. AKU-EB revises its syllabi periodically to support the needs of students, teachers and society.

The aims of the syllabus review of SSC and HSSC are to:

- Ensure continued compatibility with the goals of the National Curriculum of Pakistan.
- Review the content for inclusion of new knowledge and deletion of obsolete knowledge.
- Review the content for clarity and relevance as per the changing needs of students, teachers and society.
- Enhance and strengthen continuation and progression of content both within and across grades IX - XII (SSC and HSSC).
- Ensure the readiness of students for higher education.

During the syllabus review, the needs of all the stakeholders were identified through a needs-assessment survey. Students and teachers of AKU-EB affiliated schools from across Pakistan participated in the survey. Thereafter, a revision panel, which consisted of examiners, teachers of affiliated and non-affiliated schools, teacher trainers and university academicians, reviewed and revised the syllabus following a planned, meticulous and standardised syllabi review process.

The development of the revised syllabus has been made possible by the creativity and relentless hard work of Curriculum and Examination Development unit and the constant support provided by all the other units of AKU-EB. We are particularly thankful to
our Principal Syllabus Reviewers, Syllabus Revision Panellists and all other reviewers for their contribution. We are also thankful to all the students and teachers who took part in the needs-assessment survey and to the principals of AKU-EB affiliated schools who made this endeavour possible by facilitating and encouraging their teachers and students to be a part of the survey and the syllabus revision panel.

With your support and collective hard work, AKU-EB has been able to take the necessary steps to ensure effective implementation of the National Curriculum of Pakistan through this syllabus. We are confident that this syllabus will continue to provide the support that is needed by students to progress to the next level of education and we wish the very best to our students and teachers in implementing this syllabus.

Dr Naveed Yousuf
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Understanding of AKU-EB Syllabi

1. The AKU-EB syllabi guide the students, teachers, parents and other stakeholders regarding the topics that will be taught and examined in each grade (IX, X, XI and XII). In each syllabus document, the content progresses from simple to complex, thereby, facilitating a gradual, conceptual learning of the content.

2. The topics of the syllabi are divided into sub-topics and **student learning outcomes** (**SLOs**). The SLOs define the depth and the breadth at which each topic or subtopic will be taught, learnt and examined. The syllabi also provide enabling SLOs where needed to scaffold student learning.

3. Each SLO starts with an achievable and assessable **command word** such as describe, relate, evaluate, etc. The purpose of the command words is to direct the attention of teachers and students to specific tasks that the students are expected to undertake in the course of their studies.

4. The SLOs are classified under the following **cognitive levels** of Bloom's Taxonomy: Remember (R), Understand (U), Apply and beyond [Apply (A), Analyse (An), Evaluate (E), Create (C)]. This is to facilitate effective planning for teaching, learning and assessment. In addition, some SLOs are identified as Formative Assessments (FA), where applicable.

5. Where applicable, **Practical Activities** section is provided to elaborate the assessment in the Practical Examination.

6. The **Examination Specification** is provided which elucidates the weightage of each topic in the examinations determined on the basis of the content as well as the relevance of the topic.

7. To implement this syllabus, students and teachers can take support from additional material provided by the board to its affiliated schools including **Learning Resource Guides**, **Pacing Guides** and **Model Papers**.

8. The AKU-EB syllabi for Secondary School Certificate (SSC) and Higher Secondary School Certificate (HSSC) are designed to foster not only conceptual understanding but also critical thinking and problem-solving skills. These syllabi ensure students develop the cognitive, affective and psychomotor skills essential for success at the university and beyond.

Subject Rationale of AKU-EB Biology

What will you learn in AKU-EB Biology?

- On a wider note, biology links students to the living world; the different forms of life. It orients them about the variety of living organisms and their specific role to maintain the distinctive ecosystems.

- Biology brings awareness about the right choice of food in students' daily lives. The concepts of balanced diet, malnutrition, deficiency diseases guide them to make more informed decisions about their health.

- Since Pakistan is an agricultural country, it is very beneficial for students to learn about the favourable conditions for increased productivity. Biology helps them to understand the different textures of soil, requirement of mineral nutrition in plants, use of genetically modified crops, factors responsible for flood and soil erosion.

- Biology makes students aware about the importance of conservation of nature. It enables students to think about leaving a better planet for the next generations by following the principles of reduce, reuse and recycle.

Where will it take you?

The focus of the AKU-EB biology examination syllabus is more towards conceptual understanding of the phenomena of life which prepares students appropriately for higher secondary or tertiary level studies of biology-related fields.

The following non-exhaustive list suggests the diversity of careers which graduates in biological science can pursue:

- Biotechnology
- Medicine
- Environmental rehabilitation
- Agriculture
- Fisheries
- Bioengineering
- Forestry
- Animal husbandry
- Food technology
- Nursing
- Plant pathology
- Animal pathology
- Science teaching
- Forensic science

How to approach the syllabus?

The AKU-EB syllabi is carefully designed with a reader-friendly approach to ensure that students and teachers can easily comprehend it, making it functional for teaching, learning and assessment purposes. The syllabus includes following parts:

Subject Rationale	It is an introductory document for students.
Student Learning Outcomes (SLOs)	These guide students about what must be achieved.
Exam Specification	It guides regarding what is expected in the examination.
Practical Activities	These include laboratory activities to be performed during an academic year.
Additional Resources:	
Pacing Guide	It ensures smooth transition and curricular continuity of a school's academic year. It also predicts the time and pace of syllabi implementation.
Resource Guide	It includes teaching and learning resources for students and teachers.
Model Paper	It guides regarding exam pattern, types of questions and marking scheme.
Command Word Guide	It clarifies expectations regarding the cognitive levels and skills that should be acquired by the students and which are assessed in its examinations.

Student Learning Outcomes of AKU-EB HSSC Biology Syllabus

Part I (Grade XI)

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level[1]		
				R	U	A and beyond
1. Biological Molecules						
1.1	Introduction to Molecular Biology	1.1.1 1.1.2 1.1.3	define molecular biology and biological molecules; differentiate between organic and inorganic compounds; differentiate between condensation (dehydration synthesis) and hydrolysis reactions;	*	FA[2] *	
1.2	Properties of Carbon	1.2.1	describe properties of carbon, i.e., tetravalency, isomerism, and catenation;		FA	
1.3	The Significance of Water's Chemical Nature in Supporting Life Processes	1.3.1 1.3.2	describe the polarity of water molecules that results in hydrogen bonding; discuss the properties of water that contribute to the sustainability of life on Earth, i.e., a. cohesion and adhesion, b. high specific heat, c. anomalous behaviour of water, d. high heat of vapourisation, e. hydrophobic exclusion, f. ionisation of water;		*	E

[1]R = Remember, U = Understand, A = Apply and beyond [Apply (A), Analyse (An), Evaluate (E), Create (C)]
[2]FA= Formative Assessment, not to be assessed under examination conditions

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level[i]		
				R	U	A and beyond
1.4	Carbohydrates	1.4.1	define carbohydrates;	*		
		1.4.2	classify carbohydrates as monosaccharides, disaccharides, oligosaccharides and polysaccharides with examples;		FA	
		1.4.3	compare the properties and roles of monosaccharides with their formulae;		FA	
		1.4.4	distinguish between D and L forms of glucose (stereoisomers) based on the spatial arrangement of hydroxyl (-OH) groups around their chiral carbons;		*	
		1.4.5	illustrate the structure of α-D-glucose and β-D-glucose based on the position of the hydroxyl group at the anomeric carbon;			A
		1.4.6	illustrate the condensation (dehydration synthesis) and hydrolysis (breakdown) of disaccharides (sucrose, lactose and maltose) and polysaccharides (amylose, amylopectin, cellulose, starch and glycogen) by formation and breakage of glycosidic bonds;			A
		1.4.7	relate the structures of starch (amylose and amylopectin), glycogen and cellulose molecules to their functions in living organisms;		*	
1.5	Lipids	1.5.1	define lipids;	*		
		1.5.2	describe the properties of triglycerides (triacylglycerols), phospholipids, terpenoids (terpenes, carotenoids and steroids) and waxes with examples;		*	
		1.5.3	differentiate between saturated and unsaturated fatty acids;		*	
		1.5.4	illustrate the condensation and hydrolysis of a triglyceride molecule;			A
		1.5.5	illustrate the molecular structure of triglycerides, phospholipids, terpenoids (terpenes, carotenoids and steroids) and waxes;			A

Topics and Sub-topics		Student Learning Outcomes	Cognitive Level[i]		
			R	U	A and beyond
1.6 Proteins	1.6.1	define proteins and amino acids;	*		
	1.6.2	illustrate the structure of amino acids;			A
	1.6.3	explain that the amphoteric nature of amino acids enables them to function as buffers;		*	
	1.6.4	illustrate the condensation (dehydration synthesis) and hydrolysis (breakdown) of peptide linkages;			A
	1.6.5	differentiate between: a. essential and non-essential amino acids, b. acidic and basic amino acids, c. polar and non-polar amino acids;		*	
	1.6.6	describe the types of interaction that hold protein molecules in shape: a. hydrophobic interactions, b. hydrogen bonding, c. ionic bonding, d. covalent bonding (including disulfide bonds), e. Van der Waals forces;		*	
	1.6.7	differentiate among levels of organisation of proteins, i.e., primary, secondary, tertiary and quaternary with examples;		*	
	1.6.8	differentiate between fibrous and globular proteins with examples;		*	
	1.6.9	relate the structure of haemoglobin (globular protein) and collagen (fibrous protein) to their functions;		*	
	1.6.10	explain that change of amino acid sequence in a polypeptide chain leads to sickle cell anaemia;		*	
	1.6.11	describe the functions of proteins in living organisms;		FA	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level[i]		
				R	U	A and beyond
1.7	Nucleic Acid	1.7.1	define nucleic acid;	*		
		1.7.2	illustrate the basic structure of a nucleotide and a nucleoside;			A
		1.7.3	analyse the structure of deoxyribonucleic acid (DNA) molecule as a double helix, including: a. the importance of complementary base pairing between the 5′ to 3′ strand and the 3′ to 5′ strand (antiparallel strands), b. differences in hydrogen bonding between C–G and A–T base pairs, c. linking of nucleotides by phosphodiester bonds, d. synthesis and breakdown of polynucleotides by the formation and breakage of phosphodiester bonds;			An
		1.7.4	classify nucleotides based on their sugar molecules and nitrogen bases;		*	
		1.7.5	compare the structure and function of messenger RNA (mRNA), ribosomal RNA (rRNA) and transfer RNA (tRNA);		*	
		1.7.6	differentiate between DNA and RNA;		*	
1.8	Conjugated Molecules	1.8.1	define conjugated molecules;	*		
		1.8.2	describe the functions of glycolipids, glycoproteins, lipoproteins and nucleoproteins with examples;		*	

Topics and Sub-topics		Student Learning Outcomes	Cognitive Level[i]		
			R	U	A and beyond
1.9 Structural Biology	1.9.1	define structural biology;	*		
	1.9.2	explain the process of X-ray crystallography, including the generation of X-rays, crystal preparation, diffraction pattern collection and structure determination;		*	
	1.9.3	describe the contribution of Rosalind Franklin's in the discovery of the DNA double helix structure particularly through her X-ray diffraction images;		FA	
	1.9.4	define biological databases;	*		
	1.9.5	describe the purpose of biological databases;		*	
	1.9.6	state different primary biological databases [(e.g., GenBank, UniProt, Protein Data Bank (PDB), Protein Information Resource (PIR))].	*		

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
2. Enzymes		Students should be able to:				
2.1	Structure of Enzyme	2.1.1	describe the following terms: a. enzyme, b. apoenzyme, c. holoenzyme, d. active site, e. allosteric site;		*	
		2.1.2	classify cofactors based on their characteristic features into prosthetic groups, essential ions or activators and coenzymes, with examples;		*	
		2.1.3	analyse the effects of absence or deficiency of specific cofactors on enzyme function including common examples (i.e., Fe^{2+}, Zn^{2+}, Mg^{2+} and B-complex vitamins);			An
2.2	Mechanism of Enzyme Action	2.2.1	analyse the mode of action of enzymes in terms of: a. an active site, b. enzyme–substrate complex, c. lowering of activation energy, d. enzyme specificity, with the help of lock-and-key and induced-fit hypotheses;			An
2.3	Factors Affecting Enzyme Action	2.3.1	evaluate the effect of different factors, i.e., temperature, pH, substrate concentration, enzyme concentration on the rate of enzyme action;			E
		2.3.2	analyse the effect of temperature on the rate of enzyme action in human body and thermophilic bacteria;			An

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
		2.3.3	analyse the effect of pH on the activity of different enzymes, i.e., amylase, trypsin, pepsin, lipase and papain;			An
2.4	Enzyme Inhibition	2.4.1	define enzyme inhibition;	*		
		2.4.2	differentiate between reversible and irreversible inhibitors with examples;		*	
		2.4.3	analyse the effects of reversible inhibitors, i.e., competitive and non-competitive on enzyme activity;			An
		2.4.4	define end product inhibition (feedback inhibition);	*		
		2.4.5	explain the mechanism of end product inhibition;		*	
		2.4.6	describe the significance of inhibitors in regulation of enzymatic activity, medical applications and industrial processes such as preserving food;		*	
2.5	Classification of Enzymes	2.5.1	classify enzymes based on their substrates, i.e., lipases, diastase, amylase and proteases with examples;		*	
		2.5.2	classify enzymes based on reactions they catalyse and nature of substrate, i.e., oxidoreductases, transferases, hydrolases, isomerases and ligases with examples.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
3. The Cell		Students should be able to:				
3.1	Discovery of Cell	3.1.1	state classical cell theory;	FA		
		3.1.2	describe exceptions to classical cell theory, i.e., status of virus and the first cell, which could not have arisen from a pre-existing cell;		FA	
		3.1.3	describe the process of validating cell theory with historical and modern evidence, i.e., early microscopes provide initial evidence and modern techniques like electron microscopy and molecular biology further support it;		FA	
		3.1.4	compare classical and modern cell theory;		FA	
		3.1.5	state the contributions of different scientists in the discovery of cell (Robert Hooke 1665 to August Weismann 1880);	FA		
3.2	Microscopes	3.2.1	compare the resolution and magnification of light microscope and electron microscope (including transmission electron microscope and scanning microscope);		*	
		3.2.2	evaluate the suitability of different microscopy techniques based on their magnification and resolution capabilities for specific applications (e.g., viewing live cells vs. fixed tissues);			E
		3.2.3	calculate magnification, image size and actual size of the specimen by using the formula: Magnification = Image size (viewed under microscope) ÷ Actual size;			A

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
3.3	Structure of Animal and Plant Cell	3.3.1	describe that cells are the basic unit of life with respect to properties of life, i.e., movement, respiration, homeostasis, growth, reproduction, excretion, nutrition;		FA	
		3.3.2	explain the structure, chemical composition and functions of the cellular organelles of eukaryotic cell as revealed through the electron microscope: a. cell wall, b. cell membrane with reference to Fluid Mosaic Model, c. cytoplasm, d. rough endoplasmic reticulum and smooth endoplasmic reticulum, e. ribosomes, f. mitochondria, g. Golgi apparatus, h. lysosomes, i. vacuoles, j. cytoskeleton (microfilaments, microtubules and intermediate filaments), k. cilia and flagella, l. centrioles, m. plastids and its types, n. nucleus, o. peroxisomes, p. glyoxisomes;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
		3.3.3	compare the structure of animal and plant cells;		*	
		3.3.4	assess that different organelles interact to maintain cellular functions, i.e., protein synthesis and transport;			E
		3.3.5	analyse the effect of malfunctioning of a specific organelle on the overall function of cell;			An
3.4	Cell Membrane and Cell Signalling	3.4.1	describe the role of phospholipids, cholesterol, glycolipids, proteins and glycoproteins in cell surface membranes, with reference to stability, fluidity, permeability, transport proteins (e.g., carrier proteins and channel proteins), cell signalling (e.g., cell surface receptors) and cell recognition (e.g., cell surface antigens);		*	
		3.4.2	define the terms cell signalling and ligands;	*		
		3.4.3	explain the main stages of cell signalling, i.e., reception, transduction, transmission to effector and response;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
3.5	Mechanisms of Cellular Transport	3.5.1	compare mechanisms of passive transport (e.g., simple diffusion, facilitated diffusion and osmosis) and active transport;		FA	
		3.5.2	explain the factors influencing the rate of diffusion, i.e., concentration gradient, temperature, molecular size, medium of diffusion, surface area, distance, solvent density, permeability of the membrane, pressure and chemical nature of the molecule;		FA	
		3.5.3	analyse the roles of active and passive transport mechanisms in the movement of substances across cell membranes and their impact on homeostasis, nutrient uptake, waste removal and overall cell survival;			FA
		3.5.4	explain the steps involved in endocytosis and exocytosis, i.e., vesicle formation, movement and membrane fusion;		*	
		3.5.5	explain the types of endocytosis, i.e., phagocytosis and pinocytosis;		*	
		3.5.6	elaborate the significance of endocytosis and exocytosis in maintaining cellular function;		FA	
3.6	Lysosomal Disorders	3.6.1	describe storage diseases with reference to the malfunctioning of lysosomes, i.e., Tay-Sachs disease, Gaucher's disease, Krabbe's disease, glycogenosis type-II disease;		*	
3.7	Stem Cells	3.7.1	state the characteristic features of stem cells;	*		
		3.7.2	explain different types of stem cells based on their potency, i.e., totipotent, pluripotent and multipotent;		*	
		3.7.3	describe the advantages and disadvantages of using induced pluripotent stem cells.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
4. Classification and Acellular Life		Students should be able to:				
4.1	Classification of Living Organisms	4.1.1	describe the basis of classification of living organisms, i.e., homology, biochemistry, cytology and genetics;		*	
4.2	Binomial Nomenclature and Phylogenetic Trees	4.2.1	describe the hierarchical structure of biological classification including domain, kingdom, phylum/ division, class, order, family, genus and species;		*	
		4.2.2	describe the principles of binomial nomenclature;		*	
		4.2.3	assess the importance of standardising binomial nomenclature in scientific communication and research across different disciplines;			E
		4.2.4	define the basic terms related to phylogenetic trees: a. common ancestor, b. clade, c. monophyletic group, d. paraphyletic group, e. polyphyletic group;	*		
		4.2.5	identify the key components of a phylogenetic tree, i.e., nodes, branches, clades and common ancestors;		*	
		4.2.6	differentiate between monophyletic, paraphyletic and polyphyletic groups within phylogenetic trees;		*	
		4.2.7	analyse phylogenetic trees to reveal the evolutionary relationships between organisms;			An

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
4.3	Two and Five-Kingdom Classification Systems	4.3.1	compare the following classification systems of living organisms: a. two-kingdom and five-kingdom classification system of Whittaker, b. five-kingdom classification by Whittaker and five-kingdom classification system by Lynn Marguilis and Karlene Schwartz;		*	
4.4	Characteristics of Viruses	4.4.1 4.4.2 4.4.3	describe the discovery of viruses; describe the structural features of viruses; describe the survival of viruses inside a host cell;		FA * *	
4.5	Classification of Viruses	4.5.1 4.5.2	classify viruses based on their structure, type of nucleic acid and host; list diseases caused by viruses in animals and plants;	 FA	FA	
4.6	Life Cycle of Viruses	4.6.1 4.6.2 4.6.3 4.6.4	describe the structure of a bacteriophage and human immunodeficiency virus (HIV); illustrate lytic and lysogenic life cycles of bacteriophage; illustrate different stages of HIV life cycle; justify the name of the virus, i.e., 'Human Immunodeficiency Virus' by establishing linkage with T-helper cells as the basis of immune system;		*	 A A E

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
4.7 Viral Diseases	4.7.1	describe causative agent, symptoms, treatment, preventive measures and source of transmission of the following viral diseases: a. hepatitis, b. polio, c. herpes, d. acquired immunedeficiency syndrome (AIDS), e. leaf curl disease of cotton;			FA	
	4.7.2	define antivirals and antiretroviral drugs;		*		
4.8 Prions and Viroids	4.8.1	differentiate between prions and viroids;			*	
	4.8.2	list diseases caused by prions and viroids;		*		
	4.8.3	evaluate the potential risks posed by prions and viroids to public health and agriculture, considering factors such as transmissibility, environmental persistence and host susceptibility.				FA

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
5. Kingdom Prokaryotae		Students should be able to:				
5.1	Characteristic Features of Prokaryotes	5.1.1	state the characteristic features of prokaryotes;	*		
5.2	Morphology of Bacteria	5.2.1	state the discovery, occurrence and habitat of bacteria;	FA		
		5.2.2	describe the unique features of the following types of archaebacteria: a. methanogens, b. halophiles, c. thermophiles;		*	
		5.2.3	describe morphological diversity (shapes) of bacteria;		*	
		5.2.4	differentiate between Gram-positive and Gram-negative bacteria with reference to their colour and composition of cell wall;		*	

Topics and Sub-topics	Student Learning Outcomes		Cognitive Level		
			R	U	A and beyond
	5.2.5	relate the structure of each component of bacterial cell with its function: a. glycocalyx, b. capsule and slime, c. cell wall, d. cell membrane, e. cytoplasmic matrix, f. mesosomes, g. chromatin, h. nucleoid, i. plasmid, j. endospore, k. ribosomes, l. flagella, m. pili;		*	
	5.2.6	compare prokaryotes with eukaryotes;		*	
	5.2.7	differentiate between archaebacteria and eubacteria in the following aspects: a. habitat, b. cell wall composition, c. membrane lipids, d. genetic material, e. sensitivity to antibiotics;		*	
	5.2.8	analyse the effect of specific cellular components, i.e., cell wall and flagella, on the survival and reproduction of bacteria in various environmental conditions;			An

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
5.3	Nutrition in Bacteria	5.3.1	differentiate between the following types of nutrition in bacteria: a. autotrophic and heterotrophic nutrition, b. symbiotic and parasitic nutrition;		*	
		5.3.2	compare the chlorophyll present in bacteria and plants;		FA	
5.4	Respiration in Bacteria	5.4.1	describe obligatory aerobes, micro-aerobes, facultative and obligatory anaerobes with examples;		*	
5.5	Locomotion in Bacteria	5.5.1	compare chemotaxis and magnetotaxis methods of locomotion in bacteria in the following aspects: a. stimulus for locomotion, b. key locomotory structures, c. direction of movement, d. purpose;		*	
5.6	Growth in Bacteria	5.6.1	illustrate the different phases of growth in bacteria;			A
		5.6.2	describe endospore formation in bacteria as a mechanism of survival to withstand unfavourable conditions;		*	
5.7	Reproduction in Bacteria	5.7.1	describe the different modes of reproduction in bacteria: a. asexual reproduction (binary fission, budding and spore formation), b. genetic recombination (conjugation, transduction and transformation);		*	
5.8	Economic Importance of Bacteria	5.8.1	explain the economic importance of bacteria in: a. medicine, b. agriculture, c. industry, d. symbiosis, e. research and technology;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
	5.8.2	explain the role of harmful bacteria in: a. human and animal health, b. food spoilage;			*	
5.9 Control and Prevention of Bacteria	5.9.1	describe the following physical methods to disrupt bacterial structures or metabolic processes by inhibiting growth or killing bacteria: a. heat (e.g., autoclaving, pasteurisation), b. filtration, c. irradiation (e.g., use of UV light);			*	
	5.9.2	describe the action of following chemical agents to prevent growth or kill bacteria: a. disinfectants (e.g., chlorine, alcohol), b. antiseptics (e.g., iodine, hydrogen peroxide), c. antibiotics (e.g., bactericidal and bacteriostatic);			*	
	5.9.3	evaluate the consequences of misuse of antibiotics, including antimicrobial resistance of antibiotics;				E
	5.9.4	describe the symptoms, causative agent, treatments and preventive measures of bacterial diseases in man, i.e., cholera, typhoid, tuberculosis and pneumonia;			FA	
	5.9.5	describe the symptoms, causative bacteria and preventive measures of bacterial diseases in plants, i.e., spots, blights, soft rots, wilts and galls;			FA	

Topics and Sub-topics	Student Learning Outcomes		Cognitive Level		
			R	U	A and beyond
5.10 Cyanobacteria	5.10.1	list general characteristics of cyanobacteria;	FA		
	5.10.2	describe the habitat, structure, nutrition and reproduction in *Nostoc*;		FA	
	5.10.3	describe the ecological role of cyanobacteria [(e.g., contribution to primary production, nutrient cycling (especially nitrogen fixation), oxygen production and symbiotic relationships)] in aquatic ecosystems.		FA	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
6. Kingdom Protista (Protoctista)		Students should be able to:				
6.1	Unifying Features	6.1.1	describe the general characteristics of protists;		*	
6.2	Diversity among Protists	6.2.1	describe the evolution of diversity among protists;		*	
		6.2.2	justify protists as a polyphyletic group of organisms;			E
6.3	Animal-like Protists	6.3.1	describe the salient features of different classes of animal-like protists, i.e., flagellates/ zooflagellates, sarcodina/ rhizopoda, ciliata/ ciliophora, suctoria and sporozoa/ apicomplexan;		*	
		6.3.2	describe the importance of animal-like protist with reference to their ecological roles, i.e., in nutrient cycling, predation on bacteria and other protists and as food sources for larger organisms;		*	
		6.3.3	describe the common pathogenic animal-like protists (e.g., entamoeba, plasmodium, trypanosoma and giardia) and the diseases caused by them (e.g., amoebic dysentery, malaria, African sleeping sickness and giardiasis);		*	
6.4	Plant-like Protists	6.4.1	compare the salient features of plant-like protists, i.e., euglenoids, dinoflagellates, diatoms, brown, red and green algae with examples;		*	
		6.4.2	describe the importance of plant-like protists in food webs as primary producers and impact of algal blooms on aquatic ecosystem and in food industries such as (e.g., algal products, biofuel production);		*	

Topics and Sub-topics		Student Learning Outcomes	Cognitive Level		
			R	U	A and beyond
6.5 Fungi-like Protists	6.5.1	describe the salient features of fungi-like protists with examples;		*	
	6.5.2	describe the life cycle of slime molds (myxomycota) and water molds (oomycota);		*	
	6.5.3	describe the contribution of fungi-like protists in the decomposition of organic material and nutrient cycling in ecosystems;		*	
	6.5.4	justify the classification of animal-like protists, plant-like protists and fungi-like protists by comparing them with animals, plants and fungi respectively;			E
	6.5.5	describe plant diseases caused by fungi-like protists, i.e., potato blight (caused by *Phytophthora infestans*) and their impact on agriculture and food security.		FA	

Topics and Sub-topics		Student Learning Outcomes	Cognitive Level		
			R	U	A and beyond
7. Kingdom Fungi		Students should be able to:			
7.1 General Characteristics	7.1.1	compare the cellular features of fungi, animals and plants;		*	
	7.1.2	describe the basic structures of fungi, i.e., hyphae, mycelium, spores and fruiting bodies;		*	
	7.1.3	describe the structure of hyphae, i.e., septate and coenocytic hyphae along with their role in nutrient absorption and growth;		*	
	7.1.4	identify the unique components of fungal cell walls, i.e., chitin and glucans along with their role in providing structural support and protection;		*	
	7.1.5	explain mutualistic relationships in fungi, i.e., lichens and mycorrhizae (ectomycorrhiza and endomycorrhiza);		*	
	7.1.6	describe different methods of asexual reproduction in fungi, i.e., spores, conidia, fragmentation and budding;		*	
	7.1.7	describe different steps of sexual reproduction in fungi, i.e., plasmogamy, karyogamy, meiosis and spore formation;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
7.2	Classification of Fungi	7.2.1	classify kingdom fungi on the basis of their sexual reproductive structures (zygomycota, ascomycota, basidiomycota and deuteromycota);		*	
		7.2.2	describe the life cycle of *Rhizopus*, focusing on the formation of zygospores during sexual reproduction and sporangia during asexual reproduction;		*	
		7.2.3	describe the life cycle of a typical ascomycete, emphasising the formation of ascospores within asci during sexual reproduction and conidia during asexual reproduction;		*	
		7.2.4	describe the life cycle of a basidiomycete, highlighting the formation of basidiospores on basidia during sexual reproduction;		*	
		7.2.5	define parasexuality in deuteromycetes;	*		
		7.2.6	describe the main stages of parasexual life cycle of deuteromycetes, i.e., plasmogamy, karyogamy and mitotic recombination;		*	
		7.2.7	describe that genetic recombination occurs without meiosis during parasexual life cycle;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
7.3	Land Adaptations of Fungi	7.3.1	describe specific structural adaptations that enable fungi to thrive in diverse environments such as in: a. arid deserts: (e.g., thick cell walls, spore formation, fast-spreading hyphae, lack of flagellated cells, thick-walled zygote), b. extreme temperatures: (e.g., production of cryoprotective compounds such as glycerol and trehalose to protect from freezing damage, heat-shock proteins, thermophilic enzymes and specialised pigment melanin);		*	
7.4	Importance of Fungi	7.4.1	explain ecological and commercial importance of fungi (e.g., economic gains and losses).		FA	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
8. Kingdom Plantae		Students should be able to:				
8.1	Diversity among Plants	8.1.1	state general characteristics of plants;	*		
		8.1.2	classify kingdom plantae;		*	
8.2	Bryophytes (Non-vascular Plants)	8.2.1	describe the salient features of bryophytes (non-vascular plants) along with their sub-divisions, i.e., musci, hepaticae and anthocerotae;		*	
		8.2.2	illustrate the life cycle of moss (polytrichum);			A
		8.2.3	describe the significance of alternation of generation in bryophytes;		*	
		8.2.4	explain the adaptive characteristics of bryophytes in the land habitat;		*	
8.3	Tracheophytes (Vascular Plants)	8.3.1	state characteristic features of tracheophytes;	*		
		8.3.2	compare the characteristic features of major groups of tracheophyta, i.e.: a. psilopsida, b. lycopsida, c. sphenopsida, d. pteropsida;		*	
		8.3.3	explain evolution of single-veined (microphyllus) and multi-veined (megaphyllus) leaf;		FA	
		8.3.4	differentiate between homospory and heterospory;		*	
		8.3.5	explain the evolution of seed;		FA	
		8.3.6	illustrate the life cycle of ferns;			A
		8.3.7	describe general characteristics of gymnosperms and angiosperms with examples;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
8.4	Spermatophytes (Seed-producing Plants)	8.4.1	describe the development of male and female gametophytes in angiosperms and gymnosperms;		*	
		8.4.2	illustrate the life cycles of gymnosperm and angiosperm plants;			A
		8.4.3	compare the features of dicotyledonous and monocotyledonous plants;		FA	
		8.4.4	analyse specific adaptations in vascular plants that make them successful land plants, i.e., root systems, lignified cell walls, cuticle layer, xylem, phloem and seed production;			An
8.5	Angiospermic Families	8.5.1	explain the inflorescence**, floral characteristics and economic importance of the following angiospermic families: (**Note**: **Only Racemose and cymose inflorescence, further description of sub types is not required.) a. Brassicacaeae, b. Solanaceae, c. Poaceae;		*	
		8.5.2	derive the floral formulae and floral diagrams of the flowers of angiospermic families (given in SLO 8.5.1).			A

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
9. Kingdom Animalia		Students should be able to:				
9.1	Introduction	9.1.1	describe the general characteristics of animals;		FA	
9.2	Criteria for Animal Classification	9.2.1	explain the body plan of various phyla of kingdom animalia based on the following aspects: a. type of symmetry (radial and bilateral symmetry), b. tissue organisation (diploblastic and triploblastic), c. body cavities (acoelomates, pseudocoelomates and coelomates), d. pattern of development (protostomes and deuterostomes);		*	
9.3	Phyla and Comparative Anatomy of Invertebrates • Phylum Porifera • Phylum Coelentrata • Phylum Platyhelminthes • Phylum Aschelminthes/ Nematoda • Phylum Annelida • Phylum Arthropoda • Phylum Mollusca • Phylum Echinodermata	9.3.1	explain the general characteristics and economic importance of poriferans;		*	
		9.3.2	explain coelenterates with reference to their: a. general characteristics, b. origin of diploblastic organisation, c. radial symmetry, d. polymorphism and alternation of generation, e. formation of coral reefs, f. economic importance;		*	
		9.3.3	explain the general characteristics, parasitic adaptations and economic importance of platyhelminthes;		*	

Topics and Sub-topics	Student Learning Outcomes		Cognitive Level		
			R	U	A and beyond
	9.3.4	explain the general characteristics, parasitic adaptations and economic importance of nematodes;		*	
	9.3.5	explain general characteristics of annelids with reference to their: a. general characteristics, b. segmentation and its advantages, c. coelom and its advantages d. economic importance;		*	
	9.3.6	explain the general characteristics of arthropods and insects;		*	
	9.3.7	describe the types of metamorphosis in insects with examples;		*	
	9.3.8	explain the key adaptations in insects that enable them to survive in diverse habitats;		*	
	9.3.9	explain the economic importance (beneficial and harmful) of insects;		*	
	9.3.10	explain the general characteristics and economic importance of molluscs;		*	
	9.3.11	explain the general characteristics of spiny skinned animals (echinoderms) and their affinities;		*	
	9.3.12	compare the characteristics of different invertebrate phyla;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
9.4	Phylum Chordata	9.4.1	describe the fundamental characteristics of chordates;		*	
		9.4.2	classify chordates with examples;		*	
		9.4.3	differentiate between: a. acraniata and craniata, b. urochordata and cephalochordata;		FA	
9.5	Sub-phylum Vertebrata	9.5.1	describe the general characteristics of super-class pisces;		*	
		9.5.2	differentiate among cyclostomes, chondrichthyes (cartilaginous) and osteichthyes (bony fishes) with examples;		*	
		9.5.3	describe aquatic adaptations of super-class pisces;		*	
		9.5.4	list some familiar edible fish in Pakistan;	FA		
		9.5.5	describe the general characteristics of amphibians with examples;		*	
		9.5.6	elaborate that amphibians are unsuccessful land vertebrates;		*	
		9.5.7	explain general characteristics of reptiles;		*	
		9.5.8	elaborate reptiles as successful land vertebrates;		*	
		9.5.9	describe general characteristics of birds;		*	
		9.5.10	explain the adaptations of birds for aerial mode of life (flight adaptations);		*	
		9.5.11	differentiate between running and flying birds;		FA	
		9.5.12	describe general characteristics and classification of mammals (e.g., prototheria, metatheria and eutheria);		*	
		9.5.13	compare prototheria, metatheria and eutheria based on their reproductive strategies, anatomical features, geographic distribution and examples;		*	
		9.5.14	compare the characteristics of various classes of vertebrates, i.e., fish, amphibians, reptiles, birds and mammals.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
10. Bioenergetics		Students should be able to:				
10.1	Role of ATP	10.1.1	define bioenergetics;	*		
		10.1.2	describe the structure of ATP and its mechanism of storing energy in high-energy phosphate bonds;		*	
10.2	Photosynthesis	10.2.1	define photosynthesis with word and chemical equation;	FA		
		10.2.2	describe the significance of photosynthesis;		FA	
		10.2.3	illustrate the internal structure of thylakoid membrane to show the arrangement of photosynthetic pigments in the form of photosystems, electron transport chain and ATP-synthase complex;			A
		10.2.4	explain the role of chlorophyll and other photosynthetic pigments, light, carbon dioxide and water in photosynthesis;		FA	
		10.2.5	illustrate the absorption spectrum and action spectrum of photosynthetic pigments (e.g., chlorophyll a, b and carotenoids);			A
		10.2.6	define the terms: a. photolysis, b. photophosphorylation;	*		
		10.2.7	illustrate the main events of light dependent reactions (energy conversion, formation of ATP and NADPH) through Z-scheme;			A
		10.2.8	compare cyclic and non-cyclic photophosphorylation in light dependent reactions;		*	

Topics and Sub-topics	Student Learning Outcomes		Cognitive Level		
			R	U	A and beyond
	10.2.9	illustrate the different phases of Calvin cycle/ light independent reactions/ dark reactions, i.e., carbon fixation, reduction and regeneration;			A
	10.2.10	summarise the products formed at each step of light dependent and light independent reactions by detailing the specific molecules produced and their quantities;			A
	10.2.11	explain the process and importance of photorespiration;		*	
	10.2.12	describe the effect of temperature on the oxidative activity of RuBP carboxylase;		*	
	10.2.13	compare C_3, C_4 (Hatch-Stack pathway) and CAM plants;		*	
10.3 Cellular Respiration	10.3.1	define the following terms: a. cellular respiration, b. substrate level phosphorylation, c. oxidative phosphorylation and chemiosmosis;	*		
	10.3.2	differentiate between alcoholic and lactic acid fermentation;		*	
	10.3.3	relate the structure of the mitochondrion, [including the inner mitochondrial membrane (cristae, ATP synthase and electron transport chain complexes), intermembrane space, matrix and outer membrane] to their roles in ATP production during the electron transport chain and chemiosmosis;		*	
	10.3.4	analyse the steps involved in the mechanism of cellular respiration: a. glycolysis, b. pyruvic acid oxidation/ link reaction (formation of acetyl CoA), c. Krebs cycle (Citric acid cycle), d. respiratory chain (oxidative phosphorylation);			An

Topics and Sub-topics	Student Learning Outcomes		Cognitive Level		
			R	U	A and beyond
	10.3.5	explain the substrate-level phosphorylation during which exergonic reactions coupled with the synthesis of ATP, i.e., glycolysis and Krebs cycle;		*	
	10.3.6	relate chemiosmosis with electron transport chain and oxidative phosphorylation;		*	
	10.3.7	summarise the products formed at each step of cellular respiration, i.e., glycolysis, the link reaction, the Krebs cycle and oxidative phosphorylation by detailing the specific molecules produced and their quantities;			A
	10.3.8	describe the formation of acetyl CoA from fats through β oxidation;		FA	
	10.3.9	compare the cellular respiration of fats and glucose.		FA	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
11. Nutrition		Students should be able to:				
11.1	Nutrition in Plants	11.1.1	define nutrition;	*		
		11.1.2	list the macro and micronutrients of plants;	FA		
		11.1.3	describe the role and deficiency symptoms of: a. nitrogen, b. phosphorus, c. potassium, d. magnesium;		*	
		11.1.4	assess leaf colour and growth patterns of various plants to diagnose specific nutrient deficiencies;			E
		11.1.5	explain different modes of heterotrophic nutrition in plants, i.e., saprophytic, parasitic, symbiotic and insectivorous;		*	
11.2	Digestive System of Human Beings	11.2.1	relate the structure of each organ of human digestive system with its function: a. gastrointestinal tract (GIT): i. oral cavity, ii. pharynx, iii. oesophagus, iv. stomach, v. small intestine, vi. large intestine, vii. rectum and anus, b. accessory digestive organs: i. tongue, ii. salivary glands (composition of saliva), iii. liver (composition of bile), iv. gall bladder, v. pancreas (composition of pancreatic juice);		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
11.3	Human Dentition	11.3.1	describe the structure and function of different types of human teeth, i.e., incisors, canines, premolars and molars;		*	
		11.3.2	analyse the human dental formula (2-1-2-3) for both primary and permanent dentition;			An
		11.3.3	relate each structural component of a human tooth, i.e., crown, root, enamel, dentin, pulp cavity, cementum, periodontal ligament and gingiva with its function in processes like chewing, protection and sensory response;		*	
		11.3.4	describe factors that contribute to dental health issues, i.e., poor oral hygiene, dietary habits, smoking or tobacco use, lack of regular dental care and genetic predisposition;		*	
		11.3.5	describe the characteristics and preventive measures of common dental diseases, i.e., dental caries, gingivitis, periodontitis, halitosis (bad breath), tooth sensitivity;		*	
		11.3.6	evaluate dietary choices that affects the human dentition and overall oral health;			FA
11.4	Swallowing	11.4.1	describe three stages of swallowing: the oral (voluntary), pharyngeal (involuntary) and oesophageal (involuntary) phases;		*	
		11.4.2	describe the coordination of circular and longitudinal muscles in peristalsis;		*	

Topics and Sub-topics		Student Learning Outcomes	Cognitive Level		
			R	U	A and beyond
11.5 Digestion	11.5.1	explain the processes of mechanical and chemical digestion of carbohydrates, proteins and lipids in different parts of human digestive system;		*	
	11.5.2	describe the role of gastrin, secretin and cholecystokinin (CCK) hormones in stimulating secretion of digestive enzymes and production of gastric acid;		*	
	11.5.3	analyse the following: a. impact of gastric glands malfunction on acid and enzyme secretion, b. symptoms of acid reflux in relation to the malfunction of lower oesophageal sphincter/ cardiac sphincter, c. role of the pyloric sphincter in regulating food passage, d. consequences of damage to the mucosal lining in terms of protection against acidic content;			An

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
11.6	Absorption and Egestion	11.6.1	compare the mechanisms of absorption of nutrients, i.e., amino acids, monosaccharides and fatty acids by small intestine;		*	
		11.6.2	explain the role of the lymphatic system in lipid absorption;		*	
		11.6.3	evaluate the consequences of structural damage to the small intestine on nutrient absorption, i.e., loss of any structural component of villi;			E
		11.6.4	identify the regions of the large intestine, i.e., caecum, appendix, ascending colon, transverse colon, descending colon, sigmoid colon, rectum and anus;		*	
		11.6.5	describe the structural features of the large intestine, including its thick muscular walls that facilitate movement of waste and the presence of goblet cells that secrete mucus to aid in lubrication;		*	
		11.6.6	assess the role of the large intestine in the absorption of water and electrolytes, formation and storage of faeces and role of gut microbiota in synthesising essential vitamins like vitamin K and certain B vitamins;			E
11.7	Gastrointestinal Disorders	11.7.1	describe causes, symptoms, treatment and preventive measures of gastrointestinal disorders, i.e., diarrhoea, dysentery, constipation, piles, dyspepsia, peptic ulcer, food poisoning, anorexia and bulimia nervosa.		FA	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
12. Gaseous Exchange		Students should be able to:				
12.1	Gaseous Exchange in Plants	12.1.1	describe gaseous exchange in plants through stomata, lenticels and the leaf surface;		*	
12.2	Respiratory System of Human Beings	12.2.1	relate the structure of each respiratory organ with its function: a. upper respiratory tract: i. nose (nasal cavity), ii. pharynx, iii. larynx, b. lower respiratory tract: i. trachea, ii. bronchi and bronchioles, iii. chest cavity, ribs, external and internal intercostal muscles, diaphragm, iii. lungs, iv. pleurae;		*	
		12.2.2	explain structural adaptations in alveoli that collectively optimise the efficiency of gaseous exchange, i.e., large surface area, single layer of epithelial cells, rich capillary network, thin layer of moisture, surfactant and presence of macrophages;		*	
		12.2.3	explain the mechanism of breathing, i.e., inspiration and expiration;		*	

Topics and Sub-topics	Student Learning Outcomes		Cognitive Level		
			R	U	A and beyond
	12.2.4	describe the neural and physiological mechanisms involved in the involuntary control of breathing, i.e., the roles of medulla oblongata, pons and peripheral chemoreceptors (e.g., carotid bodies and aortic bodies);		*	
	12.2.5	explain the transportation of carbon dioxide and oxygen by the blood;		*	
	12.2.6	relate the structures of haemoglobin and myoglobin with their function as respiratory pigments;		*	
	12.2.7	analyse the effect of changes in pH, temperature and carbon dioxide concentration on haemoglobin's oxygen binding and releasing capability through oxyhaemoglobin dissociation curves;			An
	12.2.8	evaluate the impact of environmental factors on the efficiency of breathing mechanisms and respiratory system, i.e., high altitude, air pollution and smoking;			E
12.3 Respiratory Disorders	12.3.1	explain causes, symptoms and preventive measures of: a. upper respiratory tract infections: i. sinusitis, ii. otitis media, b. lower respiratory tract infections: i. Chronic Obstructive Pulmonary Disease or COPD (chronic bronchitis, emphysema and asthma), ii. lung cancer.		FA	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
13. Transport		Students should be able to:				
13.1	Introduction	13.1.1	describe the importance of transport of materials in living organisms;		FA	
13.2	Transportation in Plants	13.2.1	define water potential, osmotic/ solute potential and pressure potential;	*		
		13.2.2	differentiate between plasmolysis and deplasmolysis;		*	
		13.2.3	analyse the effects of different solute concentrations on plant and animal cells;			An
		13.2.4	calculate water potentials of plant cells;			A
		13.2.5	explain apoplast, symplast and vacuolar pathways through which water and minerals can move into the root system;		*	
		13.2.6	relate the structure of xylem and phloem to their functions;		*	
13.3	Ascent of Sap	13.3.1	explain that ascent of sap in plants is driven by TACT mechanism (Transpiration pull, Adhesion, Cohesion, Tension), root pressure, capillary action and imbibition;		*	
13.4	Transpiration	13.4.1	define transpiration;	*		
		13.4.2	differentiate among cuticular, lenticular and stomatal transpiration;		*	
		13.4.3	explain mechanisms involved in opening and closing of stomata: a. starch sugar hypothesis, b. influx of potassium ions;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
		13.4.4	assess the effect of following factors on the rate of transpiration: a. light, b. wind, c. humidity, d. temperature;			E
		13.4.5	explain transpiration as a necessary evil;		*	
13.5	Translocation	13.5.1	define translocation;	*		
		13.5.2	exemplify different parts of plants that function as sources or sinks in relation to the movement of nutrients;		*	
		13.5.3	explain the mechanism of phloem translocation, i.e., diffusion and pressure flow hypothesis;		*	
13.6	Circulatory System of Human Beings • Heart • Blood • Blood Vessels • Blood Pressure and Pulse Pressure	13.6.1	explain the structure and function of human heart with reference to the: e. layers of heart wall, a. chambers, b. valves and associated blood vessels;		*	
		13.6.2	explain the sequence of events in the cardiac cycle, including the contraction and relaxation of atria and ventricles;		*	
		13.6.3	describe the functioning of heart valves (tricuspid, bicuspid, pulmonary and aortic valves) in maintaining unidirectional blood flow during the cardiac cycle and producing heart sounds (lub-dub);		*	
		13.6.4	analyse the pressure changes in the left side of the heart during a cardiac cycle;			An
		13.6.5	define the terms: cardiac output, heart/ pulse rate and stroke volume;	*		

Topics and Sub-topics	Student Learning Outcomes		Cognitive Level		
			R	U	A and beyond
	13.6.6	calculate cardiac output by using the formula (Cardiac Output = Heart Rate × Stroke Volume) during rest, exercise and stress;			A
	13.6.7	assess that different bodily states affect the cardiac output, i.e., resting, physical exercise or stress;			E
	13.6.8	explain the following: a. role of the sinoatrial (SA) node as the natural pacemaker, b. transmission of electrical impulses through the atrioventricular (AV) node, bundle of His and Purkinje fibres, c. sequence of electrical conduction in coordinating the contraction of atria and ventricles;		*	
	13.6.9	describe the function of an artificial pacemaker in regulating heart rhythm in cases of sinoatrial (SA) node dysfunction or conduction blockages;		*	
	13.6.10	analyse different components of ECG report, i.e., ECG waveform (P wave, QRS complex, T wave) and their relationship to cardiac cycles and electrical activity;			An
	13.6.11	explain the causes of blue babies with reference to atrial and ventricular septum defects and ductus arteriosus;		*	
	13.6.12	explain the structure, function and composition of each blood component, i.e., plasma and blood cells;		*	

Topics and Sub-topics		Student Learning Outcomes	Cognitive Level		
			R	U	A and beyond
	13.6.13	describe the functions of blood;		FA	
	13.6.14	describe the causes, symptoms, preventions and treatments of disorders of blood, i.e.: a. leukaemia, b. thalassemia, c. anaemia, d. haemophilia;		FA	
	13.6.15	relate the structure of artery, vein and capillary with their functions;		*	
	13.6.16	describe the role of precapillary sphincters in regulating the flow of blood through capillaries;		*	
	13.6.17	trace the pathway of blood through the pulmonary and systemic circulation, i.e., coronary, hepatic-portal and renal circulation;		*	
	13.6.18	analyse the factors, i.e., vessel diameter and total cross-sectional area, affecting the rate of blood flow and blood pressure through arteries, arterioles, capillaries, venules and veins;			An
	13.6.19	differentiate between blood pressure and pulse pressure;		*	
	13.6.20	interpret normal and abnormal pulse pressure values and their potential health implications;			E
	13.6.21	describe the role of baroreceptors and volume receptors in regulating the blood pressure;		*	
13.7 Cardiovascular Disorders	13.7.1	describe various aspects of cardiovascular health, i.e., atherosclerosis, arteriosclerosis, thrombus formation, embolus, coronary thrombosis, stroke, haemorrhage and hypertension;		*	
	13.7.2	categorise angina pectoris, heart attack and heart failure as progressive stages in the development of cardiovascular disease;		*	

Topics and Sub-topics		Student Learning Outcomes	Cognitive Level		
			R	U	A and beyond
	13.7.3	describe the purpose of angiography, including its role in visualising blood vessels and diagnosing conditions such as blockages or aneurysms (localised, abnormal dilation or bulging of a blood vessel due to a weakened vessel wall);		FA	
	13.7.4	describe the basic procedure of angiography, including the use of contrast dye and imaging techniques to obtain detailed pictures of blood vessels;		FA	
	13.7.5	describe the main principles of angioplasty and open-heart surgery (coronary bypass);		FA	
	13.7.6	describe the causes of hypertension and hypotension;		*	
	13.7.7	design a lifestyle modification plan that includes dietary changes, physical activity, stress management and smoking cessation strategies tailored to individuals at risk of or suffering from hypertension or cardiovascular diseases;			C
13.8 Lymphatic System of Human Beings	13.8.1	explain the lymphatic system with respect to: a. formation of lymph, b. lymph vessels, c. lymph trunk, d. lymph nodes, e. lymphoid organs/ masses/ tissues (e.g., bone marrow, thymus, adenoids, tonsils, spleen, Peyer's patches and appendix);		*	
	13.8.2	compare intercellular fluid (tissue fluid) and lymph;		*	
	13.8.3	explain the functions of lymphatic system;		*	
	13.8.4	assess that malfunctioning of lymphatic system leads to oedema.			E

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
14. Immune System		Students should be able to:				
14.1	Introduction and Types of Immune System	14.1.1	define immunity;	*		
		14.1.2	classify immune system as innate [first (non-specific) and second line of defense)] and adaptive [(specific) antibody-mediated and cell-mediated as third line of defense)] immune systems;		*	
		14.1.3	identify the major routes pathogens may take when entering the body;		*	
		14.1.4	differentiate between: a. antigen and antibodies, b. self-antigens and non-self-antigens;		*	
14.2	Innate Immune System	14.2.1	explain the role of physical barriers (e.g., skin, ciliated epithelium, nasal hairs and mucous membrane) and chemical barriers (e.g., stomach acid, tears, mucus, saliva) in protecting the body from infection as the first line of defense;		*	
		14.2.2	describe the structure and mode of action of phagocytes, i.e., neutrophils, macrophages, natural killer cells and antigen-presenting cells;		*	
		14.2.3	identify the roles of cytokines, opsonin, phagosomes and lysosomes in immune response;		*	
		14.2.4	explain the non-specific responses of the body to infection, including inflammation, lysozyme action, interferon and phagocytosis;		*	
		14.2.5	compare the bacterial-killing function of complement system proteins and the virus-inhibiting role of interferons;		*	
		14.2.6	describe the release of pyrogens by microbes and their effect on the hypothalamus to boost the body's temperature;		*	
		14.2.7	describe different ways in which fever impacts microbes;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
14.3	Antibody Mediated (Humoral) Immune Response	14.3.1	describe the structural features of an antibody, i.e., variable and constant regions, heavy and light chains and antigen-binding sites;		*	
		14.3.2	describe the role of B-cells in recognising antigens, producing antibodies and retaining memory for the long-term immunity;		*	
		14.3.3	explain the process of clonal selection and expansion of B-cells in response to an antigen;		*	
		14.3.4	describe that antibodies neutralise pathogens, opsonise them for phagocytosis and activate the complement system;		*	
14.4	Cell Mediated Immune Response	14.4.1	describe the role of T-cells in recognising and responding to infected or abnormal cells;		*	
		14.4.2	identify the different types of T-cells (helper T-cells, cytotoxic or killer T-cells and regulatory or suppressor T-cells) and their specific functions in the immune response;		*	
		14.4.3	describe that cytotoxic T-cells destroy infected or cancerous cells by releasing perforins and granzymes;		*	
		14.4.4	explain the process of T-cell activation, including the roles of antigen-presenting cells (APCs) and major histocompatibility complex (MHC) molecules;		*	
		14.4.5	explain the role of helper T-cells in supporting the activation and function of other immune cells, including B-cells and macrophages;		*	
		14.4.6	state the role of T-cells and B-cells in transplant rejections;	*		

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
14.5	Primary and Secondary Immune Responses	14.5.1	describe the primary immune response, including the lag phase, production of antibodies and gradual increase in antibody concentration;		*	
		14.5.2	explain the secondary immune response, highlighting the faster and more robust production of antibodies, due to the presence of memory B cells;		*	
		14.5.3	illustrate the differences between primary and secondary immune responses in terms of antibody concentration and response time;			A
14.6	Active and Passive Immunity (Natural and Artificial)	14.6.1	differentiate between active (natural and artificial) and passive (natural and artificial) immunity;		*	
		14.6.2	identify immunisation strategies for active immunity (e.g., first exposure to a pathogen, vaccination) and passive immunity (e.g., administration of antibodies through antiserum or immunoglobulin injections and the natural transfer of antibodies from mother to infant through breastfeeding or placental transfer);		*	
		14.6.3	evaluate real-life scenarios to decide whether a patient should receive active or passive immunity or both immunities, i.e., exposure to rabies, snakebite, tetanus wound, hepatitis B virus, newborn protection, measles in an unvaccinated individual and immune deficiency disorder);			E
		14.6.4	describe the role of histamines in producing allergy symptoms in humans;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
14.7	Autoimmune Diseases	14.7.1 14.7.2	define autoimmune diseases; exemplify autoimmune diseases, i.e., rheumatoid arthritis, lupus, multiple sclerosis and type-1 diabetes;	*	*	
14.8	Monoclonal Antibodies	14.8.1 14.8.2 14.8.3	define monoclonal antibodies; describe the steps of production of monoclonal antibodies through hybridoma method, i.e., immunisation, cell fusion, selection and cloning, production and purification); describe the applications of monoclonal antibodies in the following: a. disease treatment, i.e., cancer, autoimmune disorders and infectious diseases, b. diagnostic tests, i.e., pregnancy tests, blood tests and viral infection tests.	*	* *	

Part II (Grade XII)

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level[3]		
				R	U	A and beyond
15. Homeostasis		Students should be able to:				
15.1	Introduction	15.1.1	define homeostasis;	*		
		15.1.2	differentiate among the different aspects of homeostasis, i.e., osmoregulation, excretion and thermoregulation;		*	
		15.1.3	describe the significance of homeostasis with examples;		*	
15.2	Feedback System	15.2.1	describe the components of the feedback system in living organisms, i.e., stimulus, receptor/ detector, control centre, effector and response/ output with examples;		*	
		15.2.2	explain positive feedback systems in humans with examples, i.e., blood clotting, childbirth/ labour contractions, lactation/ milk ejection reflex;		*	
		15.2.3	explain negative feedback systems in humans with examples, i.e., blood glucose regulation;		*	
15.3	Osmoregulation in Plants and Animals	15.3.1	explain osmoregulatory adaptations in plants, i.e.: a. hydrophytes, b. halophytes, c. mesophytes, d. xerophytes;		*	
		15.3.2	differentiate between osmoregulator and osmoconformer animals with examples;		*	
		15.3.3	explain osmoregulatory adaptations in aquatic (fresh water and marine fish) and terrestrial animals;		*	

[3]R = Remember, U = Understand, A = Apply and beyond [Apply (A), Analyse (An), Evaluate (E), Create (C)]

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
15.4	Excretion in Plants	15.4.1	differentiate between excretion, egestion and secretion;		*	
		15.4.2	explain different ways in which excretory products are stored and removed from plant body;		*	
		15.4.3	differentiate between transpiration and guttation as methods of removal of water in plants;		*	
15.5	Excretion in Animals	15.5.1	analyse the relationship between the mode of nitrogenous excretion and the habitat of animals, i.e., ammoniotelic, uricotelic and ureotelic;			An
15.6	Excretion in Man	15.6.1	identify different excretory organs in man, i.e., kidney, liver, skin, with the type of metabolic waste excreted by each of them;		*	
		15.6.2	explain the steps of the urea cycle or ornithine cycle;		*	
		15.6.3	explain the role of liver in homeostasis;		*	
		15.6.4	identify the function of each part of the urinary system;		*	
		15.6.5	describe the shape, location and protective coverings of the kidney (fibrous capsule);		*	
		15.6.6	describe the internal structure of kidney, i.e., cortex, medulla, renal pyramids, renal pelvis, calyces and nephrons;		*	
		15.6.7	relate the internal structure of nephron with its functions (simple filtration, reabsorption and secretion);		*	
		15.6.8	identify glomerular capillaries and peritubular capillaries as two major capillary beds in kidneys;		*	
		15.6.9	explain the effect of hormones, i.e., antidiuretic hormone, aldosterone and parathyroid hormone on the working of kidneys;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
		15.6.10	analyse the effects of changes in antidiuretic hormone levels on urine concentration and the body's hydration status under conditions such as dehydration or excessive water intake;			An
		15.6.11	state the composition of urine in a healthy person;	*		
		15.6.12	interpret urine test results (for presence of proteins, glucose, blood, or altered electrolyte levels) to identify dysfunctions of specific part of nephron;			E
15.7	Kidney Diseases	15.7.1	describe the causative bacteria and symptoms of urinary tract infections, i.e., pyelonephritis, urethritis and cystitis;		*	
		15.7.2	explain the causes and treatments of kidney stones;		*	
		15.7.3	describe the causes and treatments of kidney failure;		*	
		15.7.4	explain the mechanism and problems related to dialysis, i.e., haemodialysis and peritoneal dialysis;		*	
		15.7.5	describe the principles of kidney transplant with respect to blood compatibility;		FA[4]	
		15.7.6	identify the problems associated with administration of immunosuppressant drugs after kidney transplant;		FA	
15.8	Thermoregulation in Plants	15.8.1	describe the significance of thermoregulation in living organisms;		*	
		15.8.2	describe adaptations of plants to low and high temperatures;		*	
15.9	Thermoregulation in Animals	15.9.1	classify animals on the basis of their ability to thermoregulate, i.e., poikilotherms and homeotherms with examples;		*	
		15.9.2	compare the mechanisms of ectothermy, heterothermy and endothermy with examples;		*	
		15.9.3	analyse structural, physiological and behavioural adaptations in animals for thermoregulation in different environments.			An

[4]FA= Formative Assessment, not to be assessed under examination conditions

[2]FA = Formative Assessment, not to be assessed under examination conditions

Topics and Sub-topics		Student Learning Outcomes	Cognitive Level		
			R	U	A and beyond
16. Support and Movement		Students should be able to:			
16.1 Support in Plants	16.1.1	describe the role of turgor pressure in providing support to herbaceous plants;		*	
	16.1.2	differentiate among different supporting structures in plants, i.e., parenchyma, collenchyma and sclerenchyma (fibres/ tracheids, vessels, sclereids and stone cells) in terms of their structure, function, location and examples;		*	
	16.1.3	differentiate between primary and secondary growth in plants;		*	
	16.1.4	explain the significance of secondary growth in plants;		*	
	16.1.5	describe the formation and significance of annual rings;		*	
	16.1.6	differentiate between: a. spring/ summer and autumn/winter wood, b. heartwood and sapwood;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
16.2	Movement in Plants	16.2.1	classify movements exhibited by plant as: a. movement of locomotion, b. movement of curvature;		*	
		16.2.2	describe the types of movement of locomotion with examples: a. autonomic (ciliary/ flagellar movements, amoeboid movements and cyclosis), b. paratonic (phototactic, chemotactic and thermotactic);		*	
		16.2.3	explain types and sub-types of movement of curvature: a. autonomic movement [i.e., growth movements (nutation, circumnutation, epinastic and hyponastic movements)], b. paratonic or induced movement [i.e., (tropic and nastic movements)] with examples;		*	
		16.2.4	explain types of tropic movements, i.e., phototropism, geotropism, thigmotropism, hydrotropism, chemotropism and thermotropism with examples;		*	
		16.2.5	explain types of nastic movements, i.e., nyctinastic (sleeping), photonastic, thermonastic, thigmonastic (haptonastic) and seismonastic movements with examples;		*	
		16.2.6	discuss that hormones like auxins control tropisms (phototropism and geotropism) by distributing hormones unevenly to stimulate directional growth;			E
16.3	Support and Locomotion in Animals	16.3.1	define skeleton;	*		
		16.3.2	compare hydrostatic skeleton, exoskeleton and endoskeleton with respect to their structure, composition, location, flexibility, growth, protection, adaptation for movement and examples;		*	

Topics and Sub-topics	Student Learning Outcomes		Cognitive Level		
			R	U	A and beyond
16.4 Human Skeleton	16.4.1	describe the functions of: a. bone cells (osteogenic/ stem cells, osteoblasts, osteocytes and osteoclasts), b. cartilage cells (chondroblasts and chondrocytes);		*	
	16.4.2	explain the composition and structure of compact and spongy bone;		*	
	16.4.3	compare bone and cartilage based on their composition, hardness, function, blood supply, strength and regenerative ability;		*	
	16.4.4	compare the hyaline cartilage, fibrocartilage and elastic cartilage based on their flexibility, composition and location;		*	
	16.4.5	explain the structure, function and articulation of different components of human skeletal system, i.e., axial and appendicular skeleton;		*	
	16.4.6	explain the functions of human skeleton;		*	
	16.4.7	explain different types of joints, i.e., immovable/ fixed, slightly movable/ cartilaginous, freely movable/ synovial joints (with their sub-types);		*	
	16.4.8	elaborate the structure of a synovial joint;		*	
	16.4.9	compare tendon and ligament in terms of their composition, function, elasticity, location and role in movement;		*	
	16.4.10	differentiate between origin and insertion as attachment points of muscles on bones with examples, i.e., biceps brachii;		*	
	16.4.11	evaluate the impact of improper joint alignment (dislocation) on mobility and the potential for long-term damage to the skeletal system;			FA

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
16.5	Skeleton-Related Diseases and Injuries	16.5.1	explain the causes, symptoms, treatments and preventive measures of skeleton-related diseases, i.e.: a. disc slip (herniated disc), b. spondylitis, c. sciatica, d. osteoarthritis, e. osteoporosis;		*	
		16.5.2	analyse clinical cases of skeleton-related diseases, based on the symptoms or diagnostic tests, i.e., X-rays, MRIs;			An
		16.5.3	suggest appropriate management strategies for skeleton-related diseases given in SLO 16.5.1;			E
		16.5.4	explain the process of repairing of fractured bones;		*	
		16.5.5	recommend modifications to the workplace to prevent strain on the axial and appendicular skeletons;			E
16.6	Muscular System	16.6.1	differentiate between voluntary and involuntary muscles;		*	
		16.6.2	relate the structure of different types of muscles with their functions, i.e., skeletal, smooth and cardiac muscles;		*	
		16.6.3	describe the ultrastructure of skeletal muscles;		*	
		16.6.4	illustrate the changes in the sarcomere during contraction and relaxation;			A
		16.6.5	explain the mechanism of muscle contraction (sliding filament theory of Huxley, cross bridge cycle and regulation of muscle contraction);		*	
		16.6.6	describe the cause and mechanism of rigor mortis (including the depletion of ATP, calcium ion accumulation and the formation of sustained cross-bridges between actin and myosin in muscle fibres) after death;		*	

Topics and Sub-topics	Student Learning Outcomes		Cognitive Level		
			R	U	A and beyond
	16.6.7	predict the effects of calcium deficiency and ATP depletion on muscle contraction;			E
	16.6.8	describe all or none response in muscles;		*	
	16.6.9	compare the structure and functions of fast twitch and slow twitch muscle fibres;		*	
	16.6.10	describe the causes of abnormal muscle contraction, i.e., tetany and cramps;		*	
16.7 Antagonistic Muscles	16.7.1	define antagonistic muscles;	*		
	16.7.2	describe the action of antagonistic muscles, i.e., quadriceps and hamstrings in the movement of knee joint;		*	
	16.7.3	differentiate between tetanus and muscle tetany.		FA	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
17. Coordination and Control		Students should be able to:				
17.1	Introduction	17.1.1	define coordination and control in living organisms;	*		
		17.1.2	describe the need for coordination and control;		*	
17.2	Control and Coordination in Plants	17.2.1	explain the types of plant hormones with their functions;		*	
		17.2.2	describe that plants respond to stress factors, i.e., drought, temperature changes and salinity, through hormones like abscisic acid, which can promote stomatal closure to reduce water loss;		*	
		17.2.3	describe commercial applications of plant hormones;		*	
		17.2.4	define biological clock and circadian rhythm;	*		
		17.2.5	identify different physiological processes influenced by circadian rhythms, i.e., sleep-wake cycles, hormone secretion (e.g., cortisol in the morning and melatonin at night), flowering time and leaf movements;		*	
17.3	Coordination in Man • Receptors • Neurons	17.3.1	define nervous coordination, receptors and neurons;	*		
		17.3.2	classify receptors based on the types of stimuli;		*	
		17.3.3	describe the working of sensory mechanoreceptors with reference to skin, i.e., Pacinian corpuscles, Meissner corpuscles, Merkel complexes, Ruffini corpuscles;		*	
		17.3.4	compare the structure and function of sensory, relay/ intermediate and motor neurons;		*	
		17.3.5	describe the role of neuroglial cells in the nervous system (e.g., Schwann cells and oligodendrocytes);		*	
		17.3.6	classify neurons based on their structural differences, i.e., multipolar, unipolar, bipolar and pseudo-unipolar;		*	
		17.3.7	differentiate between myelinated and non-myelinated neurons;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
17.4	Nerve Impulse	17.4.1	define nerve impulse;	*		
		17.4.2	describe the factors affecting the velocities of nerve impulse, i.e., temperature, diameter of axon, myelination in neurons;		*	
		17.4.3	analyse different steps involved in the action potential and propagation of nerve impulse;			An
		17.4.4	describe saltatory conduction of nerve impulse in a myelinated neuron;		*	
		17.4.5	define synapse, pre synapse, post synapse and	*		
		17.4.6	neurotransmitter;		*	
		17.4.7	explain synaptic transmission of nerve impulse;		*	
			classify neurotransmitters as inhibitory (e.g., Gamma-aminobutyric acid (GABA), glycine and serotonin) and excitatory (e.g., glutamate, epinephrine and norepinephrine);			
17.5	Nervous System of Human Beings a. Central Nervous System: • Brain • Spinal Cord b. Peripheral Nervous System • Somatic • Autonomic (Sympathetic and Parasympathetic) c. Reflex Arc	17.5.1	classify the types of the human nervous system;		*	
		17.5.2	explain the functions of different parts of human brain;		*	
		17.5.3	analyse the impact of injuries to various regions of the brain, i.e., the cerebrum, cerebellum, brainstem and basal ganglia on motor coordination such as movement, balance and fine motor skills;			An
		17.5.4	analyse the structures visible in the cross-section of spinal cord;			An
		17.5.5	describe cranial and spinal nerves in man;		*	
		17.5.6	describe peripheral nervous system along with its subtypes, i.e., somatic and autonomic nervous systems;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
		17.5.7	differentiate between sympathetic and parasympathetic nervous systems;		*	
		17.5.8	trace the sequence of events in a reflex arc (from stimulus detection by the receptor, signal transmission along the sensory neuron, processing in the spinal cord and response through the motor neuron to the effector.);		*	
		17.5.9	illustrate monosynaptic and polysynaptic reflexes;			A
17.6	Effects of Drugs on Human Nervous System	17.6.1	compare the use and abuse of drugs with respect to heroine, *Cannabis*, nicotine, alcohol and inhalants like nail polish remover and glue;		FA	
		17.6.2	explain drug addiction and drug tolerance with reference to nicotine and caffeine and their adverse effects on nervous system;		*	
		17.6.3	describe that pain medicines can reduce or numb pain in the human body;		FA	
		17.6.4	describe that certain pain medications are addictive;		FA	
		17.6.5	describe narcotic drugs as agents that interact with the normal nervous activity;		FA	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
17.7	Disorders of Nervous System	17.7.1	classify nervous disorders into vascular, infectious, structural, functional and degenerative disorders;		*	
		17.7.2	describe the causes, symptoms and treatment of each category of disorders (e.g., stroke as vascular, meningitis as infectious, brain tumor as structural, headache as functional, and Alzheimer disease as degenerative disorder);		*	
		17.7.3	describe EEG, CT scan and MRI as important diagnostic tests for nervous disorders with examples;		*	
		17.7.4	assess clinical symptoms and diagnostic results to identify various nervous system disorders;			E
17.8	Chemical (Hormonal) Coordination	17.8.1	differentiate between nervous and chemical coordination;		*	
		17.8.2	identify the major endocrine glands and their locations in the human body, i.e., pituitary, hypothalamus, pineal, thyroid, parathyroid, thymus, pancreas, adrenal, testes and ovaries);		*	
		17.8.3	explain the hormones secreted by each endocrine gland and their functions;		*	
		17.8.4	describe the neurosecretory role of hypothalamus;		*	
		17.8.5	assess the role of hormones and the problems associated with their imbalance in the body;			E
		17.8.6	illustrate the negative feedback mechanism of hormones, i.e., thyroxin and cortisol;			A
		17.8.7	describe positive feedback with reference to oxytocin and negative feedback with reference to insulin and glucagon;		*	
		17.8.8	analyse the role of insulin and glucagon in regulation of blood glucose levels through the processes of glycogenesis, glycogenolysis and gluconeogenesis in different scenarios (e.g., after a meal, during fasting, intense physical activity, diabetes mellitus or hypoglycaemia);			An

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
17.9	Cell Signalling	17.9.1	describe the chemical nature of hormones;		*	
		17.9.2	identify different cell signalling molecules (ligands), i.e., hormones and neurotransmitters;		*	
		17.9.3	explain different types of cell surface receptors and intracellular receptors and the process through which they bind to signalling molecules (ligands);		*	
		17.9.4	explain signal transduction pathways (for protein and steroid hormones) with the key components like G-proteins, kinases and secondary messengers such as cAMP.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
18. Reproduction		Students should be able to:				
18.1	Asexual Reproduction in Plants	18.1.1	compare asexual reproduction and sexual reproduction in plants;		*	
		18.1.2	describe advantages and disadvantages of asexual reproduction;		*	
		18.1.3	exemplify natural and artificial methods of reproduction in plants, i.e., a. vegetative reproduction, b. parthenocarpy, c. apomixes;		*	
18.2	Photoperiodism	18.2.1	define photoperiodism, long day, short day and day neutral plants;	*		
		18.2.2	explain the mechanism of photoperiodism with respect to mode of action of phytochromes;		*	
		18.2.3	differentiate between florigen and phytochromes;		*	
18.3	Germination in Plants	18.3.1	describe seed dormancy;		*	
		18.3.2	differentiate between epigeal, hypogeal and viviparous germination of seeds with examples;		*	
		18.3.3	define vernalisation;	*		
		18.3.4	explain the effect of low temperature treatment on flower production in biennials and perennials;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
18.4	Sexual Reproduction in Animals	18.4.1	compare the following: a. internal fertilisation and external fertilisation, b. identical and fraternal twins, c. spermatogenesis and oogenesis, d. unisexual and bisexual animals, e. oviparity, viviparity and ovoviviparity;		*	
		18.4.2	describe the male and female reproductive systems of humans;		*	
		18.4.3	describe male reproductive hormones and their functions;		*	
		18.4.4	explain different stages of female reproductive cycles, i.e., ovarian cycle (follicular phase, ovulation and luteal phases) and uterine cycle (menstrual, proliferative and secretory phases) with their hormonal control in human females;		*	
		18.4.5	analyse the effect of hormonal levels on the female reproductive cycles;			An
18.5	Sexually Transmitted Diseases (STDs)	18.5.1	describe causative agent, symptoms and prevention of sexually transmitted diseases, i.e.: a. gonorrhoea, b. syphilis, c. genital herpes, d. acquired immune deficiency syndrome (AIDS).		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
19. Growth and Development		Students should be able to:				
19.1	Introduction	19.1.1	differentiate between: a. growth and development, b. embryo and larva;		*	
19.2	Growth and Development in Plants	19.2.1 19.2.2	define open growth, growing points and meristems in plants; describe the types of meristems with their functions in plants;	FA	 *	
19.3	Phases of Growth in Plants	19.3.1 19.3.2 19.3.3 19.3.4	describe different phases of growth in plants; explain external and internal factors affecting the growth rate in plants; describe cell differentiation in the embryo of a plant; explain growth correlations and their effects (inhibitory and compensatory) in plants;		* * * *	
19.4	Growth and Development in Animals	19.4.1	describe the key events in development of animals;		*	
19.5	Development of Chick	19.5.1 19.5.2 19.5.3 19.5.4 19.5.5	differentiate between animal and vegetal pole of avian/ hen egg; describe the cleavage pattern of avian/ hen egg; describe development of chick up to three germinal layers; explain the stages of chick development, i.e.: a. morula formation, b. blastulation, c. gastrulation, d. notochord formation, e. neurulation, f. somites and coelom formation; explain fate of the three germ layers that form during gastrulation;		* * * * *	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
19.6	Cell Differentiation and its Mechanism	19.6.1	explain the role of nucleus and cytoplasm in development through Hans Spemann's experiments;		*	
		19.6.2	explain the role of nucleus in development through experiments performed on *Acetabularia*;		*	
		19.6.3	define cell differentiation;	*		
		19.6.4	describe the significance of cell differentiation;		*	
		19.6.5	describe the following factors that control cell differentiation and gene expression: a. cytoplasmic determinants, b. signalling molecules or induction, c. transcription factors, d. DNA methylation, e. histone modifications, f. apoptosis, g. environmental factors, e.g., nutrients, hormones, physical signals;		*	
		19.6.6	explain embryonic induction as investigated by Hans Spemann and Hilde Mangold;		*	
19.7	Aging	19.7.1	define gerontology;	*		
		19.7.2	describe aging as a part of normal development;		*	
		19.7.3	differentiate between primary and secondary aging in humans;		*	
		19.7.4	explain the genetic and extrinsic factors responsible for aging;		*	
19.8	Abnormal Development	19.8.1	define teratology;	*		
		19.8.2	describe abnormalities inherited from parent to offspring (at gene level and chromosomal level) with examples;		*	
		19.8.3	relate different environmental and metabolic factors with abnormal development.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
20. Chromosomes and DNA		Students should be able to:				
20.1	Structure and Types of Chromosomes	20.1.1	differentiate among the types of chromosomes, i.e.: a. autosomes and sex chromosomes, b. homologous and non-homologous chromosomes, c. telocentric, acrocentric, metacentric and sub-metacentric chromosomes;		*	
		20.1.2	describe levels of eukaryotic chromosomal organisation;		*	
		20.1.3	define chromosome karyotype;	*		
		20.1.4	describe the significance of chromosome karyotype in genetics;		*	
		20.1.5	analyse karyotype images to identify chromosomal abnormalities in humans;			An
		20.1.6	differentiate between heterochromatin and euchromatin;		*	
20.2	DNA as the Hereditary Material	20.2.1	explain deoxyribonucleic acid (DNA) as heredity material with reference to the experiments conducted by: a. Frederick Griffith, b. Colin Macleod, c. Maclyn McCarty, d. Alfred Hershey, e. Martha Chase;		FA	
		20.2.2	assess the double helical molecular structure of DNA;			E
		20.2.3	determine the complementary base composition using Chargaff's Rule and the impact of changes in base composition (e.g., mutations) on the total hydrogen bond count in a DNA fragment;			A

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
20.3	DNA Replication	20.3.1	illustrate the three proposed models, i.e., conservative, semi conservative and dispersive models of DNA replication;			A
		20.3.2	explain the Meselson and Stahl experiment to demonstrate the semi-conservative replication of DNA;		FA	
		20.3.3	analyse the process of semi-conservative replication of DNA;			An
		20.3.4	identify DNA stability and variability as two characters of the replicating DNA molecule;		*	
		20.3.5	describe mechanisms that contribute to DNA stability, i.e., proofreading during replication, DNA repair systems and structural features of DNA;		*	
		20.3.6	describe sources of variability in DNA, i.e., mutations, genetic recombination and genetic drift;		*	
20.4	Gene Expression	20.4.1	define gene expression;	*		
		20.4.2	identify the steps involved in gene expression, including transcription and translation;		*	
		20.4.3	describe the importance of regulation of gene expression;		*	
		20.4.4	explain the concept of regulatory genes and their role in controlling gene expression;		*	
		20.4.5	explain the negative and positive control of gene expression (the lac operon) by repressor and activator proteins respectively;		*	
20.5	Genetic Code	20.5.1	differentiate between the terms genetic code and codon;		*	
		20.5.2	explain the features of genetic code, i.e., universality, triplet nature, nonoverlapping, degeneracy/ redundancy, comma less, non-ambiguous, polarity, start and stop codons;		*	
		20.5.3	describe one-gene-one enzyme hypothesis;		FA	

Topics and Sub-topics	Student Learning Outcomes		Cognitive Level		
			R	U	A and beyond
20.6 Protein Synthesis	20.6.1	illustrate the mechanism of protein synthesis;			A
	20.6.2	explain the post transcription modification in mRNA molecule (of eukaryotes);		*	
	20.6.3	justify that the length of transcribed mRNA molecule (in eukaryotes) shortens as it enters the cytoplasm for translation;			E
	20.6.4	compare protein synthesis in prokaryotes and eukaryotes with reference to their location, occurrence of transcription and translation, mRNA, ribosomes and initiation of translation;		FA	
	20.6.5	describe that the synthesised protein can be used within or outside a cell for structural, enzymatic, regulatory and signalling functions;		FA	
20.7 Types of Mutation	20.7.1	illustrate the following types of gene mutation with their outcomes: a. point/ base substitutions (i.e., silent, missense and nonsense mutations), b. frameshift mutations (i.e., insertion and deletion), c. single chromosome mutations (i.e., duplication, inversion, deletion and translocation), d. interchromosomal mutations (i.e., translocation and insertion);			A
	20.7.2	analyse the effects of point mutations on the amino acid sequence of a polypeptide and their contribution to genetic disorders such as sickle cell anaemia, phenylketonuria and cystic fibrosis;			An
	20.7.3	differentiate between natural mutagens (e.g., microbes, plants and fungi) and induced mutagens (e.g., ionisation, ultraviolet rays and chemicals);		*	
	20.7.4	explain that all mutations are not harmful, i.e., lactase persistence in adults and antibiotic resistance in bacteria.		*	

Topics and Sub-topics	Student Learning Outcomes		Cognitive Level		
			R	U	A and beyond
21. Cell Cycle	Students should be able to:				
21.1 Phases of Cell Cycle	21.1.1	define cell cycle;	*		
	21.1.2	differentiate between interphase and M-phase;		*	
	21.1.3	explain changes that occurs during G_1 phase, G_o phase, S-phase and G_2-phase;		*	
	21.1.4	differentiate between: a. amitosis and mitosis, b. karyokinesis and cytokinesis;		*	
21.2 Mitosis	21.2.1	define mitosis;	*		
	21.2.2	explain the different stages of mitosis;		*	
	21.2.3	compare cytokinesis in plant and animal cells;		*	
	21.2.4	explain the significance of mitosis;		*	
	21.2.5	define cell cycle checkpoints;	*		
	21.2.6	describe G1 checkpoint (at the G1/ S transition), G2 checkpoint (at the G2/ M transition and spindle or M checkpoint (at the transition from metaphase to anaphase);		*	
	21.2.7	describe the following aspects of cancer as uncontrolled cell division: a. differences between normal and cancerous cells, b. differences between benign and malignant tumours, c. spreading of cancer to other parts of the body (metastasis);		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
21.3	Mitotic Index	21.3.1	define mitotic index;	*		
		21.3.2	calculate the mitotic index of dividing cells in the microscopic images (micrographs) by using formula: Mitotic Index = (Cells in mitosis with visible chromosomes ÷ Total number of cells) × 100			A
		21.3.3	describe the significance of mitotic index in the study of cell division;		*	
21.4	Meiosis	21.4.1	define meiosis;	*		
		21.4.2	explain the different stages of meiosis;		*	
		21.4.3	describe the significance of meiosis;		*	
		21.4.4	analyse changes in DNA content and chromosome number during different stages of interphase, mitosis and meiosis;			An
		21.4.5	predict the number of chromatids, chromosomes and DNA molecules in daughter cells during different phases of mitotic and meiotic divisions based on the given number of chromosomes and DNA molecules in parent cells;			E

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
21.5	Meiotic Errors (Non-Disjunction)	21.5.1	define non-disjunction;	*		
		21.5.2	illustrate the mechanism of meiotic errors (non-disjunction) during meiosis-I and II;			A
		21.5.3	evaluate the phenotypic consequences of specific aneuploid conditions, i.e., Down syndrome (trisomy 21), Turner syndrome (monosomy X) and Klinefelter syndrome (XXY);			E
		21.5.4	analyse karyotypes to identify aneuploidies resulting from non-disjunctions;			An
21.6	Cell Death	21.6.1	differentiate between necrosis and apoptosis in terms of their causes, processes and outcomes;		FA	
		21.6.2	explain the biological significance of necrosis and apoptosis in maintaining tissue homeostasis and their contribution to disease processes.		FA	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
22. Variation and Genetics		Students should be able to:				
22.1	Gene and Allele	22.1.1	define the terms: gene, loci, allele, gene pool, phenotype, genotype, homozygous, heterozygous, dominant, recessive, pedigree and sex-linked traits;	*		
22.2	Mendel's Law of Inheritance	22.2.1	state characteristics of pea plant used by Gregor Mendel in his experiment;	FA		
		22.2.2	state Mendel's laws of dominance, i.e., law of segregation and law of independent assortment;	*		
		22.2.3	determine the phenotype and genotype ratios of offspring (by using Punnett squares) in real-world examples of monohybrid and dihybrid crosses;			A
		22.2.4	describe the law of independent assortment with respect to its limitations and usefulness;		*	
		22.2.5	determine the purpose and method of test cross in inheritance of traits in plants and animals;			A
22.3	Incomplete Dominance and Codominance	22.3.1	differentiate between incomplete dominance and codominance;		*	
		22.3.2	determine the phenotype and genotype ratios of offspring (by using Punnett squares) in real-world examples of incomplete dominance and codominance;			A

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
22.4	Multiple Allele	22.4.1	describe multiple alleles with reference to ABO blood group system;		*	
		22.4.2	solve genetic problems of inheritance of blood groups;			A
		22.4.3	describe Rh factor in blood group;		*	
		22.4.4	discuss the role of Rh factor in erythroblastosis foetalis and its prevention in newborns;			E
		22.4.5	describe epistasis and its types, i.e., dominant and recessive epistasis;		*	
		22.4.6	analyse real-world examples of dominant and recessive epistasis (e.g., coat colour inheritance in Labrador retrievers, mice and fruit colour in summer squash, flower colour in foxgloves plant);			An
		22.4.7	explain polygenic inheritance in plants, animals and humans;		*	
		22.4.8	explain the phenomenon of pleiotropic inheritance;		*	
22.5	Linkage and Crossing-over	22.5.1	describe gene linkage and crossing-over in drosophila;		*	
		22.5.2	explain that gene linkage counters independent assortment and crossing-over modifies the progeny;		*	
		22.5.3	describe that linkage can be observed only if the number of progeny is quite large;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
22.6	Sex Determination and Sex Linkage	22.6.1	describe the following patterns of sex determination, i.e.: a. XO-XX type, b. XY-XX type, c. ZZ-ZW type;		*	
		22.6.2	compare chromosomal determination of sex in drosophila and human;		*	
		22.6.3	describe sex-linked inheritance in drosophila;		*	
		22.6.4	analyse the inheritance patterns of sex-linked traits in humans, i.e., colour blindness and haemophilia;			An
		22.6.5	interpret symbols and patterns in pedigree charts for different types of inheritance (e.g., autosomal dominant, autosomal recessive and X-linked);			E
		22.6.6	describe that holandric gene (SRY gene on the Y-chromosome) influences the development of male characteristics and sex-linked inheritance patterns;		*	
22.7	Genetic Disorder (Diabetes mellitus)	22.7.1	describe diabetes mellitus as a genetic disorder;		*	
		22.7.2	compare type I and type II of diabetes mellitus.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
23. Biotechnology		Students should be able to:				
23.1	Introduction to Biotechnology	23.1.1	define biotechnology;	*		
		23.1.2	describe the importance of biotechnology;		*	
23.2	Genetic Engineering/ Recombinant DNA (rDNA) Technology	23.2.1	explain the steps of recombinant DNA (rDNA) technology, i.e.: a. isolation of the gene of interest, b. cutting of DNA (role of restriction endonuclease), c. amplifying the gene of interest, d. insertion of DNA into a vector, e. introduction of recombinant DNA into host cells (transformation), f. selection of transformed cells using selectable markers (e.g., antibiotic resistance genes), g. expression of gene of interest, h. scaling up and production, i. purification of the gene product;		*	
		23.2.2	illustrate the following techniques used in genetic engineering: a. polymerase chain reactions/ PCR (denaturation, annealing, and extension) as a technique to amplify the gene of interest, b. genome library as a collection of DNA fragments, c. gel electrophoresis as a technique to analyse proteins and nucleic acids, d. dideoxy chain termination method as a technique to determine the sequence of DNA fragments;			A

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
23.3	Applications of Genetic Engineering	23.3.1	analyse the applications of: a. polymerase chain reaction, b. DNA fingerprinting;			An
		23.3.2	describe the goals and significance of the Human Genome Project (HGP);		*	
23.4	Biotechnology and Health	23.4.1	describe the techniques employed for embryonic screening, i.e., amniocentesis and chorionic villus sampling;		*	
		23.4.2	explain the current methods employed for gene therapy, i.e., in-vitro and in-vivo methods;		*	
		23.4.3	describe the process of gene therapy used in the treatment of haemophilia, Severe Combined Immunodeficiency Syndrome (SCID) and cystic fibrosis;		*	
		23.4.4	evaluate the applications of genetic counselling, genetic screening and cloning in real-life scenarios;			E
		23.4.5	explain tissue culture and its types in plants, i.e., anther culture, ovary culture, meristem culture and embryo culture);		FA	
23.5	Biotechnology and Agriculture	23.5.1	illustrate the process of producing Genetically Modified Organisms (GMO), i.e., bacteria, plants and animals;			A
		23.5.2	discuss the role of biotechnology in improving the quality and yield of crops;			FA
		23.5.3	describe the working of vertical food farms (soil free);		FA	
		23.5.4	compare the advantages of vertical food farms with general agricultural practices prevalent in Pakistan;		FA	
		23.5.5	describe the social and ethical aspects of genetic engineering.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
24. Evolution		Students should be able to:				
24.1	Introduction	24.1.1	describe organic evolution, relating it to Quranic verses (Al-Quran-6:98, 37:11, 4:1, 51:49);	FA		
		24.1.2	differentiate between theories of evolution and special creation;		FA	
		24.1.3	trace evolution from prokaryotes to eukaryotes by endosymbiotic and membrane invagination theories;		*	
24.2	Theories of Evolution	24.2.1	state inheritance of acquired characters as proposed by Lamarck (Lamarckism);	*		
		24.2.2	discuss criticisms on Lamarck's theory of evolution;			E
		24.2.3	describe basic features of Darwin's theory of natural selection: a. over reproduction, b. struggle for existence, c. variation and heredity, d. survival of the fittest, e. formation of new species;		*	
		24.2.4	discuss criticisms on Darwin's natural selection theory of organic evolution;			E
		24.2.5	describe the contribution of De-Varies in recognising the role of mutation in evolution;		*	
		24.2.6	describe the synthetic (modern) theory of evolution (Neo-Darwinism);		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
24.3	Evidences of Evolution	24.3.1	describe evidences of organic evolution from: a. biogeography, b. palaeontology, c. comparative anatomy, d. comparative embryology, e. biochemistry;		*	
		24.3.2	differentiate between convergent and divergent evolution based on inheritance of the homologous and analogous structures;		*	
24.4	Mechanism of Evolution and Population Genetics	24.4.1	compare artificial selection and natural selection;		*	
		24.4.2	discuss the application of artificial selection in the production of economically important plants and animals and controlled breeding;			FA
		24.4.3	define the following terms: a. gene flow, b. gene/ allele frequency, c. genotype frequency, d. phenotype frequency, e. genetic drift;	*		
		24.4.4	describe gene/ allele frequency and its role in evolution;		*	
		24.4.5	calculate allele, genotype and phenotype frequencies of populations;			A
		24.4.6	describe factors affecting gene frequency of a population;		*	
		24.4.7	explain Hardy Weinberg's law and its implications;		*	
		24.4.8	solve problems related to gene/ allele frequencies using the Hardy-Weinberg's equation.			A

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
25. Ecosystem		Students should be able to:				
25.1	Introduction	25.1.1	exemplify population, community, environment, ecosystem, habitat, niche, biome and biosphere;		*	
		25.1.2	differentiate between autecology and synecology;		*	
25.2	Components of Ecosystem	25.2.1	differentiate between abiotic and biotic components;		*	
		25.2.2	explain climatic, topographic and edaphic factors of environment;		*	
		25.2.3	differentiate among producers, consumers and decomposers in an ecosystem;		*	
		25.2.4	assess the relation of different types of ecological interactions with population growth, i.e.: a. positive ecological interactions: i. mutualism, ii. commensalism, b. negative ecological interactions: i. parasitism, ii. competition, iii. predation;			E
25.3	Biogeochemical Cycles	25.3.1	define the terms aquifers and water table;	FA		
		25.3.2	illustrate the steps of water cycle;			FA
		25.3.3	illustrate the key processes of nitrogen cycle, i.e., nitrogen fixation, nitrification, denitrification and ammonification;			A

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
25.4	Energy Flow in Ecosystems	25.4.1	explain the loss of energy between Sun and producers and among different trophic levels;		*	
		25.4.2	analyse energy efficiencies of short and long food chains using specific examples from terrestrial and aquatic ecosystems;			An
		25.4.3	construct pyramids of energy, biomass and number for different food chains;			A
		25.4.4	calculate the amount of energy transferred and lost among the Sun, producers and consumers in specific ecosystems (e.g., terrestrial and aquatic ecosystems) using the 10% energy transfer rule;			A
		25.4.5	analyse the impact of change in population sizes within a food web on trophic levels, species interactions and ecosystem stability;			An
25.5	Productivities of Ecosystem	25.5.1	define primary productivity, gross primary and net primary productivities of ecosystem;	*		
		25.5.2	calculate the gross primary and net primary productivity of an ecosystem;			A
25.6	Ecological Succession	25.6.1	define succession;	*		
		25.6.2	differentiate between primary and secondary succession;		*	
		25.6.3	describe the stages of ecological succession, i.e., pioneer, intermediate and climax communities in both hydrosere (hydrach) and xerosere (xerarch) successions.		*	

Topics and Sub-topics		Student Learning Outcomes	Cognitive Level		
			R	U	A and beyond
26. Some Major Ecosystems		Students should be able to:			
26.1 Aquatic Ecosystem	26.1.1	explain abiotic and biotic components of different zones of lake ecosystem, i.e., littoral, limnetic, profundal and benthic zones;		*	
	26.1.2	explain abiotic and biotic components of different zones of marine ecosystem, i.e., neritic, pelagic and abyssal or benthic zones;		*	
26.2 Terrestrial Ecosystem • Forest • Grassland • Desert • Tundra	26.2.1	describe abiotic and biotic components of forest ecosystems, i.e.: a. tropical rain forest, b. coniferous (alpine and boreal) forest, c. temperate deciduous forest;		*	
	26.2.2	describe the characteristics and ecological importance of different grassland ecosystems, i.e., prairies, savannas and steppes;		*	
	26.2.3	describe the climatic conditions, common plant and animals found in grasslands and their adaptations to this environment;		*	
	26.2.4	describe the characteristics, i.e., low precipitation, extreme temperatures and arid conditions and ecological importance of desert ecosystems;		*	
	26.2.5	describe the common plant and animal species found in deserts and their adaptations to survive in harsh conditions;		*	
	26.2.6	identify the key characteristics, i.e., low temperatures, short growing seasons and permafrost of tundra ecosystem;		*	
	26.2.7	describe the common plant and animal species found in tundra and their adaptations to survive in extreme cold and nutrient-poor conditions;		*	
	26.2.8	locate the major biomes and their respective flora and fauna on a world map.			A

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
27. Man and His Environment		Students should be able to:				
27.1	Resources	27.1.1	define renewable and non-renewable energy resources;	FA		
		27.1.2	exemplify types of renewable and non-renewable resources;		FA	
		27.1.3	explain degradation and depletion of resources;		FA	
27.2	Characteristics of Population	27.2.1	describe the characteristics of population, i.e.: a. growth, b. density, c. distribution, d. carrying capacity, e. minimum/viable size;		FA	
		27.2.2	interpret population graphs of various countries and global trends over different time periods;			FA
		27.2.3	explain the need of population control;		FA	
27.3	Environmental Pollution	27.3.1	define pollution;	*		
		27.3.2	explain the causes and effects of different types of pollution, i.e.: a. air pollution, b. land pollution, c. water pollution, d. noise pollution;		*	
		27.3.3	relate the process of eutrophication to water pollution;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
27.4	Man's Impact on Environment	27.4.1	describe that climate change impacts flora and fauna of terrestrial ecosystems;		*	
		27.4.2	describe that climate change can impact marine ecosystem in terms of its temperature and acidity;		*	
		27.4.3	differentiate between deforestation and afforestation with examples;		*	
		27.4.4	describe the factors causing species to become endangered and increase their risk for extinction;		*	
27.5	Conservation of Environment	27.5.1	suggest strategies for the management of: a. natural resources, b. pollution free environment, c. recycling of waste, d. biodiversity;			E
		27.5.2	discuss bioremediation as an effective way to control pollution;			E
		27.5.3	list the endangered species of Pakistan mentioned in the International Union for Conservation of Nature (IUCN) Red List;	FA		
		27.5.4	list species that have gone extinct due to climate change in Pakistan.	FA		

Practical Activities of AKU-EB HSSC Biology Syllabus

Topics

Content Covered	Actions Performed	Attitude Developed
• Identification of slides and specimen • Temporary slide preparation • Investigations of different biological phenomenon • Construction of graphs/ histogram/ pie charts by using the given data • Development of precise and careful motor skills in microscope handling, to enhance both technical and observational competencies • Classification of organisms into their respective kingdom, phylum and class	• Follow the safety precautions provided in the Lab guidelines • Collect the required apparatus for the experiments • Handle the apparatus/ equipment/ chemicals appropriately • Perform the experiments with the help of given method/ steps • Modify the steps to perform a similar experiment in the real-life settings • Demonstrate proper disposal techniques for chemical wastes and used materials, to ensure a clean and safe workspace	• Ensure safety of yourself, others around you and your surroundings • Demonstrate a scientific mindset by asking questions and planning further investigations • Display ethical dealings and practices while performing experiments • Show willingness to solve problems and challenges • Show self-reliance and cooperation when working independently and in a group setting respectively • Revise judgements and change behaviour in light of new evidence

Topic-Wise Practical Activities

Grade XI

S. No.	Topic-Wise Practical Activities	Apparatus/ Slide/ Material	Chemicals
	Topic 1: Biological Molecules		
1. 2.	Perform Benedict's test to confirm the presence of reducing sugar Perform iodine test to confirm the presence of starch	Bunsen burner, test tubes, test tube stand, test tube holder, droppers, tripod stand, wire gauze, graduated pipettes, beaker	Solutions of glucose and starch, Benedict's solution, iodine solution
3.	Perform emulsion test to confirm the presence of lipids	Test tubes, dropper, graduated pipettes	A fat source (coconut oil/ peanuts), ethyl alcohol, distilled water
4.	Perform Biuret test to confirm the presence of proteins	Bunsen burner, test tubes, test tube stand, test tube holders, droppers, graduated pipettes, beaker	5% sodium hydroxide solution, 1% copper sulphate solution
	Topic 2: Enzymes		
5.	Perform amylase test on starch with boiled and un-boiled amylase and confirm the presence of starch through iodine test	Bunsen burner, test tubes, test tube stand, test tube holders, droppers, tripod stand, wire gauze, graduated pipettes, beaker	Starch solution, amylase solution, iodine solution

	Topic 3: The Cell		
6. 7. 8.	Prepare samples of frog epithelial cells, onion epidermal cells and leaf epidermal cells, handling specimens gently to avoid damage Prepare temporary slides of animal cells (squamous epithelial of frog) and plant cells (onion epidermal and leaf epidermis) by using appropriate temporary staining and mounting techniques Demonstrate microscope focusing techniques to identify the key cellular features of specimen	Microscope, glass slide, cover slip, petri dish, watch glass, needle, brush and dropper	Dye for staining, i.e., methylene blue/ safranin/ iodine solution and glycerin
	Topic 5: Kingdom Prokaryotae		
9.	Perform Gram staining technique to differentiate between Gram-positive and Gram-negative bacteria	Microscope, glass slides, nichrome wire, Bunsen burner, cover slip, dropper	Crystal violet, iodine, safranin, alcohol, distilled water, immersion oil
10. 11.	Observe fresh or preserved *Nostoc* slide/ specimen Draw labelled diagrams of *Nostoc* as observed under the microscope	Slide/ specimen of *Nostoc*, Microscope/ magnifying glass, pencil, notebook	-
	Topic 6: Kingdom Protista		
12. 13.	Observe permanent slides of each group of protists Draw labelled diagrams of each group of protists as observed under the microscope	Microscope, slides of amoeba, euglena, paramaecium, chlorella, spirogyra, pencil and notebook	-

	Topic 7: Kingdom Fungi		
14. 15. 16.	Observe fresh or preserved mushroom specimen Prepare temporary slides of rhizopus, yeast and penicillium Draw labelled diagrams of each specimen/ slide as observed under the microscope	Specimen of mushroom, Preserved samples/ culture of rhizopus, yeast and penicillium, microscope, glass slide, nichrome wire, Bunsen burner, cover slip, dropper, watch glass, petri dish, needle, brush, pencil, notebook	Dye for staining, i.e., methylene blue/ safranin/ iodine solution and glycerin
	Topic 8: Kingdom Plantae		
17.	Examine the male and female plant specimen of marchantia and draw labelled diagrams	Specimen of male and female plant of marchantia, pencil, notebook	-
18.	Observe the key features of male and female cones of pinus and draw labelled diagrams	Specimen of male and female cones of pinus, pencil, notebook	-
19. 20. 21.	Examine the floral parts of Brassica campestris, Solanum nigrum/ Datura alba and Avena sativa Draw floral diagrams of the given flowers Construct the floral formula for the given flowers by using standard botanical symbols and numbers to represent symmetry, number and arrangement of floral organs	Flowers or images of Brassica campestris, Solanum nigrum/ Datura alba and Avena sativa, pencil, notebook	-

	Topic 9: Kingdom Animalia		
22. 23. 24.	Observe the specimen/ models of invertebrates and vertebrates Record observations with labelled diagrams Classify each specimen into its respective phylum and class, using observed characteristics as a basis for classification	Specimen of sycon, hydra/ obelia, liver fluke/ planaria, tapeworm, roundworm, earthworm, leech, crab, butterfly/ wasp, spider, mussel, snail/ slug, brittle star/ sea star specimen/ model of fish, frog/ toad, lizard/ snake, bird, mouse/ squirrel, pencil, notebook	-
	Topic 10: Bioenergetics		
25.	Separate the leaf pigments using paper chromatography	Test tubes with stopper, test tube stand, test tube holder, pestle and mortar, pins, chromatography paper or filter paper, droppers, tripod stand, Bunsen burner, beaker, glass, wool, funnel, forceps, measuring cylinder, pencil, ruler	Pigment solution, 80% acetone, 90% acetone-petroleum, ether mixture (1:9), ethyl alcohol
	Topic 11: Gaseous Exchange		
26. 27.	Examine the lungs of goat/ sheep Draw a labelled diagram of the respiratory system of goat/ sheep	Goat/ sheep lungs, dissecting tray, pointer, pencil, notebook	-
	Topic 13: Transport		
28. 29.	Observe the slide of transverse section (T.S) of a dicotyledonous stem Draw labelled diagrams of vessel element, vessels and phloem sieve tubes	Slide of T.S of dicotyledonous stem, microscope, needle/ pointer, pencil, notebook	-

S. No	Topic-Wise Practical Activities	Apparatus/ Slide/ Material	Chemicals
30. 31.	Examine the heart of goat/ sheep Draw a labelled diagram of the internal structure of goat's heart	Goat/ sheep heart, dissecting tray, pointer, pencil, notebook	-
32.	Measure the blood pressure by using sphygmomanometer	Sphygmomanometer, stethoscope, pencil, notebook	-
	Topic 14: Immune System		
33. 34.	Observe prepared slides of neutrophils and lymphocytes Record observation in the form of labelled diagrams	Slides of neutrophils and lymphocytes, pencil, notebook	-

Grade XII

S. No.	Topic-Wise Practical Activities	Apparatus/ Slide/ Material	Chemicals
	Topic 16: Support and Movement		
1.	Calculate the age of a plant by counting number of annual rings	Log of a tree	-
2.	Set up experimental conditions for phototropism and geotropism by arranging light sources and plant orientations to observe directional growth responses	Cardboard box or a shoebox (to create a controlled dark environment), potted plant, shallow tray or box (for tilting the plants), light source	-
3. 4.	Demonstrate proper handling of skeletal models to identify bones of axial and appendicular skeleton, their features and articulations Observe different types of joints in a human skeleton model	Model of human skeleton	-
5. 6. 7.	Prepare temporary slides of skeletal, smooth and cardiac muscles of frog Demonstrate microscope focusing techniques to identify the key features of skeletal, smooth and cardiac muscles of frog Draw labelled diagrams of skeletal, smooth and cardiac muscles as seen under microscope	Slides, cover slips, forceps, microscope, specimen of frog to prepare samples of skeletal, smooth and cardiac muscles, pencil, notebook	Dye for staining, i.e., methylene blue/ safranin/ iodine solution and glycerin

	Topic 18: Reproduction		
8.	Examine different parts of the female reproductive system of rabbit and draw labelled diagram	Model/ chart of female reproductive system of rabbit, pencil, notebook	-
9. 10.	Observe prepared slides of mammalian ovaries Record observations in the form of labelled diagram	Slide of histology of ovaries, microscope, pencil, notebook	-
	Topic 19: Growth and Development		
11.	Observe the different stages (48 and 72 hours) of chick development using photomicrographs/ permanent slides	Photomicrographs/ permanent slides of stages of development in chick	-
	Topic 22: Variation and Genetics		
12. 13. 14.	Set up a controlled experiment using dice to simulate genetic inheritance, ensuring accurate representation of dominant and recessive alleles Record each combination of alleles (e.g., TT, Tt, tt) by rolling the dice Calculate the probability of each genotype occurring based on the results	Dice, notebook, pencil	-
15. 16. 17.	Collect data on the height of individuals within a given population to study continuous variation Organise and record the height data clearly in a table, categorising the measurements into appropriate intervals Calculate the frequency of individuals within each height range	Pencil, ruler, graph paper, notebook, measuring tape or stadiometer	-

18.	Create a histogram using graph paper, accurately plotting the frequency of each height range on the x-axis and the corresponding frequency on the y-axis.		
19. 20. 21.	Collect and record the data, to categorise the number of classmates with each blood group (A, B, AB, O) in a table Draw a pie chart, ensuring each segment accurately represents the proportion of each blood group and is labelled Analyse the pie chart to identify trends or patterns, such as which blood group is most or least common in the class	Drawing paper, pencil, ruler	-
	Topic 25: Ecosystem		
22.	Construct food chains and food web of local ecosystem.	Pencil, notebook	-

Scheme of Assessment

Grade XI

Table 1: Exam Specifications

Topic No.	Topics	Marks Distribution			Total Marks
		MCQs	CRQs	ERQs	
1.	Biological Molecules	6	-	7 Marks Choose any ONE from TWO	19
3.	The Cell	6	-		
2.	Enzymes	3	Total 3 Marks (1 CRQ)	-	6
4.	Classification and Acellular Life	4	-	-	4
5.	Kingdom Prokaryotae	2	Total 3 Marks (1 CRQ)	-	5
6.	Kingdom Protoctista	3	-	-	3
7.	Kingdom Fungi	3	-	-	3
8.	Kingdom Plantae	2	Total 3 Marks (1 CRQ)	-	5
9.	Kingdom Animalia	2	Total 3 Marks (1 CRQ)	-	5
10.	Bioenergetics	6	-	7 Marks Choose any ONE from TWO	20
13.	Transport	7	-		
11.	Nutrition	2	Total 3 Marks (1 CRQ)	-	5
12.	Gaseous Exchange	2	Total 3 Marks (1 CRQ)	-	5
14.	Immune System	2	Total 3 Marks (1 CRQ)	-	5
	Total	**50**	**21**	**14**	**85**
	Practical*				**15**
	Total				**100**

Note: The cognitive distribution of marks for Biology HSSC are as follows
Remember: 0 to 15%
Understand: 45 to 60%
Apply and beyond: 25 to 40%

Grade XII

Table 2: Exam Specifications

Topic No.	Topics	Marks Distribution			Total Marks
		MCQs	CRQs	ERQs	
15.	Homeostasis	6	-	7 Marks Choose any ONE from TWO	20
20.	Chromosomes and DNA	7	-		
16.	Support and Movement	6	Total 2 Marks (1 CRQ)	-	8
17.	Coordination and Control	7	-	7 Marks Choose any ONE from TWO	20
22.	Variation and Genetics	6	-		
18.	Reproduction	2	Total 2 Marks (1 CRQ)	-	4
19.	Growth and Development	2	Total 3 Marks (1 CRQ)	-	5
21.	Cell Cycle	3	Total 3 Marks (1 CRQ)	-	6
23.	Biotechnology	2	Total 3 Marks (1 CRQ)	-	5
24.	Evolution	2	Total 3 Marks (1 CRQ)	-	5
25.	Ecosystem	3	Total 3 Marks (1 CRQ)	-	6
26.	Some Major Ecosystems	2	Total 2 Marks (1 CRQ)	-	4
27.	Man and His Environment	2	-	-	2
	Total	**50**	**21**	**14**	**85**
	Practical*				**15**
	Total				**100**

Note: The cognitive distribution of marks for Biology HSSC are as follows
Remember: 0 to 15%
Understand: 45 to 60%
Apply and beyond: 25 to 40%

Examination Structure and Practical Requirements for Grades XI and XII

Theory:

- Multiple Choice Question (MCQ) requires candidates to choose one best/ correct answer from four options for each question. Each MCQ carries ONE mark.
- Constructed Response Question (CRQ) requires students to respond with a short text (few phrases/ sentences), calculations or diagrams.
- Extended Response Question (ERQ) requires students to answer in a more descriptive form. The answer should be in paragraph form, with diagrams where needed, and address all parts of the question.
- Table 1 and 2 contains the mark distribution for each topic.
- There will be two examinations, one at the end of grade XI and one at the end of grade XII.
- In each grade, the theory paper will be of 3 hours and will consist of two parts: paper I and paper II.
- Paper I theory will consist of 50 compulsory, multiple choice items. These questions will involve four responses options. The OMR (Optical Mark Recognition) sheet for paper I will be provided separately.
- Paper II theory will carry 35 marks and consist of Constructed Response Questions (CRQs) and Extended Response Questions (ERQs). Each extended response question will be presented in an either/ or form.
- The booklet for paper II will serve as an answer script.

Practical:

- In each grade, practical examination (Paper III) will be conducted separate from the theory paper and will consist of 15 marks.
- Practical examination (Paper III) will be based on the list of practical activities given in the examination syllabus. Schools may design their own practical manuals based on these activities for teaching and learning purpose.
- Practical journal/ portfolio should be developed by students and endorsed by a figure of authority, such as a teacher or principal, and submitted at the time of the practical examination (Paper III).
- It is essential for each school to equip its laboratories with chemicals, instruments, apparatus, specimens etc. according to the requirements of the practical activities. Each school will be responsible to make sure that each student is provided the opportunity to do the practical activities.

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