DRAFT
LEARNING FRAMEWORK
CLASSES 11-12
BIOLOGY

CO-CREATED BY

CBSE- CENTRE FOR EXCELLENCE IN ASSESSMENT IN COLLABORATION

WITH EDUCATIONAL INITIATIVES

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FOREWORD

The vision of the National Education Policy (NEP) 2020 released by the Government of India, directs that children not only learn, but more importantly learn how to learn. Education, must move towards less content, and more towards learning about how to think critically and solve problems, how to be creative and multidisciplinary, and how to innovate, adapt, and absorb new material in novel and changing fields. Pedagogy must evolve to make education more experiential, holistic, integrated, inquiry-driven, discovery-oriented, learner-centred, discussion-based, flexible, and, of course, enjoyable. The policy has a clear mandate for competency-based education (CBE) to enhance acquisition of critical 21st century skills by the learners. The first determinant for implementing CBE is a curriculum which is aligned to defined learning outcomes and that clearly states the indicators to be achieved.

The Central Board of Secondary Education (CBSE) has collaborated with Educational Initiatives, to develop the Learning Framework for English, Hindi, Mathematics, Physics, Chemistry, Biology, History, Geography, Economics, Accountancy, Business Studies and Computer Science in Grade 11 and 12. The Learning Frameworks comprise explicitly stated knowledge, skills and dispositions that an education system should try to achieve. These frameworks would help develop a common shared understanding among teachers, students and other stakeholders and would serve as a common benchmark for teaching, learning and assessment across the country.

These frameworks present indicators that are aligned to the CBSE curriculum and the NCERT learning outcomes. They further outline samples of pedagogical processes and assessment strategies to encourage curiosity, objectivity, creativity with a view to nurture scientific temper. This framework would be a key resource for teachers as they execute the curriculum. They have been developed to ensure that teachers align the learning to meet the set quality standards and also use it to track learning levels of students. The effort has been to synchronize focus on quality education with uniformity in quality of standards across CBSE schools.

We hope, these frameworks would not only become a reference point for competency-based education across the country but also facilitate planning and design of teaching-learning processes and assessment strategies by teachers and other stakeholders. Any feedback regarding the framework is welcomed.

CBSE Academic Unit

PREFACE

The National Education Policy 2020 has outlined the importance of competency-based education in classrooms, leading to curricular and pedagogical reforms in the school systems. The policy emphasizes on the development of higher order skills such as analysis, critical thinking and problem solving through classroom instructions and aligned assessments. These skills are important indicators which will further the dissemination of pedagogy and learning outcomes across schools and boards.

In order to propagate indicator-based learning through 'Learning Frameworks', the Central Board of Secondary Education has collaborated with Educational Initiatives (Ei). Learning frameworks are a comprehensive package which provides learning outcomes, indicators, assessment frameworks, samples of pedagogical processes, tools and techniques for formative assessment, blueprint, assessment items and rubrics. 12 such frameworks have been developed for English, Hindi, Mathematics, Physics, Chemistry, Biology, History, Geography, Economics, Accountancy, Business Studies and Computer Science in Grade 11 and 12.

The frameworks are adopted from the learning outcomes outlined in the NCERT which are mapped to key concepts of the content. These content domain specific learning outcomes are broken down into indicators which defines the specific skills a learner needs to attain. A clear understanding of these LOs will be immensely helpful for teachers and students to learn better. This document will help teachers to focus on skills of the subject in addition to concepts.

As per the National Focus group Position Paper on Teaching of Science, "At the higher secondary stage science should be introduced as separate disciplines with emphasis on experiments/technology and problem solving. The content should not be information laden, and not aim to widely cover all aspects of the subject. Considering the vast breadth of knowledge in any subject, the exigencies of time and the student's capacity, some delimitation, or rather, identification of core areas has to be done. At this stage, core topics of a discipline, taking into account recent advances, should be carefully identified and treated with appropriate rigour and depth" As per NCERT Learning Outcomes for Higher Secondary Stage "Physics and Chemistry dominated public perception of science for a long time. Day-to-day life of man was influenced by developments in Physics, Chemistry and their respective manufacturing industries. Slowly and steadily, Biology, not to be left behind, demonstrated its utility for human welfare. Thus, the subject Biology has emerged as one of the separate disciplines of science at higher secondary level. Although the nature of biology and nature of physical sciences share many common aspects, however, focus of biology creates unique philosophical, methodological and ethical premises on which biology should be understood and assessed. The curriculum in Biology should provide learners with sufficient conceptual clarity of biological phenomena which will provide the basic understanding required to further learn about the intricacies of the concepts by developing higher order thinking skills".

2. NATURE OF THE SUBJECT

Biology is the story of life on earth. It is the science of life forms and living processes. Biological systems, often appear to challenge physical laws that govern the behaviour of matter and energy in our world. Historically, biological knowledge was ancillary to knowledge of human body and its function. The latter as we know, is the basis of medical practice. However, parts of biological knowledge developed independent of human application. Fundamental questions about origin of life, the origin and growth of biodiversity, the evolution of flora and fauna of different habitats, etc., caught the imagination of biologists.

The very description of living organisms, be it from morphological perspective, physiological perspective, taxonomical perspective, etc., engaged scientists to such an extent that for sheer convenience, if not for anything else, the subject matter got artificially divided into the subdisciplines of botany and zoology and later into even microbiology. Meanwhile, physical sciences made heavy inroads into biology, and established biochemistry and biophysics as new subdisciplines of biology. Mendel's work and its rediscovery in the early twentieth century led to the promotion of study of genetics. The discovery of the double-helical structure of DNA and the deciphering of three-dimensional structures of many macromolecules led to the establishment of and phenomenal growth in the dominating area of molecular biology. In a sense, functional disciplines laying emphasis on mechanisms underlying living processes, received more attention, support, intellectual and social recognition. Biology, unfortunately, got divided into classical and modern biology. To the majority of practising biologists, pursuit of biological research became more empirical rather than a curiosity and hypothesis driven intellectual exercise as is the case with theoretical physics, experimental physics, structural chemistry and material science. Fortunately, general unifying principles of biology were also being discovered, rediscovered and emphasised.

In the nineteenth and twentieth centuries, Physics and Chemistry were applied to Biology and the new science of Biochemistry soon became the dominant face of biology. On one hand Biochemistry was integrating with Physiology, becoming almost synonymous with it. On the other hand, it gave rise to Structural Biology (structure of biomacromolecules), originally called Molecular Biology. The work of eminent biologists established a modern version of Molecular Biology dealing with life processes at molecular level. Physics and Chemistry dominated public perception of science for a long time. Day-to-day life of man was influenced by developments in Physics, Chemistry and their respective manufacturing industries. Slowly and steadily, Biology, not to be left behind, demonstrated its utility for human welfare. Medical practice, especially diagnostics, green revolution and the newly emerging biotechnology and its success stories made the presence of biology felt by the common man. Patent laws brought biology into political domain and commercial value of biology became obvious.

Thus, the subject Biology has emerged as one of the separate disciplines of science at higher secondary level. Although the nature of biology and nature of physical sciences share many common aspects, however, focus of biology creates unique philosophical, methodological and ethical premises on which biology should be understood and assessed. The curriculum in Biology should provide learners with sufficient conceptual clarity of biological phenomena which will provide the basic understanding required to further learn about the intricacies of the concepts by developing higher order thinking skills.

3. STAGE SPECIFIC CURRICULAR EXPECTATIONS

Learning Outcomes at Higher Secondary stage developed by National Council for Educational Research and Training (NCERT) mentions the following curricular expectations for Biology.

CE1. Identify and develop understanding of concepts, principles, theories, and laws governing the physical world around a biological entity

CE2. Develop ability to acquire and use the methods and processes of science, such as observing, questioning, planning investigations, hypothesising, collecting, analysing and interpreting data, communicating explanations with evidence, justifying explanations, thinking critically to consider and evaluate alternative explanation, etc., in the biological perspectives

CE3. Build upon the perceptive of basic tools and techniques used in concepts to analyze various issues in biology

CE4. Conduct experiments, also involving quantitative measurements in biology

CE5. Appreciate how concepts of biology evolve with time giving importance to its historical prospective

CE6. Develop scientific temper with respect to biological phenomena (objectivity, critical thinking, creative skills, freedom from fear and prejudice, etc.)

CE7. Nurture natural curiosity, aesthetic sense, and creativity in biological processes and phenomena

CE8. Imbibe the values of honesty, integrity, cooperation, concern for life and preservation of environment

CE9. Develop respect for human dignity and rights, equity and equality

CE10. Connect biological concepts to real life problems and develop innovative problem-solving abilities to solve problems related to life situations through understanding of biological concepts

CE11. Widen skills to illustrate linkages of elementary aspects of biology with complex phenomena

CE12. Apply biological discoveries/ innovations in everyday life

CE13. Integrate and interrelate the biological concepts with other areas of knowledge by underlying common principles

4. CONTENT DOMAINS

The content for biology for grades 11-12 in CBSE curriculum has been organized around content units.

Content units for the two grades, along with the chapters from the NCERT textbooks are mentioned in the tables below.

Table I. Grade 11 Content units and textbook chapters

Content units	NCERT textbook chapters
I. Diversity of Living Organisms	1. The Living World
	2. Biological Classification
	3. Plant Kingdom
	4. Animal Kingdom
II. Structural Organization in Plants and Animals	5. Morphology of Flowering Plants
	6. Anatomy of Flowering Plants
	7. Structural Organisation in Animals
III. Cell: Structure and Functions	8. Cell-The Unit of Life
	9. Biomolecules
	10. Cell Cycle and Cell Division
IV. Plant Physiology	13. Photosynthesis in Higher Plants
	14. Respiration in Plants
	15. Plant - Growth and Development
V. Animal Physiology	17. Breathing and Exchange of Gases
	18. Body Fluids and Circulation

	19. Excretory Products and their Elimination
	20. Locomotion and Movement
	21. Neural Control and Coordination
	22. Chemical Coordination and Integration

Table II. Grade 12 Content units and textbook chapters

Content units	NCERT textbook chapters
I. Reproduction	2. Sexual Reproduction in Flowering Plants
	3. Human Reproduction
	4. Reproductive Health
II. Genetics and Evolution	5. Principles of Inheritance and Variation
	6. Molecular Basis of Inheritance
	7. Evolution
III. Biology and Human Welfare	8. Human Health and Diseases
	10. Microbes in Human Welfare
IV. Biotechnology and its Applications	11. Biotechnology - Principles and Processes
	12. Biotechnology and its Application
V. Ecology and Environment	13. Organisms and Populations
	14. Ecosystem
	15. Biodiversity and Conservation

5. SUBJECT SPECIFIC COGNITIVE DOMAINS

> "As the Board is progressively allowing more space to 'learning outcome based' assessment in place of textbook driven assessment, question papers of Board examinations will have more questions based on real-life situations requiring students to apply, analyse, evaluate and synthesize information as per the stipulated outcomes. The core-competencies to be assessed in all questions, however, will be from the prescribed syllabus and textbooks recommended therein. This will eliminate predictability and rote learning to a large extent." [CBSE Curriculum for classes 11-12]

CATEGORIES OF COGNITIVE DOMAINS

Revised Bloom's taxonomy (Anderson and Krathwohl, 2001) of cognitive process dimension has six categories, each associated with a set of specific cognitive processes. CBSE curriculum intends to have a balance of these categories of intellectual tasks in the teaching-learning and assessment of learning of a subject. These six categories as described in the revised Bloom's taxonomy, with their specific cognitive processes, are mentioned below.

COGNITIVE DOMAIN – **REMEMBER**

'Remember' involves retrieving relevant knowledge from long-term memory. **Recognising** and **recalling** are the specific cognitive skills associated with this cognitive domain. Asking students to provide definition of a concept, e.g., State the law of limiting factors for photosynthesis.

COGNITIVE DOMAIN – **UNDERSTAND**

'Understand' involves 'constructing meaning from instructional messages, including oral, written and graphic communication'. **Interpreting**, **exemplifying**, **classifying**, **summarizing**, **inferring**, **comparing**, **explaining** are the specific cognitive skills associated with this cognitive domain. Asking students to explain a phenomenon in terms of physical concepts/principles, e.g., Explain the major changes the cell and chromosomal material undergo in prophase of meiosis.

COGNITIVE DOMAIN – **APPLY**

'Apply' involves carrying out or using a procedure in a given situation. **Executing** and **implementing** are the specific cognitive skills associated with this cognitive domain. Assessment tasks wherein students have to use the knowledge and/or procedures to solve a problem or to arrive at a decision in a given real-life situation cover this cognitive domain. e.g., Predict the age of a tree based on the number of annual rings.

COGNITIVE DOMAIN – **ANALYZE**

'Analyze' involves breaking material into constituent parts and determining how parts relate to one another and to an overall structure and purpose. **Differentiating**, **organising** and **attributing** are the specific cognitive skills associated with this cognitive domain. Asking students to compare and explain the relationship between two physical quantities from the same content domain, e.g., Differentiate between the lifecycle of gymnosperms with that of pteridophytes and Bryophytes.

COGNITIVE DOMAIN – **EVALUATE**

'Evaluate' involves making judgments based on criteria and standards. **Checking** and **critiquing** are the specific cognitive skills associated with this cognitive domain. Assessment tasks that require a deeper level of understanding wherein students are required to provide justification for their choice, e.g., Examine how temperature and amount of carbon dioxide affect the rate of photosynthesis of a plant.

COGNITIVE DOMAIN – **CREATE**

'Create' involves putting elements together to form a coherent or functional whole; or reorganising elements into a new pattern or structure. **Generating**, **planning** and **producing** are the specific cognitive skills associated with this cognitive domain. Tasks that require students to produce new artefacts based on what they have learnt, e.g., Design an experiment to show that the rate of photosynthesis decreases with a decrease in the level of surrounding carbon dioxide.

KINDS OF ASSESSMENT TASKS FOR DIFFERENT COGNITIVE DOMAINS

Some more examples of kinds of assessment tasks that can be associated with the different cognitive domains are given below. The following list should be taken as an indicative not an exhaustive one.

Table III. Cognitive Domains and assessment tasks

Cognitive domain	Assessment tasks
Remember • **recognising** • **recalling**	• recognising the scientific names of plants and animals, floral formulae of plant families etc. • recalling observations made by scientists that led to discovery of cell organelles, laws of inheritance etc. • defining scientific terms, processes, factors, laws, etc.
Understand • **interpreting** • **exemplifying** • **classifying** • **summarizing** • **inferring** • **comparing** • **explaining**	• summarizing the events of different stages of a biological process • describing structure-function relationship of different part of plants and human body • inferring graphs, tables to explain a biological concept • classifying organisms in a scientific manner • comparing organisms, phenomena and processes based on certain characteristics • explaining scientific concepts and biological relationships between with examples • making inferences from the given information about a phenomenon
Apply • **executing** • **implementing**	• solving problems by applying the scientific concepts in daily life • predicting outcomes based on given set information from an experiment or process
Analyze • **differentiating** • **organising** • **attributing**	• differentiating between different organisms, processes and phenomenon • making conclusion based of data collected in activities / experiments • relating processes and phenomena with causes and effects
Evaluate • **checking** • **critiquing**	• conducting an experiment to verify the scientific facts or hypotheses • justifying effects of different factors on a process or phenomena
Create • **generating**	• planning investigations and experiments to verify the scientific facts or hypotheses

• **planning** • **producing**	• producing a flow chart or diagram to represent the flow of biological phenomena or process • generating a graphical representation of a given biological process or concept

SAMPLE TASKS FROM DIFFERENT COGNITIVE DOMAINS SPECIFIC TO A CONTENT UNIT

Some specific examples of tasks from different cognitive domains are described below for two content chapters from classes 11 and 12 NCERT Biology textbooks. A chapter may not always cover all six cognitive domains. The following list of tasks should be taken as an indicative list not a comprehensive one.

CHAPTER 18 – CLASS 11

Table IV: Chapter 18. Body Fluids and Circulations – Class:11

CHAPTER 1. BODY FLUIDS AND CIRCULATIONS – CLASS:11

Cognitive domain	Sample tasks
Remember	• What is the instrument used for measuring blood pressure? • State the three formed elements of human blood.
Understand	• Describe the events of the three stages of cardiac cycle. • Blood exhibits coagulation or clotting in response to an injury or trauma. What is the role of calcium in clotting?
Apply	• Tara has blood group B-ve and her husband's blood group is O +ve. Their first child has blood group B+ve. Her second child was born with severe anaemia and jaundice. a. What could be the reason for the condition of second child? b. How this condition could have been avoided?
Analyze	• How does the open circulatory system differ from closed circulatory system? Explain with examples.
Evaluate	• Arterial wall is thicker and elastic than walls of veins. What would happen if the wall thickness of arteries is as same as veins? • Why do veins have valves but, arteries don't?
Create	• Draw a schematic flow chart of the pathway of human blood circulation highlighting how it prevents the mixing of oxygenated and deoxygenated blood.

Table V: Chapter 8. Human health and Disease – Class:12

CHAPTER 8. (HUMAN HEALTH AND DISEASE)– CLASS: 12

Cognitive domain	Sample tasks
Remember	• Name the four barriers of innate immunity. • Name two bacterial diseases.
Understand	• Describe different stages of the life cycle of Plasmodium. • Thymus is an endocrine gland and also act as secondary lymphoid organ. What is its role in causing immune response?
Apply	• When exposed to grass pollen, Arjun experiences sneezing, watery eyes, and scratchy throat. a. What is this condition called? b. Suggest the drugs to reduce the symptoms.
Analyze	• How does benign tumour differ from malignant tumour?
Evaluate	• Why do breastfed babies are more likely to be immune to diseases than bottle fed babies? • It is necessary for a patient to take immunosuppressants after undertaking any graft/transplant. Justify.
Create	• Human Immunodeficiency Virus (HIV), a member of a group of viruses called retrovirus. Draw a diagram depicting how HIV virus ensures its DNA replication in an infected cell.

6. LEARNING OUTCOMES

"Competency based Learning focuses on the student's demonstration of desired learning outcomes as central to the learning process. Learning outcomes are statements of abilities that are expected to be gained by students as a result of learning the activity. Learning outcomes are, thus, statements of what a learner is expected to know, understand and/or be able to demonstrate after completion of a process of learning. Therefore, the focus is on measuring learning through attainment of prescribed learning outcomes, rather than on measuring time." [Senior School Curriculum, CBSE]

Following learning outcomes for senior secondary stage developed by National Council for Educational Research and Training (NCERT) state important knowledge, skills and dispositions students need to attain at the end of an academic year in classes 11 and 12 in the context of learning Biology.

CLASS 11 LEARNING OUTCOMES FOR BIOLOGY

(1) **differentiates organisms, phenomena and processes based on certain characteristics and salient features**, such as, prokaryotes and eukaryotes, plant cell and animal cell, diffusion and osmosis, meristematic tissues and permanent tissues; squamous epithelium and cuboidal epithelium, diploblastic and triploblastic organisation; metacentric, submetacentric, acrocentric and telocentric chromosomes; etc.

(2) **classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner;** such as five kingdom classification system of organisms under various hierarchical structural organizations; natural resources, etc.

(3) **relates processes and phenomena with causes and effects,** such as, characteristics of living with cell as basic unit of life, transpiration pull with absorption of water by roots of plants; tissues with their functions, deficiency symptoms of essential elements, pumping of heart with circulation of blood, hormones with various physiological functions, digestive enzymes electrocardiograph (ECG) and heart diseases; smoking and lung diseases; etc.

(4) **applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions,** such as, systematic technical description of flowers, taxonomic study of plants and animals; Binomial nomenclature of organisms; coelom, bisymmetric body etc.; bisexual and unisexual organisms, actinomorphic and zygomorphic flowers, aestivations, placentation, physiological processes, cardiac cycle; organ structures; SA node; AV node; etc.

(5) **explains efficiently systems, relationships, processes and phenomena** such as; organ systems in frog, cockroach and earthworms, structures and function of cell organelles, photosynthesis, respiration, mechanism of contraction of skeletal muscles, etc.

(6) **describes contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines etc;** such as; Anton Von Leeuwenhoek described a live cell and later, Robert Brown discovered the nucleus; in classification systems of living organisms, Aristotle was the earliest and then Linnaeus proposed two kingdom classification and later R. H. Whittaker proposed five kingdom classification, etc.

(7) **makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts** such as; mathematical models on arithmetic and geometric growth rates in plants/organisms, absorption and transfer of light energy in photosynthesis; secondary metabolites, structure of protein, structure of DNA, etc.

(8) **draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams,** such as, floral diagrams of given flowers, parts of flowers, modified roots external features of earthworm, cockroach and frog, Z-scheme of light reaction, Calvin cycle, etc.

(9) **writes floral formulae in technical language based on floral diagrams of different flowers** such as flowers of pea, makoi and onion etc.

(10) **prepares slides for study the structural intricacies of life forms and structural organisations,** such as, transverse sections of root, stem and leaves, mitosis and meiosis; pollen germination, etc.

(11) **handles laboratory tools, and apparatuses, instruments and devices properly for performing activities/ experiments/ investigations** such as; uses foldscope/microscope for observing internal structure of transverse section of root, stem and leaves, intricacies of chloroplasts, stomata, etc.; digital balance/scale for weighing chemicals; pipette for drawing liquid, etc.

(12) **plans and conducts investigations and experiments to arrive at and verify the facts, principles, phenomena, or to seek answers to queries on their own**, such as, what is the pattern and structure of organisms in nature? Does Pisum sativum carry bisexual and zygomorphic flowers, how do plants grow in length? Do plants breath?, What does (mainly which gas) our breath contains?, What happens to cooked rice when we chew and when we do not chew? etc.

(13) **analyzes and interprets graphs and figures** such as, Enzyme activity, temperature, pH and substrate concentration graphs, growth versus time graphs, oxygen dissociation curve etc.

(14) **uses scientific conventions, symbols, and equations to represent various quantities, elements, and units,** such as, SI units, symbols of elements, formulae of simple compounds, pathways of aerobic and anaerobic respiration, organic compounds in living organisms, etc.

(15) **draws conclusion on the basis of data collected in activities / experiments and investigatory projects conducted by them,** such as, roots, stem and leaves modify to perform various functions, deficiency of nutrients affect physiological processes in plants, deficiency of protein in diet causes protein-energy malnutrition (PEM), etc.

(16) **communicates the findings and conclusions effectively,** such as, those derived from experiments, activities, and projects both in oral and written form using appropriate figures, tables, graphs, and digital forms, takes part in the discussions, argumentations etc.

(17) **applies scientific concepts of Biology in daily life and solving problems,** such as; by mowing the grass of a lawn assuming that due to lateral meristem grass will regrow, determine the age of a fallen tree by counting concentric rings present on the transverse cut of tree trunk, drinking less/more water changes the concentration and volume of urine, etc.

(18) **appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development,** such as, Hydroponic plant production, uses of algae as commercially like Algin (brown algae), Carrageen (red algae), Agar; Chlorella uses as food supplement in space; dialysis for kidney failure patients; uses of artificial arms and limbs, etc.

(19) **exhibits creativity in designing models using eco-friendly resources / preparing charts / paintings / sketching/ etc. on different topics;** such as; structure of cockroach, etc.

(20) **exhibits ethics and values of honesty, objectivity, rational thinking and freedom from myth and superstitious beliefs while taking decisions,** such as, reports and records experimental data accurately, reveals respect for life by using weed plant for investigatory studies/ activities, etc.,

(21) **makes efforts to conserve environment realizing the inter- dependency and inter-relationship in the biotic and abiotic factors of environment,** such as, by appreciating use of weed plants in the study, using eco-friendly waste material, etc.

(22) **applies learning to hypothetical situations,** such as, possibility of life on other planets, etc.

CLASS 12 LEARNING OUTCOMES FOR BIOLOGY

(1) **differentiates organisms, phenomena and processes based on certain characteristics and salient features**, such as, reproduction in organisms, reproductive parts of commonly available flowers; autogamy and geitonogamy, cytokinesis in plant and animal cells, innate and acquired immunity, vaccination and immunisation, divergent and convergent evolution; homologous and analogous organs; transcription and translation; in-breeding and outbreeding; in-vitro and in-vivo fertilization; genotype and phenotype; etc.

(2) **relates processes and phenomena with causes and effects**, such as, diseases with symptom, production with use of fertilisers, menstruation and hygiene; pregnancy and embryonic development, etc.

(3) **applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions** such as, parthenocarpic fruits polyembryony seminiferous tubules, parthenogenesis, pericarp, microsporangia, geitonogamy, albuminous seeds, apomixis, medical termination of pregnancy (MTP); Acquired Immuno-Deficiency Syndrome (AIDS); mutation; pleiotropy; sex determination; syndrome; plasmid; vectors; genetically modified organisms (GMO); biomass; ecological pyramids; biomagnification, etc.

(4) **explains efficiently systems, relationships, processes and phenomena**, such as; double fertilisation, flower is a modified shoot, process of embryonic development in mammals, adaptations in animals living in xeric and hydric conditions, sexually transmitted infections, mendelian and chromosomal disorders, human genome project, replication of retrovirus, population interactions, energy flow in ecosystem, succession of plants, use of DNA finger printing in forensic science, process of evolution etc.

(5) **describes contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines etc.**; such as; Mendalian genetics to Morgan's work for linkage and recombination, Hershey and Martha Chase's experiment to establish the concept that the DNA is genetic material, Watson and Crick model of DNA, etc.

(6) **makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts** such as; using mathematical models of monohybrid and dihybrid cross; pedigree analysis; molecular basis of DNA and RNA, recombinant DNA technology, bioprocess engineering, population growth curve, etc.

(7) **draws labelled diagrams, flow charts, concept maps, graphs**, such as, reproductive parts of flowers, decomposition cycle in terrestrial ecosystem, nutrient cycles, male and female reproductive system of human; ecological pyramids; life cycle of Plasmodium, etc.

(8) **prepares slides for study the structural intricacies of life forms and structural organisations**, such as, staining of nucleic acid by acetocarmine, etc.

(9) **plans and conducts investigations and experiments to arrive at and verify the facts, principles, phenomena, or to seek answers to queries on their own**, such as, How many daughter cells are produced at the end of meiosis?, At which stage of follicular development, is ovum released?, How is independent assortment of alleles important from the point of view of variation?, Which type soil has poor nutrient status and high leaching?, How can water-holding capacity of soil be improved?, What is the importance of succulent leaves and stem for a xerophytic plant?, etc.

(10) **handles laboratory/ agricultural tools, and apparatuses, instruments and devices properly for performing activities/ experiments/ investigations** such as; uses agarose gel electrophoresis, pH meter, spectrophotometer, etc.

(11) **analyzes and interprets graphs and figures** such as, species-area relationship graphs, crop yield with stipulated time graph after use of fertilisers, effect of sewage discharge on some important characteristics of a river, etc.

(12) **uses scientific conventions, symbols, and equations to represent various quantities, elements, and units,** such as, SI units, symbols of elements in macromolecules, genetic code, formulae of simple compounds, biochemical equations, etc.

(13) **draws conclusion on the basis of data collected in activities/ experiments and investigatory projects conducted by them**, such as, only one pollen tubes reach the ovules, algal bloom and biochemical oxygen demand, etc.

(14) **communicates the findings and conclusions effectively**, such as, takes part in the discussions, participate and present the experiments, activities, projects and investigations using appropriate figures, tables, graphs, and digital forms, etc.

(15) **applies scientific concepts in daily life and solving problems**, such as; maintain hygiene and sanitation during menstruation, organic farming, coping up with the plastic and e-waste, etc.

(16) **appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development,** such as; multiple ovulation embryo transfer technology for herd improvement; plant breeding for development of resistant varieties of plants; plant tissue culture; microbial fermentation for industrial production, waste water treatment, biogas production technology, using vehicles having standard mass emission norms to control air pollution, etc.

(17) e**xhibits creativity in designing models using eco-friendly resources / preparing charts / paintings / sketching/ etc. on different topics**; such as; water purification systems, electrostatic precipitator, etc.

(18) **exhibits ethics and values of honesty, objectivity, rational thinking and freedom from myth and superstitious beliefs while taking decisions, respect for life, etc.**, such as, reports and records experimental data accurately, myth that sexually transmitted diseases are spread by casual physical contact, belief that vaccination is not important for prevention of diseases, ethical arguments for conservation of biodiversity and conducts plantation drive of endangered species? etc.

(19) **applies/ makes efforts to conserve environment realizing the interdependency and inter-relationship in the biotic and abiotic factors of environment**, such as, by appreciating use of weed plants in the study, solid waste management, etc.

(20) **calculates using the data given**, such as, percentage of pollen germination, determination of population density, productivity, etc.

(21) **applies learning to hypothetical situations**, such as, what will happen if there is no producer as biotic component on the earth? etc.

7. CONTENT DOMAIN SPECIFIC LEARNING OUTCOMES AND INDICATORS

The learning outcomes defined by NCERT are generic and broadly defined for the content defined in the curriculum. They articulate the discipline-specific skills that students need to attain through learning different concepts in the syllabus. A clear understanding of the scope of these learning outcomes for each concept dealt in the NCERT textbook chapters will be very helpful for both teachers and students in planning teaching and learning better. The following process has been followed to list out the content domain specific learning outcomes (CLOs) and indicators for all the content units and textbook chapters.

Concepts discussed in the textbook chapters were mapped to key concepts under each content domain in the CBSE syllabus.

Relevant NCERT learning outcomes were identified for each key concept in the chapter.

Content domain specific learning outcomes (CLO) were defined for the NCERT learning outcomes relevant for the chapter. The cognitive process in the NCERT learning outcome and the CLO is the same.

Each CLO was broken down into specific learning indicators called as 'indicators' which defines the specific skill or knowledge that a student needs to attain. The cognitive procces addressed in indicators may be same or lower than the cognitive process addressed in CLO.

Table VI: Content domain specific learning outcomes and indicators – Class:11

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
I: Diversity of Living Organisms 1. The Living World	Diversity in the Living World	LO21. Makes efforts to conserve environment realizing the inter-dependency and inter-relationship in the biotic and abiotic factors of environment	CLO1. Relates the concept of "Biodiversity "with the number of species already known and still not described.	C1. Explains the need to identify classify and provide nomenclature to living organisms.
		LO4. Applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO2. Applies scientific terminology for taxonomic study of plants and animals	C2. Defines binomial nomenclature
		LO4. Applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO2. Applies scientific terminology for taxonomic study of plants and animals	C3. Summarizes universal rules of binomial system of nomenclature of plants and animals with examples
		LO4. Applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO2. Applies scientific terminology for taxonomic study of plants and animals	C4. Identifies the scientific names of organisms as per the binomial system of nomenclature based on the distinct similarities and differences
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO3. Differentiates generic and scientific system of nomenclature of organisms	C5. Differentiates generic name and specific epithet
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO3. Differentiates generic and scientific system of nomenclature of organisms	C6. Infers the importance of universally accepted principles to provide scientific names to organisms

		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO4. Differentiates between the basic methods of taxonomic study	C7. Compares classification and identification with examples
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO4. Differentiates between the basic methods of taxonomic study	C8. Explains the branch of study called taxonomy
		LO6. Describes contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines	CLO5. Describes the contribution of scientists and researchers in the field of taxonomy	C9. Describes the contribution of Linnaeus and his publications in naming and classifying living organisms
	Taxonomic categories	LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO6. Differentiates scientific terminologies used for taxonomic study of plants and animals	C10.Differentiates between terms taxonomic category, taxonomic hierarchy and taxon with examples
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO7. Explains the characteristics of different taxonomical categories and shows the hierarchical arrangement between them	C11.Explains different taxonomic categories with examples – kingdom, phylum, class, order, family, genus and species
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO8. Illustrates the taxonomic categories of organisms showing hierarchical arrangement in ascending order	C12. Draws a flow chart indicating the hierarchy of taxonomic categories of some common organisms
		LO17. Applies scientific concepts of Biology in daily life and solving problems	CLO9. Categorises the collected plant and animal specimens and groups them into respective taxa and provide descriptions	C13.Collects plant specimens in the herbarium and pond water sample with planktons to study their characters and classifies them on the basis of similarities and dissimilarities

		LO10. Prepares slides for study the structural intricacies of life forms and structural organisations	CLO9. Categorises the collected plant and animal specimens and groups them into respective taxa and provide descriptions	C14. Prepares slides of pond water to observe characters of different planktons under microscope
		LO11. Handles laboratory tools, and apparatuses, instruments and devices properly for performing activities/ experiments/ investigations	CLO9. Categorises the collected plant and animal specimens and groups them into respective taxa and provide descriptions	C15. Observes planktons under microscope to analyze their characters
		LO12. Plans and conducts investigations and experiments to arrive at and verify the facts, principles, phenomena, or to seek answers to queries on their own	CLO9. Categorises the collected plant and animal specimens and groups them into respective taxa and provide descriptions	C16.Describes and groups collected plant specimen and organisms into specific taxa based on similarities and dissimilarities
I: Diversity of Living Organisms 2. Biological Classification	Classification system	LO6. Describes contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines etc	CLO10. Describes contribution of scientists in evolution of different classification systems developed over time	C17.Explains observations made by scientists to develop and improve and change the classification systems of living organisms when the scientific criteria of classification change
		LO6. Describes contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines etc	CLO11. Describes the recently proposed three-domain system of classification	C18. Explains the three -domain classification
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO12. Explains the characteristics of five kingdom classification	C19. Describes the characteristics of the proposed Five Kingdom classification of R.H. Whittaker in the form of a table

		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO12. Explains the characteristics of five kingdom classification	C20. Differentiates prokaryotic cells and eukaryotic cells, autotrophic vs. heterotrophic, modes of nutrition, and various cell wall compositions, which places organisms in the appropriate kingdom based on cell type, mode of nutrition, and cell wall composition
		LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO13. Classifies organisms using 5-kingdom classification system based on certain characteristics in more scientific manner	C21.Compares the different classification systems listing the advantages of five Kingdom classification
	Kingdom Monera	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO14. Describes the organisms of kingdom Monera	C22.Explains the criteria used to classify organisms into kingdom Monera
		LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO15. Classifies the organisms of kingdom Monera	C23.Classifies the organisms of kingdom Monera based on their characteristic features with examples
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO16. Illustrates the organisms of Kingdom Monera on the basis of shape	C24. Draws well labelled diagrams of bacteria grouped on the basis of shape
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO17. Illustrates the organisms of Eubacteria and identifies blue green algae (BGA) with heterocysts	C25. Draws well labelled diagram of a blue green algae (BGA) having heterocyst and explains the significance of heterocyst

		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO18. Differentiates between the different types of Eubacteria on the basis of mode of nutrition	C26. Compares between the given types of eubacteria—photosynthetic autotrophs, chemosynthetic autotrophs and heterotrophic bacteria; and types of archaebacteria
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO19. Illustrates the reproduction in bacteria	C27.Draws a well labelled diagram of a dividing bacteria
	Kingdom Protista	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO20. Describes characteristic features of the organisms of kingdom Protista	C28. Explains the criteria used to classify organisms into kingdom Protista
		LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO20. Describes characteristic features of the organisms of kingdom Protista	C29. Describes the characteristics of different groups of protists with examples
		LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO20. Describes characteristic features of the organisms of kingdom Protista	C30. Describes the applications of protists in every-day life
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO21. Differentiates between different types of protistan	C31.Differentiates between diatoms and dinoflagellates
		LO7. Makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO22. Relates the toughness of the cell wall of various groups of protists with the composition of their cell wall.	C32. Differentiates the chemical composition of the cell wall in various groups of protists
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO23. Illustrates the organisms of the kingdom Protista	C33.Draws well labelled diagram of Euglena and Paramecium

		LO17. Applies scientific concepts of Biology in daily life and solving problems	CLO24. Describes the organisms of kingdom Protista in daily life and solving problems	C34.Explains protistan members in context the following phenomenon/processes such as a) Why cell wall deposits of diatoms are called diatomaceous earth? What is its utility? b) Why does very often sea appears red in colour?
	Kingdom Fungi	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO25. Describes the organisms of kingdom Fungi	C35. Explains the criteria used to classify organisms into kingdom Fungi
		LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO25. Describes the organisms of kingdom Fungi	C36. Classifies fungi based on certain characteristics
		LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO25. Describes the organisms of kingdom Fungi	C37. Illustrates fruitification in Fungi
		LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO25. Describes the organisms of kingdom Fungi	C38. Describes the applications of fungi in every-day life
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO25. Describes the organisms of kingdom Fungi	C39.Explains the process of formation of basidiocarp in the edible mushroom (Agaricus).

		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO26. Differentiates between various classes of kingdom fungi on the basis of morphology of mycelium, mode of spore formation, and fruiting bodies	C40.Distinguishes between various types of spores and fruiting bodies in fungi
		LO4. Applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO27. Applies scientific terminology to describe the mode of nutrition and life history of fungi	C41.Applies terms such as symbionts, lichens, and mycorrhiza to relate to the natural association of fungi with other groups of organisms
		LO3. Relates processes and phenomena with causes and effects	CLO28. Relates rotting of food with bacterial and fungal diseases in plants	C42.Describes the economic importance of fungi and their role in various plant and animal diseases
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO29. Illustrates the organisms of kingdom fungi	C43.Draws labelled figures of various examples of kingdom fungi
		LO10. Prepares slides for study the structural intricacies of life forms and structural organisations	CLO30. Prepares a temporary mount of organisms of kingdom fungi	C44.Prepares a temporary mount of the bread mould (Rhizopus) to study its structure
		LO17. Applies scientific concepts of Biology in daily life and solving problems	CLO31. Describes the organisms of kingdom fungi in daily life and solving problems	C45. Collects a pond water sample and a rotting food sample to explore and analyze the categories of different microscopic organisms
	Kingdom Plantae	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO32. Describes the organisms of kingdom Plantae	C46.Explains the criteria used to classify organisms into kingdom Plantae

		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO33. Describes lifecycle of angiosperms	C47. Draws a flow chart of the reproduction of angiosperm
	Kingdom Animalia	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO34. Describes the organisms of kingdom Animalia	C48.Explains the criteria used to classify organisms into kingdom Animalia
	Viruses, Viroids, Prions and Lichens	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO35. Describes features of viruses and their discovery	C49.Explains the criteria used to classify organisms as virus or viroid
		LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO35. Describes features of viruses and their discovery	C50.Explains the observations by scientists that led to the discoveries of viruses
		LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO35. Describes features of viruses and their discovery	C51.Describes the structural features of viruses help in infection
		LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO35. Describes features of viruses and their discovery	C52. Enlists new examples of RNA and DNA viruses

		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO36. Draws well labelled diagram of few common viruses	C53.Explains the structure of the Tobacco Mosaic Virus and Bacteriophage with the help of labelled diagram
		LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO37. Describes structure of viroid, prions and lichens	C54.Explains the criteria used to classify viroid, prions and lichens
		LO3. Relates processes and phenomena with causes and effects	CLO38. Relates viral diseases with their causes	C55.Relates the viral diseases in the humans with their causes
		LO3. Relates processes and phenomena with causes and effects	CLO38. Relates viral diseases with their causes	C56.Gives reasons for mosaic formation, curling, etc. in plants
		LO19. Exhibits creativity in designing models using eco-friendly resources / preparing charts / paintings / sketching/ etc. on different topics	CLO39. Prepares 3D models of viruses	C57.Uses wool, cardboard, etc. to prepare 3D models of viruses
I: Diversity of Living Organisms 3. Plant Kingdom	Classification systems of Plants	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO40. Explains the process used to classify organisms	C58.Explains the factors that affect the classification system
		LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO41. Describes the features of organisms of kingdom Plantae	C59.Classifies the organisms of kingdom Plantae based on certain characteristics
	Algae	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO42. Describes the features of organisms of division Algae	C60.Explains the criteria used to classify organisms into division algae

		LO18. Appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO43. Explains the usage of algae for mankind	C61.Infers how algae is (are) useful to humans with examples
		LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO44. Classifies the organisms of division Algae	C62.Classifies algae into different classes—red, green, and brown algae—based on certain characteristics
		LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO45. Explains the characteristics of various classes of algae	C63.Describes the characteristics of the various classes of algae in a tabular form
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO46. Draws to show different types of algae (Green, Red and Brown) on the basis of morphology	C64.Draws well labelled diagrams of green, brown and red algae and gives their characteristic differences
		LO10. Prepares slides for study the structural intricacies of life forms and structural organisations	CLO47. Prepares slides and identifies different types of algae under the microscope	C65.Prepares a slide of pond water and identify different types of algae under compound microscope
		LO11. Handles laboratory tools, and apparatuses, instruments and devices properly for performing activities/ experiments/ investigations	CLO48. Observes permanent slides of algae	C66. Observes permanent slides of various algae to study their features
	Bryophytes	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO49. Describes the features of organisms of division Bryophytes	C67.Classifies the organisms into the division Bryophytes based on their salient features

		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO50. Draws labelled diagrams different types of bryophytes	C68. Draws well labelled diagrams of bryophytes (mosses and liverworts) and highlights their distinguishing characteristic
		LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO51. Classifies the organisms of division Bryophytes	C69.Classifies bryophytes into different classes based on salient features
		LO18. Appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO52. Explains the use of organisms of bryophytes	C70.Explains how some mosses are of great economic importance to us and Sphagnum is used in moss stick by a gardener
		LO3. Relates processes and phenomena with causes and effects	CLO53. Justifies why bryophytes and pteridophytes are amphibians of plant kingdom	C71. Explains why bryophytes and pteridophytes are found in moist, shady, cool and damp places
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO54. Draws flow charts to explain the life cycle of bryophytes	C72. Draws flow chart to explain the life cycle of moss
		LO11. Handles laboratory tools, and apparatuses, instruments and devices properly for performing activities/ experiments/ investigations	CLO55. Observes permanent slides of liverworts and moss	C73. Observes permanent slides of liverworts and moss capsules to explain their structure
	Pteridophytes	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO56. Describes the features of organisms of division Pteridophytes	C74.Explains the criteria used to classify organisms into division Pteridophytes

		LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO56. Describes the features of organisms of division Pteridophytes	C75.Classifies Pteridophytes into different classes based on certain characteristics
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO57. Draws labelled diagrams different types of pteridophytes (ferns)	C76. Draw well labelled diagrams of pteridophytes (ferns) and highlights their distinguishing morphological characteristics
		LO10. Prepares slides for study the structural intricacies of life forms and structural organisations,	CLO58. Prepares slides to study the structural intricacies of parts of pteridophytes	C77. Identifies various commonly available ferns and prepares a slide of sorus
	Gymnosperms	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO59. Describes the features of organisms of division Gymnosperms	C78.Classifies Gymnosperms into different classes based on salient characteristics
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO60. Differentiates the lifecycles of different division of plants	C79.Differentiates between the lifecycle of Gymnosperms with that of Pteridophytes and Bryophytes
		LO12. Plans and conducts investigations and experiments to arrive at and verify the facts, principles, phenomena, or to seek answers to queries on their own	CLO61. Investigates the structural features of different parts of gymnosperms	C80. Explores the different types of gymnosperms as cones, leaves of Biota (morpankhi), Pinus, Araucaria, Cycas / seeds of Chilgoza (Pinus gerardiana)
		LO11. Handles laboratory tools, and apparatuses, instruments and devices properly for performing activities/ experiments/ investigations	CLO62. Observes permanent slides of longitudinal section of cones and pollens of Pinus	C81. Observes permanent slides of longitudinal section of male and

				female cone, as well as winged pollen grain of Pinus
		LO3. Relates processes and phenomena with causes and effects	CLO63. Relates the features of the leaves of gymnosperms to their habitat	C82.Explains why needle shaped leaves are present in Pinus
		LO17. Applies scientific concepts of Biology in daily life and solving problems	CLO64. Observes and deduces division of different plants through field trips	C83. Observes characters of ten different plant specimens on a field trip to botanical garden or unmaintained outdoor places and classifies them into appropriate divisions of Kingdom Plantae.
I: Diversity of Living Organisms 4. Animal Kingdom	Basis of Classification of Animals Kingdom	LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO65. Explains how animals can be classified based on different criteria with examples	C84.Differentiates organisms of Animal Kingdom based on levels of organisations, complexities in the organ systems, different embryonic layers, symmetry, segmentation, presence of coelom, notochord and distinctive features
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO66. Draws well labelled diagram different types of symmetry /diploblastic and triploblastic organization and types of coelom	C85. Describes different types of symmetry, diploblastic and triploblastic organization and types of coelom with the help of well labelled diagram
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO67. Draws a flow chart to indicate broad classification of kingdom Animalia	C86. Draws a flowchart illustrating the broad classification of the kingdom Animalia based on common fundamental features

	Phylum Porifera	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO68. Identifies the common structural and organisational characteristics of phylum Porifera	C87.Describes the characteristic features of Phylum Porifera
	Phylum Coelenterata	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO69. Identifies the common structural and organisational characteristics of phylum Coelenterate	C88.Explains the characteristic features of Phylum Coelenterate
	Phylum Ctenophora	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO70. Identifies the common structural and organisational characteristics of phylum Ctenophora	C89.Explains the characteristic features of Phylum Ctenophora
	Phylum Platyhelminthes	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO71. Identifies the common structural and organisational characteristics of phylum Platyhelminthes	C90.Explains the characteristic features of Phylum Platyhelminthes
	Phylum Aschelminths	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO72. Identifies the common structural and organisational characteristics of phylum Aschelminths	C91.Explains the characteristic features of Aschelminths
	Phylum Annelida	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO73. Identifies the common structural and organisational characteristics of phylum Annelida	C92.Explains the characteristic features of Annelida
	Phylum Arthropoda	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO74. Identifies the common structural and organisational characteristics of phylum Arthropoda	C93.Describes the distinguishing characteristics of organisms in Phylum Arthropoda

	Phylum Mollusca	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO75. Identifies the common structural and organisational characteristics of phylum Mollusca	C94.Explains the characteristic features of Mollusca
	Phylum Echinodermata	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO76. Identifies the common structural and organisational characteristics of phylum Echinodermata	C95.Explains the characteristic features of Echinodermata
	Phylum Hemichordata	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO77. Identifies the common structural and organisational characteristics of phylum Hemichordata	C96.Explains the characteristic features of Hemichordates
	Phylum Chordata	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO78. Describes the criteria used to classify organisms into Phylum Chordata and into sub-phylum Vertebrata	C97.Explains the distinguishing characteristics of organisms of Phylum Chordata and sub-phylum Vertebrata
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO79. Describes the distinguishing characteristics of organisms in Phylum Chordata and non-chordates	C98.Distinguishes chordates from non-chordates
		LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO80. Classifies sub-phylum vertebrates into different classes	C99.Explains the characteristic features of different classes of chordates – Pisces, Amphibian, Reptiles, Aves and Mammals
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO81. Distinguishes between cartilaginous and bony fishes	C100. Distinguishes between cartilaginous and bony fishes on the basis of their features

		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO82. Differentiates based on mechanism that organisms have to regulate body temperature	C101. Analyzes how different mammals regulate their body temperature
		LO12. Plans and conducts investigations and experiments to arrive at and verify the facts, principles, phenomena, or to seek answers to queries on their own	CLO83. Conducts investigations to study the diversity in animal kingdom	C102. Studies and explores the animal diversity as types of insects / birds /amphibians /birds present in your neighbourhood garden / pond / lake / river / home garden
		LO20. Exhibits ethics and values of honesty, objectivity, rational thinking and freedom from myth and superstitious beliefs while taking decisions	CLO84. Reasons to debunk some misunderstandings to fully grasp the criteria to classify Kingdom Animalia	C103. Explains the reasoning and clarifies the misconceptions using different questions using following such as a) Do bats belong to Aves or Mammals? Why? (b) Do Seals /Walrus belong to Pisces or Mammals?
		LO4. Applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO85. Interprets the characteristics of each phylum/class to support theory of evolution (Increase in size of cerebrum, chamber of heart)	C104. Analyses the characteristics of different classes/phyla and understand their evolutionary complexities
II: Structural Organization in Plants and Animals 5. Morphology of Flowering Plants	The Root	LO3. Relates processes and phenomena with causes and effects	CLO86. Explains the structure and function of the root	C105. Explains and relates the structure and function of different parts of root system
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO87. Illustrates the distinguishing characteristics of fibrous root and taproot	C106. Compares taproot and fibrous root system
	The Stem	LO3. Relates processes and phenomena with causes and effects	CLO88. Explains the structure and function of stem	C107. Relates the structure of stem to its function

	The leaf	LO3. Relates processes and phenomena with causes and effects	CLO89. Explains structure and function of leaf	C108. Relates the structure of different parts of the leaf to their function
		LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO90. Explains the different types of leaves based on its feature	C109. Classifies the different types of leaves based on different criteria – venation, absence or extent of incisions in the leaf lamina, pattern of arrangement of leaves and different modification of leaves
	The flower	LO4. Applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO91. States the definition of terms associated with flowers	C110. Defines the term inflorescence, staminode and aestivation
	Parts of flower	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO92. Describes the features of a flower	C111. Explains different parts of flowers
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO93. Compares flowers based on different salient characteristics	C112. Differentiates flowers based on different salient characteristics such as presence of stamens or carpels, arrangement of flowers around the main axis, symmetry, number of floral appendages, presence or absence of bracts, position of floral members in respect of the ovary, if sepals are united or free, if petals are united or free, positional arrangement of the parts of a flower within a flower, attachment types of stamen, and number of stamen bundles

		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO94. Describes the parts of gynoecium of a flower	C113. Differentiates parts of gynoecium and different types of carpels
		LO4. Applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO95. Identifies the different types of placentation in plants	C114. Describes different types of placentation – marginal, axile, parietal, free central and basal – with examples
	The Fruit	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO96. Describes the parts of a fruit	C115. Explains the parts of fruits and differentiates true and false fruits
	The Seed	LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO97. Compares monocot and dicot seeds	C116. Differentiates between monocot and dicot seeds
	Semi-Technical Description of a Typical Flowering Plant	LO13. Analyzes and interprets graphs and figures	CLO98. Illustrates the parts of flower and floral diagram of different plants	C117. Draws and interprets figures-position of flower parts on thalamus and floral diagram of plants
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO99. Draws labelled diagrams of morphological features and modifications of different parts of plants	C118. Draws labelled figures of morphological features of all parts of plant
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO99. Draws labelled diagrams of morphological features and modifications of different parts of plants	C119. Draws floral diagram describing family Solanaceae
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO100. Compares different systems of angiosperm with a gymnosperm	C120. Study and compare the root system /stem /leaves and flowers of an angiosperm and compare it with a typical gymnosperm

		LO17. Applies scientific concepts of Biology in daily life and solving problems	CLO101. Studies the economic importance of flowering plant family	C121. Relates family Solanaceae economic importance for applications in daily life
		LO17. Applies scientific concepts of Biology in daily life and solving problems	CLO102. Observes the characters of commonly available flowering plants	C122. Describes the structural/morphological details of various commonly available angiosperms on a field visit to a garden/park
II: Structural Organization in Plants and Animals 6. Anatomy of Flowering Plants	Permanent Tissues	LO3. Relates processes and phenomena with causes and effects	CLO102. Describes the function and structure of permanent tissues	C123. Explains formation of permanent tissues and relates the structure of different permanent tissues with its function
	Complex Tissues	LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO103. Compares between different types of complex tissues	C124. Differentiates between constituent elements of xylem and phloem on various parameters
	The plant tissue system	LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO104. Differentiates between the different types of plant tissue system	C125. Differentiates and explains the features of different types of plant tissue system – epidermal, stomatal, vascular ground tissue system
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO105. Describes vascular bundles	C126. Explains the features of vascular tissues
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO106. Draws figures of different vascular bundles	C127. Draws labelled figures of different vascular bundles – radial, conjoint closed and conjoint open

	The Root Tissue System	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO107. Explains different regions of T.S of root	C128. Explains and differentiates the different regions of T.S of dicot and monocot root
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO108. Draws figures of transverse section of dicot and monocot root	C129. Draws labelled figures of transverse section of dicot and monocot root
	The Stem Tissue System	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO109. Explains different regions of T.S of stem	C130. Explains and differentiates the different regions of T.S of dicot and monocot stem
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO110. Draws figures of different regions of T.S of stem	C131. Draws labelled diagrams of T.S of stem depicting different regions
	The Leaf Tissue System	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO111. Explains different regions of a leaf with figures	C132. Analyzes the different regions of T. S of leaf with the help of slides and figures
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO111. Explains different regions of a leaf with figures	C133. Compares the different regions of T.S of dicot and monocot leaf
		LO11. Handles laboratory tools, and apparatuses, instruments and devices properly for performing activities/ experiments/ investigations	CLO112. Prepare slides of T.S of dicot and monocot root/stem /leaf	C134. Dissects T.S. of dicot and monocot root/stem /leaf and prepares temporary mount to observes under a microscope
		LO15. Draws conclusion on the basis of data collected in activities / experiments and investigatory projects conducted by them	CLO113. Observes slides of T.S. of different parts of dicot and monocot plants	C135. Prepares temporary mount/uses permanent slides of T.S. of dicot and monocot root/stem /leaf and draws their labelled figures

		LO13. Analyzes and interprets graphs and figures	CLO114. Analyzes and interprets the figures of different parts of dicot and monocot plants	C136. Compares the features of dicot and monocot root/stem/leaf and identifies the given slide/chart/figure/spot
		LO16. Communicates the findings and conclusions effectively	CLO114. Communicates the data collected from analysis of slides of T.S. of dicot and monocot	C137. Presents and explains the slide/chart/figure from observations of T.S of different parts of dicot and monocot plants
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO115. Explains vascular tissues	C138. Describes the formation of cambial ring and medullary rays
II: Structural Organization in Plants and Animals 7. Structural Organisation in Animals	Organ and Organ System	LO3. Relates processes and phenomena with causes and effects	CLO116. Explains cellular complexity and organisations in multicellular organisms	C139. Explains the organisation of tissues to form organs which in turn associate to form organ systems in the multicellular organisms.
	Frog	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO117. Describes the morphology and anatomy of frog	C140. Explains the physical features and organ systems in frog
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO117. Describes the morphology and anatomy of frog	C141. Explains the importance of frog in environment
III: Cell: Structure and Functions 8. Cell: The Unit of Life	Cell theory	LO3. Relates processes and phenomena with causes and effects	CLO118. Explains the relevance of cell theory	C142. Explains cell theory and justifies the independent existence of a cell
		LO6. Describes contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines etc	CLO119. Illustrates the observations by scientists that led to the discovery of cell	C143. Describes contribution of scientists/researchers for the scientific discoveries of cell and tools to study it

	Cell	LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO120. Compares different cell types and their organelles with examples	C144. Differentiates and draws different types of cells and explains different cell organelles.
	Cell Envelope and its Modifications	LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO121. Differentiates the different types of cell envelopes	C145. Compares cell envelope of different kinds of bacteria and its modifications
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO122. Explains the features of plasma membrane and cell wall	C146. Describes the structures and function of plasma membrane and cell wall
		LO6. Describes contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines etc	CLO123. Describes role and relevance of fluid mosaic theory	C147. Explains the fluid mosaic theory and relates transport of materials through the plasma membrane with its structure
		LO7. Makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO124. Describes mechanism of cellular transport	C148. Explains transport of molecules by diffusion, osmosis and facilitated transport and relates it with concentration gradient and solubility
	Endomembrane System	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO125. Explains endomembrane system	C149. Describes the features and diagrammatically illustrates the Endoplasmic Reticulum, Golgi apparatus and vacuole
	Mitochondria	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO126. Explains mitochondria	C150. Describes the features and diagrammatically illustrates the mitochondria

	Plastids	LO3. Relates processes and phenomena with causes and effects	CLO127. Explains the structure and function of plastids and mitochondria	C151. Relates semi-autonomy of plastids and mitochondria with the presence of independent DNA in them
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO128. Explains the structure and function of plastids and mitochondria	C152. Differentiates between plastids and mitochondria with the help of labelled diagrams
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO129. Explains plastids	C153. Describes the features of plastids
	Chloroplast	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO130. Explains chloroplasts	C154. Describes the features and diagrammatically illustrates the chloroplast
	Eukaryotic and prokaryotic ribosomes	LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO131. Explains ribosomes	C155. Differentiates between prokaryotic and eukaryotic ribosomes
	Cytoskeleton	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO132. Explains cytoskeleton	C156. Describes the features of cytoskeletons
	Cilia and Flagella	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO133. Explains cilia and flagella	C157. Describes the features and diagrammatically illustrates the cilia and flagella
	Centrosome and Centrioles	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO134. Explains centrosome and centrioles	C158. Describes the features of centrosome and centrioles

	Nucleus	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO135. Explains nucleus	C159. Describes the features and diagrammatically illustrates the nucleus
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient feature	CLO136. Explains the features of chromosomes	C160. Describes, compares and diagrammatically illustrates the chromosomes and indicates the position of the centromere in its types
	Cell and its Organelles	LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO137. Draws labelled diagrams of different cell organelles	C161. Draws labelled diagrams of different cell organelles such as cell plasma, mitochondria, chloroplast, chromosomes to show their parts
		LO12. Plans and conducts investigations and experiments to arrive at and verify the facts, principles, phenomena, or to seek answers to queries on their own	CLO138. Conducts an experiment to investigate the arrangement of organelles in a cell	C162. Investigates the sizes of different organelles and their location in the cell based on their functions
		LO15. Draws conclusion on the basis of data collected in activities / experiments and investigatory projects conducted by them	CLO139. Studies the size difference between different cell organelles	C163. Compares the sizes of different organelles based on data collected
		LO19. Exhibits creativity in designing models using eco-friendly resources / preparing charts / paintings / sketching/ etc. on different topics	CLO140. Creates a plant and animal cell model	C164. Creates an animal and plant cell models showing cell organelles to appropriate size scale using sustainable materials such as clay, sticks, wool threads etc.
		LO16. Communicates the findings and conclusions effectively	CLO141. Communicates the conclusions about cell organelle sizes and their function in a cell	C165. Presents the cell models of plants and animals to the class describing

				the relation between location, structure and function
III: Cell: Structure and Functions 9. Biomolecules	Organic compounds in the body	LO7. Makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO142. Makes linkages at the interface of Biology with chemistry	C166. Enlists different inorganic constituents and their percentage in living tissues explaining the importance of analytical techniques to study their structure
	Proteins	LO14. Uses scientific conventions, symbols, and equations to represent various quantities, elements, and units	CLO143. Uses symbols for diagrammatic representation of small organic compounds in living tissues	C167. Draws general chemical structure and nature of different amino acid
	Fatty acid	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO144. Describes phospholipids and fatty acid	C168. Explains phospholipids and general chemical structure of fatty acids
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO145. Describes phospholipids and fatty acid	C169. Differentiates between different types of fatty acid
	Nitrogen bases, nucleosides and nucleotides	LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO146. Compares different genetic materials	C170. Differentiates DNA and RNA; nucleosides and nucleotides
		LO14. Uses scientific conventions, symbols, and equations to represent various quantities, elements, and units	CLO147. Draws molecular structures with the help of symbols	C171. Draws the molecular structures of nitrogenous bases, nucleosides and nucleotides
	Primary and secondary metabolites	LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO148. Explains primary and secondary metabolites	C172. Explains and differentiates primary and secondary metabolites

	Biomacromolecules	LO4. Applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO149. Explains macromolecules and micro molecules	C173. Investigates the composition of macromolecules and micro molecules in living cells
	Structure of Polysaccharides	LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO150. Explains the structure of polysaccharides	C174. Differentiates between different types of polysaccharides based on structure and function
	Structure of DNA and RNA	LO7. Makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO151. Makes linkage between chemistry and structure of biomolecules	C175. Explains the structure of DNA
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO152. Illustrates the structure of DNA	C176. Draws the diagram of DNA showing its composition
	Structure of proteins	LO7. Makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO153. Makes linkage between chemistry and structure of biomolecules	C177. Explains the orientation and structural features of different protein structure with examples – primary, secondary, tertiary and quaternary structure
	Enzymes	LO3. Relates processes and phenomena with causes and effects	CLO154. Explains the features of biological enzymes and chemistry of enzymatic reactions	C178. Explains enzymatic reactions and the factors that affect the enzyme activity with examples
		LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO155. Explains cofactors in an enzyme and classify enzymes	C179. Explains enzymes and cofactor and classifies them based on their nature
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO156. Explains the mechanism of enzyme action	C180. Explains the concept of activation energy and nature of enzyme action

		LO13. Analyzes and interprets graphs and figures	CLO157. Draws and interprets graphs related with enzyme activity	C181. Draws and interprets graphs showing the concept of activation energy, effect of temperature and pH on enzyme activity
		LO12. Plans and conducts investigations and experiments to arrive at and verify the facts, principles, phenomena, or to seek answers to queries on their own	CLO158. Plans and conducts experiments to show enzyme activity	C182. Finds achromic point of salivary amylase enzyme and studies the effect of temperature and pH on enzyme activity
		LO11. Handles laboratory tools, and apparatuses, instruments and devices properly for performing activities/ experiments/ investigations	CLO159. Uses laboratory tools, and apparatuses and instruments to experiment with the activity of an enzyme	C183. Demonstrates the proper usage of thermometer, Bunsen burner etc. to investigate the effect of different temperatures / pH on the activity of salivary amylase on starch
		LO15. Draws conclusion on the basis of data collected in activities / experiments and investigatory projects conducted by them	CLO160. Collects data in a tabular format in the investigation for the activity of salivary amylase	C184. Create data table showing the time taken for colour change in a reaction (reaction time) by salivary amylase at different temperature and pH
		LO16. Communicates the findings and conclusions effectively	CLO161. Communicates the data about nature of enzyme activity to the class	C185. Presents the charts and graphs of collected data from the investigation of effects of pH and temperature on an enzyme
		LO3. Relates processes and phenomena with causes and effects	CLO162. Explains thermal stability	C186. Explains thermal stability in thermoplastic organisms

		LO17. Applies scientific concepts of Biology in daily life and solving problems	CLO163. Explains the application of mechanism of enzyme activity in daily life	C187. Explains how refrigeration increases the shelf-life of fruits and vegetables
		LO17. Applies scientific concepts of Biology in daily life and solving problems	CLO163. Explains the application of mechanism of enzyme activity in daily life	C188. Explains how competitive inhibitors are often used in control of bacterial pathogens
III: Cell: Structure and Functions 10. Cell Cycle and Cell Division	Cell cycle	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO164. Explains cell cycle and its different phases	C189. Explains the importance of cell division
		LO3. Relates processes and phenomena with causes and effects	CLO165. Describes the function of different cell different phases	C190. Co-relates and explains the different phases of cell cycle with their function and duration and represents it pictographically through pie chart
		LO4. Applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO166. Explains the terms used for various stages of cell division	C191. Explains the terms used for various stages of cell division
		LO7. Makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO167. Represents stages of cell division pictorially	C192. Represents stages of cell division pictorially
	M Phase	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO168. Explains the process of mitosis	C193. Explains the changes in the cell at each phase of mitosis
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO168. Explains the process of mitosis	C194. Explains the importance of mitosis and relates mitosis to types of growth patterns in living organisms

		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO169. Compares different processes of cytokinesis	C195. Differentiates cytokinesis in plant and animal cells
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO170. Illustrates the changes in cells in the different phases of the cell cycle	C196. Draws the events of the different stages of mitosis
	Meiosis	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO171. Explains meiosis in cells	C197. Explains changes in cells in the different phases of meiosis
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO171. Explains meiosis in cells	C198. Explains the importance of meiosis
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO172. Illustrates the meiosis in cells showing the changes in cells in the different phases	C199. Draws the events of the different stages of meiosis
	Mitosis and meiosis	LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO173. Differentiates between various stages of mitosis and meiosis	C200. Compares metaphase, anaphase and telophase of mitosis with meiosis 1 & 2
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO173. Differentiates between various stages of mitosis and meiosis	C201. Compares various substages of prophase 1 of meiosis
		LO19. Exhibits creativity in designing models using eco-friendly resources / preparing charts / paintings / sketching/ etc. on different topics	CLO174. Creates models depicting various stages of cell division	C202. Draws charts/prepares models depicting various stages of mitosis/meiosis
		LO12. Plans and conducts investigations and experiments to arrive at and verify the facts, principles, phenomena, or to seek answers to queries on their own	CLO175. Observes different stages of the mitosis through an experiment	C203. Conducts investigation to observe the features of chromosomes at different stages of mitosis of an onion root tip cells

		LO10. Prepares slides for study the structural intricacies of life forms and structural organisations	CLO176. Prepares temporary mount to show mitosis and observes permanent slides to study meiosis	C204. Prepares temporary mount of onion root tip cells to show mitosis and observes permanent slides to study meiosis
		LO15. Draws conclusion on the basis of data collected in activities / experiments and investigatory projects conducted by them	CLO177. Observes the cell division on the slides of cells	C205. Identifies correct stage of cell division after observing a given slide under microscope
		LO11. Handles laboratory tools, and apparatuses, instruments and devices properly for performing activities/ experiments/ investigations	CLO178. Handles microscope to study a mitotic and meiotic cell	C206. Uses microscope to observe temporary mount of onion root cell and to observe the stages of meiosis through permanent slides of grasshopper testis
		LO16. Communicates the findings and conclusions effectively	CLO179. Communicates features of different stages of a cell division after observing the stages in slides under microscope	C207. Represents and explains the characteristics of different phases of a cell division after correct identification of stages of cell division under microscope
IV: Plant Physiology 11. 12. 13. Photosynthesis in Higher Plants	Early Experiments of Photosynthesis	LO6. Describes contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines etc.	CLO180. Analyzes the observations made by scientists about photosynthesis	C208. Explains the observations made by the different scientists that led to the discovery of requirements for photosynthesis
	Chloroplasts and Light Reaction of Photosynthesis	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO181. Describes the role of chloroplast in photosynthesis	C209. Explains the relationship between the structure and different parts of chloroplasts and its function

		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO182. Describes the role of chloroplast in photosynthesis	C210. Describes the role of chloroplast pigments in light absorption in thylakoids
		LO13. Analyzes and interprets graphs and figures	CLO183. Draws and interprets graphs for the absorption spectrum and action spectrum for various wavelengths of light	C211. Interprets absorption and action spectrum graphs for various wavelengths of light to find out their role
		LO12. Plans and conducts investigations and experiments to arrive at and verify the facts, principles, phenomena, or to seek answers to queries on their own	CLO183. Plans and conducts experiments to study photosynthesis	C212. Plans and conducts experiment to show evolution of oxygen in photosynthesis
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO184. Explains light reactions in photosynthesis	C213. Explains process and parts involved in the light reactions of photosynthesis
	Electron Transport System	LO7. Makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO185. Describes the role of excitation of electron in light reaction	C214. Explains the mechanism of electron transport scheme in light reaction involving the excitation of electrons and its transfer to an accepter.
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO186. Compares different types of phosphorylation in photosynthesis	C215. Differentiates cyclic and non-cyclic phosphorylation in photosynthesis
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO187. Illustrates the flow of different types of phosphorylation	C216. Draws flow chart of the cyclic and non-cyclic photo-phosphorylation

	Chemiosmotic Hypothesis	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO188. Describes the mechanism of chemiosmotic hypothesis	C217. Describes how difference in proton gradient across a across membrane is linked to ATP synthesis
	Fate of ATP and NADPH produced in light phase	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO189. Explains the fate of ATP and NADPH produced in light phase of photosynthesis and describes the study by scientists for discovery of 5-carbon RuBP	C218. Describes the role of ATP and NADPH in the biosynthetic phase of photosynthesis to produce sugar from carbon dioxide with the help of flow charts
	Calvin cycle	LO14. Uses scientific conventions, symbols, and equations to represent various quantities, elements, and units	CLO190. Describes the process of the Calvin cycle	C219. Explains the Calvin pathway and calculates its energy currency
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO191. Illustrates Calvin cycle	C220. Draws flowchart of calvin cycle
	C_4 pathway	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO192. Explains the anatomy of C_4 plants and its pathway	C221. Describes the Kranz anatomy of the leaves of C_4 plants with the help of diagram and understands the significance of dimorphic chloroplast
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO192. Explains the anatomy of C_4 plants and its pathway	C222. Explains the process of Hatch and Slack Pathway cycle with illustrations
		LO3. Relates processes and phenomena with causes and effects	CLO193. Explains physiological adaptation in plants in a dry tropical region	C223. Gives reasons why C_4 pathway is seen in plants adapted to dry tropical regions

		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO194. Draws the pathway of C_4 cycle	C224. Draws the cyclic representation of C_4 cycle
	Photorespiration	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO195. Explains photorespiration	C225. Describes the process of photorespiration in plants
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO195. Compares C_3 and C_4 plants	C226. Differentiates C3 and C4 plants and their pathways
	Factors Affecting Photosynthesis	LO3. Relates processes and phenomena with causes and effects	CLO196. Explains the factors that affect photosynthesis	C227. Describes the internal factors that affect the rate of photosynthesis
		LO3. Relates processes and phenomena with causes and effects	CLO196. Explains the factors that affect photosynthesis	C228. Describes the external factors that affect the rate of photosynthesis in plants
		LO3. Relates processes and phenomena with causes and effects	CLO196. Explains the factors that affect photosynthesis	C229. States the Blackman's law of limiting factors
		LO3. Relates processes and phenomena with causes and effects	CLO196. Explains the factors that affect photosynthesis	C230. States that light intensity, carbon dioxide concentration, and temperature are examples of limiting factors for photosynthesis
		LO12. Plans and conducts investigations and experiments to arrive at and verify the facts, principles, phenomena, or to seek answers to queries on their own	CLO197. Plans and conducts experiments to study the factors affecting photosynthesis	C231. Plans and conducts experiments to study how light intensity, carbon dioxide concentration, and temperature affect photosynthesis
		LO13. Analyzes and interprets graphs and figures	CLO198. Analyzes and interprets graphs depicting the factors affecting the rate of photosynthesis	C232. Interprets and infers the graph showing the relationship between

				the factors affecting and the rate of photosynthesis in plants
		LO15. Draws conclusion on the basis of data collected in activities / experiments and investigatory projects conducted by them	CLO199. Evaluates how different factors affect photosynthesis	C233. Analyzes the results of various experiments about factors affecting photosynthesis
IV: Plant Physiology 14. Respiration in Plants	Breathing and Respiration in plants	LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO200. Differentiates photosynthesis and respiration	C234. Compares the role of photosynthesis and respiration in a plant
		LO4. Applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO201. Explains respiratory substrates and describes the energy generation by respiratory substrates	C235. Explains respiratory substrates and summarizes how in respiration oxidation of respiratory substrates generates energy in the form of ATP
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO202. Mentions the structures of breathing and respiration in plants	C236. Justifies that the plants also breathe and respirate
	Metabolic Pathways	LO3. Relates processes and phenomena with causes and effects	CLO203. Explains why metabolic pathways have many small reactions	C237. Justifies that the plants catabolize glucose in various smaller steps such that energy can be utilized by cells without liberated as heat
	Glycolysis	LO7. Makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO204. Describes the process of glycolysis	C238. Explains the reactions involved in glycolysis
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO205. Illustrates the process of glycolysis	C239. Draws the flow chart of glycolysis

		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO206. Analyses the production of energy in the process of glycolysis	C240. Explains ATPs produced in glycolysis with the help of flow charts
	Fermentation	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO207. Describes the process of anaerobic respiration	C241. Explains steps of different anaerobic respiration
	Krebs Cycle	LO7. Makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO208. Describes the process of Krebs cycle	C242. Explains the reaction of oxidative decarboxylation of pyruvate and reactions of Krebs cycle with the help of flow chart
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO208. Describes the process of Krebs cycle	C243. Explains ATPs produced in Krebs cycle using flow chart
	Electron Transport System	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO209. Describes the process of electron transport system	C244. Explains steps of electron transport system
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO209. Describes the process of electron transport system	C245. Explains ATPs produced in electron transport system
	Chemiosmotic Hypothesis	LO3. Relates processes and phenomena with causes and effects	CLO210. Explains the role of NAD and FAD in cellular respiration	C246. Explains the role of NAD and FAD in transferring hydrogen to carriers in the inner mitochondrial membrane.
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO211. Describes the process of Chemiosmotic Hypothesis	C247. Explains the phosphorylation of ADP through the proton gradient at the end of the electron transport

				system to generate energy with the help of diagrams
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO212. Draws the diagram of the process of ATP synthesis	C248. Relates and appreciates the structure of mitochondria with its role in ATP synthesis using diagrams
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO212. Describes the process of ATP synthesis	C249. States that ATP is synthesised in two ways: by the transfer of phosphate in substrate-linked reactions and by chemiosmosis in the membranes of mitochondria and chloroplasts
	The Respiratory Balance Sheet	LO14. Uses scientific conventions, symbols, and equations to represent various quantities, elements, and units	CLO213. Calculates the total ATP generated in metabolism of one glucose molecule in respiration	C250. Calculates the total net number of ATP is generated by respiration of one molecule of glucose in aerobic and anaerobic respiration
		LO15. Draws conclusion on the basis of data collected in activities / experiments and investigatory projects conducted by them	CLO214. Compares and evaluates the total ATP generated in aerobic and anaerobic respiration	C251. Evaluates and draws a conclusion about why the energy yield from respiration in aerobic conditions is much greater than the energy yield from respiration in anaerobic conditions
	Amphibolic Pathway	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO215. Explains amphibolic pathway	C252. Justifies why respiratory pathway is an amphibolic pathway rather than catabolic

	Respiratory Quotient	LO7. Makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO216. Calculates respiratory quotient to infer the calorific value of food	C253. Calculates respiratory quotient and justifies how the respiratory quotients of different nutrients—carbohydrates, protein, and fatty acid—varies
IV: Plant Physiology 15. Plant Growth and Development	Plant Growth	LO3. Relates processes and phenomena with causes and effects	CLO217. Explains the distinguish feature of plant growth	C254. Explains that plant growth is indeterminate and the role of meristem
	Phases of growth	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO218. Explains the different phases of growth	C255. Names and explains the phases of growth for a plant – Meristematic, Elongation, Maturation
	Growth Rates	LO7. Makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO219. Interpret graphical data and the symbolic expression of growth rates	C256. Explains arithmetic and geometric growth rate mathematically and in terms of cell division, expansion and differentiation
		LO7. Makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO220. Differentiates between absolute and growth rates	C257. Calculates surface area to differentiate between the absolute and relative growth rates of leaves in plants
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO221. Describes the conditions for plant growth	C258. Explains the conditions needed for plant growth
	Differentiation, Dedifferentiation And Redifferentiation	LO4. Applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO222. Explains differentiation, dedifferentiation, and redifferentiation in plants	C259. Explains the structural changes in a cell during differentiation, dedifferentiation and redifferentiation

	Plant Development	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO223. Explains the process of plant development	C260. Explains plant development and developmental plasticity with the help of examples
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO223. Explains the process of plant development	C261. Explains the intrinsic and extrinsic factors in plant growth and development
	Plant Growth Regulators	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO224. Classifies plant growth hormones in terms of their chemistry and function with examples	C262. Classifies plant growth hormones in terms of their chemistry and function with examples
		LO6. Describes contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines	CLO225. Recalls and explains the observations that led to the discoveries of various plant growth regulators	C263. Enlists and explains the observations that led to the discoveries of various plant growth regulators—auxin, gibberellic acid, kinetin, abscisic acid, and ethylene
		LO17. Applies scientific concepts of Biology in daily life and solving problems	CLO226. Explains the application of apical dominance	C264. Demonstrates the phenomenon of apical dominance and applies this scientific concept in daily life
		LO3. Relates processes and phenomena with causes and effects	CLO227. Explains the physiological effects of plant growth regulators	C265. Explains the general chemical nature role of different growth regulators—auxins, gibberellins, cytokinin, ethylene and abscisic acid—in plant growth
		LO18. Appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO228. Explains the application of plant growth regulators in agriculture	C266. Explains the application of synthetic auxins (IAA, IBA,

				NAA,2,4-D etc.) in agricultural and horticultural practices
V: Human Physiology 16. 17. Breathing and Exchange of Gases	Respiratory Organs	LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO229. Differentiates between respiratory systems across phyla	C267. Describes how respiratory organs of different groups of animals vary among depending mainly on their habitats and levels of organisation
	Human Respiratory System	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO230. Describes the structure and role of different parts of human respiratory system	C268. Explains the parts of human respiratory system
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO230. Describes the structure and role of different parts of human respiratory system.	C269. Describes the process of respiration
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO230. Describes the structure and role of different parts of human respiratory system	C270. Correlates the structure of the parts of human respiratory system to its functions
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO231. Draws a labelled diagram of human respiratory system	C271. Illustrates the parts of human respiratory system
	Mechanism of Breathing	LO3. Relates processes and phenomena with causes and effects	CLO232. Explains the process of breathing	C272. Illustrates the mechanism of inspiration and expiration by the coordinate movement of diaphragm and internal intercostals muscles
		LO7. Makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO233. Relates difference in pressure for explaining mechanism of breathing	C273. Relates pressure and volume to explain breathing mechanism
	Respiratory Volumes and Capacities	LO4. Applies scientific terminology for organisms, processes, and phenomena	CLO234. Describes respiratory volumes and capacities	C274. Defines the meaning of different respiratory volumes and capacities

		LO14. Uses scientific conventions, symbols, and equations to represent various quantities, elements, and units	CLO235. Describes SI units of respiratory volumes and capacities	C275. Gives the values of respiratory volumes and capacities in SI units
		LO13. Analyzes and interprets graphs and figures	CLO236. Analyzes and interprets the data of lung volumes from a device	C276. Analyzes of pneumotachographs generated by spirometer
	Exchange of Gases	LO14. Uses scientific conventions, symbols, and equations to represent various quantities, elements, and units	CLO237. Calculates the partial pressure of the respiratory gases in different important parts of the body and atmosphere	C277. Calculates the percentage of oxygen and carbon-dioxide saturations in different parts of the body (alveoli, blood, tissue) with respect to those in atmosphere as well as with respect to each other
		LO7. Makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO238. Explains the mechanism of transport of oxygen and carbon dioxide in the body	C278. Explains the transport of oxygen and carbon dioxide using the concept of partial pressure and solubility of gas
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO239. Explains the process of gas exchange in the lungs	C279. Relates the atmospheric pressure and partial pressure of gases (oxygen and carbon dioxide) in alveoli, blood, and tissue for proper gaseous exchange and transport
		LO3. Relates processes and phenomena with causes and effects	CLO240. Describes the structure of diffusion membrane in the lungs	C280. Describes the diffusion through three layers in diffusion membrane between alveolus with a pulmonary capillary
		LO3. Relates processes and phenomena with causes and effects	CLO241. Explains the factors affecting the rate of diffusion of respiratory gases	C281. Applies the factors which can affect the rate of diffusion of oxygen

				and carbon dioxide in the blood and body
		LO3. Relates processes and phenomena with causes and effects	CLO241. Explains the factors affecting the rate of diffusion of respiratory gases	C282. Predicts the effect on the rate of diffusion of oxygen and carbon dioxide in the blood and body due to the change in the factors
	Transport of Oxygen	LO3. Relates processes and phenomena with causes and effects	CLO242. Explains the role of haemoglobin	C283. Describes how haemoglobin binds to oxygen for transportation
		LO13. Analyzes and interprets graphs and figures	CLO243. Graphically represents the oxygen dissociation curve of haemoglobin in blood	C284. Plots oxygen dissociation curve by relating the percentage saturation of haemoglobin with oxygen against the partial pressure of oxygen
		LO3. Relates processes and phenomena with causes and effects	CLO244. Explains the effect of different factors on the binding of oxygen	C285. Analyzes the effect of the partial pressure of CO2, H+ concentration, temperature, etc. on binding and dissociation of O2 with haemoglobin using the oxygen dissociation curve
	Transport of Carbon dioxide	LO3. Relates processes and phenomena with causes and effects	CLO245. Describes the role of CO_2 in respiration	C286. Appreciates the role of carbon dioxide in the process of respiration
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO246. Explains the transport of CO_2 in blood	C287. Describes the mechanism of diffusion of carbon dioxide between lungs, body tissues and blood

	Regulation of Respiration	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO247. Describes the different factors involved in the regulation of respiration	C288. Explains the respiratory rhythm centre, chemo sensitive area and pneumotaxic center in the brain responsible for the regulation of respiration
		LO17. Applies scientific concepts of Biology in daily life and solving problems	CLO248. Infers different day-to-day activities that affect the regulation of respiration	C289. Identifies the real-life situation or variables in action and hypothesises the response of the respiratory center, chemo-sensitive area, and pneumotaxic area in the brain
		LO18. Appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO249. Describes artificial respiration	C290. Explains process and phenomena of artificial respiration
	Disorders of Respiratory System	LO3. Relates processes and phenomena with causes and effects	CLO251. Summarises the disorders associated with the respiratory system	C291. Explains the causes and symptoms of common disorders related with respiratory system
V: Human Physiology 18. Body Fluids and Circulation	Blood	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features	CLO252. Differentiates between the transport systems of different organisms	C292. Compares the system of transport of materials in simple organisms with that in complex organisms
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO253. Explains the components of human blood	C293. States different components of the blood—plasma and formed elements
	Plasma	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO254. Explains the components of human blood	C294. Describes roles of different constituents of blood plasma – proteins (fibrinogen, globulins and

				albumins), mineral ions and simple food molecules.
	Formed Elements	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO255. Explains the structure and function of formed substances	C295. Identifies and summarises the characteristics and role of RBC, WBC, and thrombocytes
		LO3. Relates processes and phenomena with causes and effects	CLO256. Predicts the conditions due to variations in the number of formed elements	C296. Evaluates the variation in formed elements in blood and predict the pathological conditions
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO257. Differentiates between the different types of WBC	C297. Compares the different types of WBC for their structure and function
	Blood Groups	LO3. Relates processes and phenomena with causes and effects	CLO258. Explains different ABO, Rh positive and negative blood group types and establishes blood donor compatibility	C298. Explains how different antigens and antibodies on RBC forms different blood groups along with Rh grouping and predicts outcomes of different combinations in blood transfusion/ reasons for erythroblastosis fetalis
		LO3. Relates processes and phenomena with causes and effects	CLO259. Explains different ABO, Rh positive, and Rh negative blood group types and establishes blood donor compatibility	C299. Predicts the suitability of blood groups for transfusion – as acceptor and donor
	Coagulation of Blood	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO260. Describes the mechanism of blood coagulation	C300. Describes the process of coagulation of blood showing the series of involved enzymatic

				reactions and appreciates the role of calcium ions
	Lymph	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO261. Describes the formation and role of lymph	C301. Explains the formation and role of lymph and its constituents to produce immune responses through lymphocytes and the distribution of fat
	Circulatory Pathways	LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO262. Analyzes the different types of circulatory system	C302. Classifies circulatory patterns into two types – open or closed – with examples and examines the anatomical comparison of two, three and four-chambered heart.
	Human Circulatory System	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO263. Describes the different parts of the human heart	C303. Illustrates and explains the structural features and roles of different parts of the human heart
		LO3. Relates processes and phenomena with causes and effects	CLO264. Describes the roles of walls of valves of human heart	C304. Explains the significance of thicker wall of ventricles and AV valves in human heart
		LO3. Relates processes and phenomena with causes and effects	CLO265. Infers the conditions arise due to deformities in the human heart	C305. Discusses cause and effect of deformity/malfunctioning of heart structures (deformed septum, hole in septum in atrial and/or ventricular region; pacemakers)
	Cardiac Cycle	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO266. Summarises the different stages of a cardiac cycle	C306. Defines scientific terminologies- systole, diastole, cardiac cycle, stroke volume, cardiac output, and

				explains the mechanism of different stages of the cardiac cycle
		LO13. Analyzes and interprets graphs and figures	CLO267. Analyzes and interprets the data regarding the cardiac cycle and volumes	C307. Analyzes data and predicts number of heart beats, duration of cardiac cycle, stroke volume, cardiac output
	Electrocardiograph	LO18. Appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO268. Describes the working of ECG	C308. Explains the representation of different stages of cardiac cycle with different waves in the presentation of a standard ECG
		LO18. Appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO269. Describes the role of pacemaker in heart	C309. Explains the role of a pacemaker to control the heartbeat.
	Double Circulation	LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO270. Differentiates veins and arteries	C310. Compares the types of blood vessels based on their structure and function
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO271. Explains the double circulatory pathway	C311. Describes how oxygenated and deoxygenated blood is circulated in the system to prevent mixing
	Regulation of Cardiac Activity	LO3. Relates processes and phenomena with causes and effects	CLO272. Describes the different factors that regulate the functioning of the human heart	C312. Explains the role of sympathetic, parasympathetic, and adrenal medullary hormones to regulate the heart's activity and cardiac output

	Disorders of Circulatory System	LO3. Relates processes and phenomena with causes and effects	CLO273. Enlists and analyzes the disorders caused by the circulatory system	C313. Explains the causes and symptoms of common disorders related with circulatory system
V: Human Physiology 19. Excretory Products and their Elimination	Human Excretory System	LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO274. Differentiates between the excretory systems of different organisms	C314. Compares the excretory organs and justifies the waste production in ammoniotelic, ureotelic, and uricotelic animals with examples
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO275. Describes the parts of human excretory system	C315. Explains the structure and function of a human kidney – Cortex and Medulla
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO275. Describes the parts of human excretory system	C316. Explains the structure of different parts of a nephron: Bowman's capsule, distal convoluted tubule, proximal convoluted tubule, Henle's loop, and collecting duct
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO276. Draws neat and labelled figure of human urinary system and associated structures	C317. Draws neat and labelled figures of the human urinary system and L.S. kidneys
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO276. Draws neat and labelled figure of human urinary system and associated structures	C318. Illustrates the structure of nephron, renal corpuscle, countercurrent system, urine formation, etc.
	Urine Formation	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO277. Explains the process of urine formation	C319. Describes the role of different stages of urine formation—glomerular filtration, reabsorption,

				and secretion—and parts of the nephron involved
	Function of PCT	LO3. Relates processes and phenomena with causes and effects	CLO278. Summarises the function and structure of PCT	C320. Explains the structural features of PCT responsible for reabsorption and secretion of electrolytes, liquids, and nutrients
	Function of Henle's Loop	LO3. Relates processes and phenomena with causes and effects	CLO279. Summarises the function and structure of Henle's loop	C321. Describes the structure and process in Henle's loop that maintains osmolarity of interstitial fluid
		LO13. Analyzes and interprets graphs and figures	CLO280. Analyzes and interprets graphs and figures related to the rate of urine formation	C322. Analyzes graphs/data on urine volumes in different regions of Henle's loop and calculates the glomerular filtration rate (% of reabsorption)
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO281. Describes the process that maintains the osmolarity in Henle's Loop and interstitial fluid	C323. Interprets movement of solutes/water to and from different regions based on osmolarity
	Function of DCT	LO3. Relates processes and phenomena with causes and effects	CLO282. Summarises the function and structure of DCT	C324. Explains the structural features of DCT responsible for reabsorption and secretion of electrolytes, liquids, and nutrients
	Function of Collecting Duct	LO3. Relates processes and phenomena with causes and effects	CLO283. Summarises the structure and function of collecting duct	C325. Describes the secretion and reabsorption by collecting duct that

				regulates the osmolarity of medullary interstitial fluid
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO284. Draws flow chart to show the movement of urine in the human excretory and urinary systems	C326. Represents flow of urine with the help of a flow chart
	Mechanism of Concentration of the Filtrate	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO285. Describes the mechanism to regulate the osmolarity of intestinal fluid	C327. Explains how the osmolarity gradient of interstitial fluid is maintained by the transport of substances between Henle's loop and vasa recta in counter current mechanism
	Regulation of Kidney Function	LO3. Relates processes and phenomena with causes and effects	CLO286. Summarises the different factors that regulate the function of the kidneys	C328. Explains how antidiuretic hormone, renin-angiotensin, and atrial natriuretic factor regulate blood flow and urine formation and its dependence on environmental factors such as water intake, temperature, etc.
	Micturition	LO3. Relates processes and phenomena with causes and effects	CLO287. Summarises how the release of urine from urinary bladder is regulated	C329. Explains the neural signals by CNS that regulates the release the urine from the urinary bladder
	Role of Other Organs in Excretion	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO288. Enlists other organs of the body involved in excretion of wastes	C330. Illustrates the different waste excreted by the organs other than kidneys – lungs, liver and skin

	Disorders of the Excretory System	LO3. Relates processes and phenomena with causes and effects	CLO289. Summarises the disorder associated with the excretory system	C331. Explains the causes and symptoms of common disorders related with excretory system
		LO3. Relates processes and phenomena with causes and effects	CLO290. Summarises the disorder - diabetes insipidus	C332. Explains the causes and symptoms of disorder- diabetes insipidus
		LO15. Draws conclusion on the basis of data collected in activities / experiments and investigatory projects conducted by them	CLO291. Draws conclusion on conditions based on the data from urine test	C333. Analyzes urine report to predict metabolic disorders
		LO18. Appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development,	CLO292. Explains dialysis	C334. Describes the mechanism of dialysis used to remove wastes from the blood
V: Human Physiology 20. Locomotion and Movement	Types of Movement	LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO293. Differentiates between the mechanisms of locomotion of different organisms	C335. Classifies movement into amoeboid, ciliary, and muscular based on the mechanism of locomotory organs
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO294. Differentiates between locomotion and movements	C336. Justifies that all locomotion are movements, but all movements are not locomotion
	Muscle	LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO295. Differentiates between different types of muscle	C337. Classifies muscles into skeletal, visceral, and cardiac based on the location, appearance, and nature of regulation of their activities

		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO296. Explains the structure and arrangement of muscle bundle and fibre	C338. Describes the structure and function of muscle bundles, muscle fibres and sarcomere in muscles
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO297. Draws labelled diagrams of types of muscles and their parts	C339. Illustrates the structure of different types of muscles, muscle bundle, fibre, sarcomere and contractile proteins
	Structure of Contractile Proteins	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO298. Describes the structure of contractile proteins	C340. Explains the structure of contractile proteins of muscle fibre– actin filament and myosin monomer
	Mechanism of Muscle Contraction	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO299. Describes the mechanism of muscle contraction	C341. Summarizes the mechanism of muscle contraction by the sliding of the thin filaments over the thick filaments using the sliding filament theory
		LO7. Makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO300. Explains the roles of proteins and ions in muscle contraction	C342. Explains the role of proteins and Ca^{2+} in the process of contraction and relation of muscles
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO301. Compares white and red fibres	C343. Differentiates between white and red fibres and their importance
	Skeletal System	LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO302. Compares bones and cartilage	C344. Differentiates between bone and cartilage based on constituents of their matrix

		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO303. Describes the parts of skeletal system	C345. Describes the different bones present in skull and their arrangement
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO303. Describes the parts of skeletal system	C346. Describes the different bones present in ribs and vertebral column and their arrangement
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO303. Describes the parts of skeletal system	C347. Describes the different bones present in pectoral girdle and pelvic girdle and their arrangement
		LO7. Makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO304. Explains the composition and function of bones and cartilages	C348. Relates the composition of the matrix of bones and cartilage with their structure and function
	Joints	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO305. Defines the function of joints	C349. Explains the role of bone joints
		LO7. Makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO306. Describes the mechanism of joint movements	C350. Relates the principles of physics to explain the movements in various kinds of joints
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO307. Differentiates between different types of joints	C351. Classifies fibrous, cartilaginous and synovial joints based on allowed types of motion and materials with examples
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO307. Differentiates between different types of joints	C352. Categorizes synovial joints into different kinds based on articulation with examples

	Disorders of Muscular and Skeletal System	LO3. Relates processes and phenomena with causes and effects	CLO308. Explains the disorder associated with the muscular system	C353. Explains the causes and symptoms of common disorders related to the muscular system
		LO3. Relates processes and phenomena with causes and effects	CLO309. Explains the disorder associated with the skeletal system	C354. Explains the causes and symptoms of common disorders relates with skeletal system
V: Human Physiology 21. Neural Control and Coordination	Neural System	LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO310. Differentiates between the nervous system of different organisms	C355. Describes how neural system of lower invertebrates like hydra vary from that of insects
	Human Neural System	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features	CLO311. Classifies the human nervous system	C356. Classifies human neural system into central (CNS) and peripheral neural system (PNS) based on information processing and control
	Neuron as Structural and Functional Unit of Neural System	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO312. Describes the structure and types of neurons	C357. Explains different parts of the structure of neurons
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO313. Illustrates the structure of neuron	C358. Draws neat and labelled figure of structure of neuron
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO314. Describes the structure and types of neurons	C359. Classifies neurons into multipolar, bipolar, and unipolar based on the number of axons and dendrites with examples and into myelinated and non-myelinated based on the presence and absence of the myelin sheath

		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO315. Describes the mechanism of propagation of a nerve impulse	C360. Explains the step-by-step mechanism of transmission of nerve impulse across a chemical synapse
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO316. Illustrates the process of impulse conduction	C361. Draws flow charts to explain the impulse conduction
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO317. Explains the roles of different neurotransmitters in nerve impulse	C362. Discusses different examples of chemical neurotransmitters and their function
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO318. Differentiates between different types of synapses	C363. Differentiates between chemical and electrical synapses
	Central Neural System	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO319. Describes different parts of the human nervous system	C364. Explains the different parts of CNS
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO319. Describes different parts of the human nervous system	C365. Explains the different parts of human brain
V: Human Physiology 22. Chemical Coordination and Integration	Endocrine Glands	LO3. Relates processes and phenomena with causes and effects	CLO320. Analyzes the relation between endocrine and neural system	C366. Explains how neural system and the endocrine system coordinate together to function
	Human Endocrine System and Hormones	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO321. Explains endocrine gland and hormones	C367. Defines key-terms like hormones; identifies position of endocrine glands, illustrates their structure and enumerates their features
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO322. Illustrates the location of different endocrine glands	C368. Draws figure to show the position of various endocrine glands

		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO323. Explains hypothalamus and its hormones	C369. Summarises the functions of hormones released by hypothalamus
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO324. Explains pituitary gland and its hormones	C370. Summarises the functions of hormones released by pituitary gland
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO325. Explains pineal gland and its hormones	C371. Summarises the functions of hormones released by pineal gland
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO326. Explains thyroid gland and its hormones	C372. Summarises the functions of hormones released by thyroid gland
		LO17. Applies scientific concepts of Biology in daily life and solving problems	CLO327. Explains the role of iodine in thyroid functioning	C373. Justifies the significance of iodine rich diet and its effect on thyroid gland
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO328. Explains parathyroid gland and its hormones	C374. Summarises the functions of hormones released by parathyroid gland
		LO3. Relates processes and phenomena with causes and effects	CLO329. Explains how hormones of thyroid and parathyroid gland together regulate calcium levels	C375. Discusses the interaction of TCT and PTH in regulating Ca^{2+} ions in the body
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO330. Explains thymus gland and its hormones	C376. Summarises the functions of hormones released by thymus
		LO3. Relates processes and phenomena with causes and effects	CLO331. Explains the role of thymus in ageing	C377. Relates thymus degeneration with less immunity in old age

		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO332. Explains adrenal gland and its hormones	C378. Summarises the functions of hormones released by adrenal gland
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO333. Illustrates the section of adrenal gland	C379. Draws diagrammatic representation of a section of adrenaline gland
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO334. Explains pancreas and its hormones	C380. Summarises the functions of hormones released by pancreas
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO335. Explains testis and ovaries and their hormones	C381. Summarises the functions of hormones released by testis and ovaries
		LO4. Applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO336. Uses scientific terminology related to hormonal imbalances and disorders	C382. Applies scientific terminology for various hormone-related disorders due to imbalance of hormones
		LO3. Relates processes and phenomena with causes and effects	CLO337. Predicts the effect of abnormal secretion of hormones	C383. Relates the hypo- and hyper-secretion of hormones to specific effects on the body
	Hormones of Heart, Kidney and Gastrointestinal Tract	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO338. Explains hormones secreted by some non-endocrine glands	C384. Explains the organs other than endocrine organ that releases hormones
	Mechanism of Hormone Action	LO3. Relates processes and phenomena with causes and effects	CLO339. Explains the mechanism of receptor action	C385. Describes the mechanism of hormone action involving formation of hormone-receptor complex.

		LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in more scientific and organized manner	CLO340. Classifies hormone on the basis of their chemical nature	C386. Classifies hormones based on their chemical nature – peptide hormones, steroid hormones, iodothyronines and amino acid derivative hormones.
		LO3. Relates processes and phenomena with causes and effects	CLO341. Explains different types of mechanism of hormone action	C387. Describes the mechanism of hydrophilic hormone action involving membrane receptors and secondary messengers.
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO342. Draws flow chart to explain mechanism of hormone action	C388. Depicts diagrammatically the mechanism of hormone action a) protein hormone b) steroid hormone

CLASS 12 CONTENT DOMAIN SPECIFIC LEARNING OUTCOMES AND INDICATORS

Table VII: Content domain specific learning outcomes and indicators – Class:12

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
VI: Reproduction 2. Sexual Reproduction in Flowering Plants	Stamen, Microsporangium, and Pollen Grain	LO4. explains efficiently systems, relationships, processes and phenomena	CLO1. Explains the structure of male reproductive part of the flower	C1. Illustrates a typical stamen, transverse section of an anther and structure of a microsporangium
		LO4. explains efficiently systems, relationships, processes and phenomena	CLO1. Explains the structure of male reproductive part of the flower	C2. Explains the structure of pollen of flower

		LO8. prepares slides for study the structural intricacies of life forms and structural organisations	CLO2. Prepares a slide to show the structure of pollen grain	C3. Examines the structure of pollen grain under the microscope
		LO4. explains efficiently systems, relationships, processes and phenomena	CLO3. Describes the process of microsporogenesis	C4. Outlines the process of microsporogenesis
		LO7. draws labelled diagrams, flow charts, concept maps, graphs	CLO4. Illustrates the structure of the anther, the sporangium, and the stages of microspore development	C5. Draws neat labelled diagram of transverse section of an anther, sporangium and stages of microspore development
		LO1. differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO5. Differentiates between pollen and microspore	C6. Differentiates between a microspore and a pollen grain
		LO4. explains efficiently systems, relationships, processes and phenomena	CLO6. Describes role of pollen	C7. Describes the process of pollen formation in flower and its importance for humans
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO7. Describes how pollens are used by athletes	C8. Explains the role of pollens as food/supplements for athletes
		LO2. relates processes and phenomena with causes and effects	CLO8. Explains the role of pollen grains as fossils	C9. Gives reasons why pollen grains can be preserved as fossils
		LO2. relates processes and phenomena with causes and effects	CLO9. Explains the allergies caused by pollen grain	C10. Applies the cause of asthma and bronchitis to pollen dehiscence and pollen release
		LO9. Plans and conducts investigations and experiments to arrive at and verify the facts, principles, phenomena, or to seek answers to queries on their own	CLO10. Studies the germination of pollen grains	C11. Plans and conducts an experiment to study pollen germination
		LO20. calculates using the data given	CLO11. Calculates the percentage of pollen grains germinated in the experiments conducted	C12. Calculates percentage of pollens germinated in the experiment conducted
	The Pistil, Megasporangium, and Embryo Sac Pollination	LO1. differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO12. Explains the structure of female reproductive part of the flower	C13. Explains the structure of pistil and ovule and differentiates between different types of carpels
		LO4. explains efficiently systems, relationships, processes and phenomena, such as	CLO13. Describes the process of megasporogenesis	C14. Illustrates the development of megaspores from the megaspores

		LO1. differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO14. Differentiates between pollen grain and embryo sac	C15. Compares between a pollen grain and mature embryo sac
		LO4. explains efficiently systems, relationships, processes and phenomena	CLO15. Describes role of pollination	C16. Explains and evaluates different types of pollination
		LO4. explains efficiently systems, relationships, processes and phenomena	CLO15. Describes role of pollination	C17. Summarises outbreeding devices and the pollen-pistil interaction after pollination
		LO2. relates processes and phenomena with causes and effects	CLO16. Analyzes differences between the seeds formed by xenogamy and geitonogamy	C18. Gives the reason why variations are seen in seeds formed by xenogamy and not from geitonogamy
		LO1. differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO17. Correlates the adaptation of flowers and floral parts to achieve pollination	C19. Understands and corelates the modified floral part to the agent of pollination
		LO3. applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO18. Applies scientific terminology to describe the pistil	C20. Applies scientific terminology to describe the pistil and other parts of the flower and embryonic development in plants
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO19. Explains the method of artificial hybridisation	C21. Defines emasculation and bagging in artificial hybridization
		LO4. Explains efficiently systems, relationships, processes and phenomena	CLO20. Summarises outbreeding devices	C22. Elaborates on inbuilt mechanism to prevent self-pollination and inbreeding depression
		LO7. draws labelled diagrams, flow charts, concept maps, graphs	CLO21. Draws labelled diagrams of reproductive parts of flowers	C23. Draws neat, labelled diagram of ovule, nucleate stages of embryo sac
		LO9. plans and conducts investigations and experiments to arrive at and verify the facts, principles, phenomena, or to seek answers to queries on their own	CLO22. Conducts experiment of dissecting a flower to study its pistil	C24. Dissects flower of hibiscus to study its pistil and observes under dissecting microscope
	Double Fertilization	LO4. explains efficiently systems, relationships, processes and phenomena	CLO23. Describes the process of double fertilisation	C25. Justifies that fertilization in flowering plants involves double fertilization and triple fusion

		LO13. draws conclusion on the basis of data collected in activities/ experiments and investigatory projects conducted by them	CLO24. Explains the process of porogamy and release of male gametes	C26. Confirms and proves that two male gametes produced from a single pollen grain is necessary for double fertilization
	Post-Fertilization: Structures and Events	LO4. explains efficiently systems, relationships, processes and phenomena	CLO25. Describes the process of embryo development	C27. Explains stages of embryo development in monocot and dicot and endosperm development
		LO4. explains efficiently systems, relationships, processes and phenomena	CLO26. Describes the characteristics of fruits and seed	C28. Explains the role and structure of seed and fruits
		LO1. differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO27. Distinguishes between different types and parts of fruits	C29. Differentiates between non-albuminous and albuminous seeds; perisperm and periderm; true fruit and false fruit
		LO7. draws labelled diagrams, flow charts, concept maps, graphs	CLO28. Illustrates of reproductive structures of flowers in the post-fertilization stages	C30. Draws neat, labelled diagram of stages of embryo development, structure of dicot and monocot embryo dicot seed, monocot seed and false fruits
	Apomixis and polyembryony	LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO29. Summarises the meaning and importance of apomixis and polyembryony	C31. Defines apomixis and polyembryony with examples
VI: Reproduction 3. Human Reproduction	The Male Reproductive System	LO4. explains efficiently systems, relationships, processes and phenomena	CLO30. Describes different parts of male reproductive system	C32. Enlists the names and explains the structure of different parts of the male reproductive system
		LO4. explains efficiently systems, relationships, processes and phenomena	CLO30. Describes different parts of male reproductive system	C33. Explains and corelates the parts of male reproductive system with their function
		LO7. draws labelled diagrams, flow charts, concept maps, graphs	CLO31. Illustrates different parts of male reproductive system	C34. Draws neat, labelled diagram of reproductive system of human male and observes the duct system of human male
	The Female Reproductive System	LO4. explains efficiently systems, relationships, processes and phenomena	CLO32. Describes different parts of female reproductive system	C35. Enlists the names, explains and correlates the functions of different parts of the female reproductive system

		LO7. draws labelled diagrams, flow charts, concept maps, graphs	CLO33. Illustrates different parts of female reproductive system	C36. Draws neat, labelled diagram of reproductive system of human female and observes the duct system of human female
	Gametogenesis	LO4. explains efficiently systems, relationships, processes and phenomena	CLO34. Summarises the process of gamete formation in males	C37. Describes and graphically represents the steps of gamete formation in males
		LO9. plans and conducts investigations and experiments to arrive at and verify the facts, principles, phenomena, or to seek answers to queries on their own	CLO35. Examines how the product of meiosis differs in human male and female	C38. Compares and contrasts between steps involved in form of sperm and ova
		LO4. explains efficiently systems, relationships, processes and phenomena	CLO36. Summarises the process of gamete formation in females	C39. Describes and graphically represents the steps of gamete formation in females
		LO1. differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO37. Compares the gamete formation in males and females	C40. Differentiates between spermatogenesis and oogenesis
		LO4. explains efficiently systems, relationships, processes and phenomena	CLO38. Describes the reproductive cycle in females	C41. Explains and predicts the different changes in the uterus during the different stages of menstrual cycle
		LO7. Makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO39. Describes the role of hormones of pituitary and ovarian hormones	C42. Describes and graphically represents the release of hormones during different stages of menstrual cycle.
		LO15. applies scientific concepts in daily life and solving problems	CLO40. Applies knowledge of the menstrual cycle for better reproductive health	C43. Lists how to maintain hygiene and sanitation during menstruation
		LO15. applies scientific concepts in daily life and solving problems	CLO40. Applies knowledge of the menstrual cycle for better reproductive health	C44. Clears myths associated with women not being allowed to offer prayers during menstruation
	Fertilization and Implantation	LO9. Plans and conducts investigations and experiments to arrive at and verify the facts, principles, phenomena, or to seek answers to queries on their own	CLO41. Identifies the growth of follicles at pre-puberty and post - puberty and during different phases of menstrual cycle	C45. Investigates at which stage of follicular development, is ovum released by differentiating between primary secondary and tertiary follicle
		LO9. Plans and conducts investigations and experiments to arrive at and verify	CLO41. Identifies the growth of follicles at pre-puberty and post -	C46. Distinguishes between Graafian follicle, Corpus luteum to

		the facts, principles, phenomena, or to seek answers to queries on their own	puberty and during different phases of menstrual cycle	investigate at which stage of follicular development, is ovum released
		LO4. Explains efficiently systems, relationships, processes and phenomena	CLO42. Explains the fertilization and placentation in humans	C47. Describes insemination and the step-by-step mechanism of fertilisation in human
		LO4. Explains efficiently systems, relationships, processes and phenomena	CLO42. Explains the fertilization and placentation in humans	C48. Illustrates the process of implantation
	Pregnancy and Embryonic Development	LO4. Explains efficiently systems, relationships, processes and phenomena	CLO43. Outlines the major developmental events at different times in pregnancy	C49. Describes the stages of development from embryo to foetus and enlists the changes in the hormonal profile of a pregnant female
		LO15. applies scientific concepts in daily life and solving problems	CLO44. Plans pregnancy with respect to menstrual cycle	C50. Applies knowledge of the menstrual cycle to plan pregnancy in adulthood
	Parturition and Lactation	LO4. Explains efficiently systems, relationships, processes and phenomena	CLO45. Describes the process of parturition and lactation	C51. Illustrates the mechanism of parturition and breast-feeding with the role of oxytocin
VI: Reproduction 4. Reproductive Health	Reproductive Health – Problems and Strategies	LO15. Applies scientific concepts in daily life and solving problems	CLO46. Summarises the problems and strategies to improve reproductive health	C52. Outlines how the government and different factors create awareness about reproductive and child health.
		LO15. Applies scientific concepts in daily life and solving problems	CLO46. Summarises the problems and strategies to improve reproductive health	C53. States and compares the indicators of improved reproductive health in a society
		LO15. Applies scientific concepts in daily life and solving problems	CLO47. Analyzes the importance of ban on amniocentesis	C54. Defines amniocentesis and justifies the statutory ban on amniocentesis for sex determination in India.
	Population Stabilization and Birth Control	LO15. Applies scientific concepts in daily life and solving problems	CLO48. Evaluates the need for and strategies for population control in India	C55. Explains the probable reasons for the high population growth in India.
		LO15. Applies scientific concepts in daily life and solving problems	CLO48. Evaluates the need for and strategies for population control in India	C56. Enlists the strategies for population control in India.
		LO4. Explains efficiently systems, relationships, processes and phenomena	CLO49. Explains different contraceptive methods	C57. States the features of an ideal contraceptive and justifies the

				benefits of contraceptive methods outweigh their side effects
		LO4. Explains efficiently systems, relationships, processes and phenomena	CLO49. Explains different contraceptive methods	C58. Describes the different kinds of natural contraceptive methods and barriers used for contraceptive with examples
		LO4. Explains efficiently systems, relationships, processes and phenomena	CLO49. Explains different contraceptive methods	C59. Outlines and differentiates the mode of action of IUDs, pills, injections, and implants
		LO4. Explains efficiently systems, relationships, processes and phenomena	CLO49. Explains different contraceptive methods	C60. Defines and illustrates the processes of tubectomy and vasectomy
		LO3. applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO50. Applies scientific terminology to various descriptions of various assisted reproductive technology	C61. Uses the scientific terms for assisted reproductive technology
	Medical Termination of Pregnancy (MTP)	LO3. Applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO51. Explains the Indian laws about Medical Termination of Pregnancy (MTP)	C62. Defines MTP or induced abortion and enlists the conditions under which MTP is legal and required and when it is not.
	Sexually Transmitted Infections (STIs)	LO2. Relates processes and phenomena with causes and effects	CLO52. Explains the causes of STDs and the measures to prevent it	C63. Describes causes, symptoms and prevention of sexually transmitted infections
		LO18. Exhibits ethics and values of honesty, objectivity, rational thinking and freedom from myth and superstitious beliefs while taking decisions, respect for life, etc.	CLO53. Summarises conscious behaviour among common people in their reproductive age to prevent the spread of disease	C64. Recognizes the importance of public conscious behaviour in the spread of sexually transmitted infections
	Infertility	LO4. Explains efficiently systems, relationships, processes and phenomena	CLO54. Describes the cause of infertility	C65. Enlists and summarises some reasons for infertility
		LO16. Appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO55. Explains different methods to help a couple in case of infertility	C66. Describes the different assisted reproductive technologies

		LO15. Applies scientific concepts in daily life and solving problems	CLO56. Differentiates different methods of IVF techniques to solve a problem	C67. Interprets and relates the type of assisted reproductive technique employed for different anomaly in infertile couple
VII: Genetic and Evolution 5. Principles of Inheritance and Variation	Mendel's law of Inheritance	LO5. Describes contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines	CLO57. Analyzes the observations and conclusions made by Mendel in the pea plant experiment	C68. Summarizes Mendel's experiments with the pea plant, covering the method, phenotypes, observation, and inference.
		LO5. Describes contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines	CLO58. Analyzes the graphical representation to find out probable genotype of offspring in genetic crosses, observing and concluding by making a punnets' square developed by Reginald. C. Punnett	C69. Schematically illustrates monohybrid, dihybrid, and test crosses by making a Punnett square
		LO6. Makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO59. Interprets and predicts the genotype and phenotype by analysing monohybrid and dihybrid cross and pedigree analysis	C70. Evaluates the genotype and phenotype of monohybrid and dihybrid cross
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO60. Compares different nature of protein expression by an allele	C71. Differentiates between dominance, incomplete dominance, and co-dominance with examples
		LO4. Explains efficiently systems, relationships, processes and phenomena	CLO61. Describes the nature of protein expression by an allele	C72. Describes how dominance occurs at the molecular (gene-enzyme) level
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO62. Compares chromosomes and genes	C73. Differentiates between chromosomes and genes based on structure and function
		LO7. draws labelled diagrams, flow charts, concept maps, graphs	CLO63. Draws monohybrid and dihybrid cross	C74. Draws monohybrid and dihybrid cross to show inheritance of genes in pea plants by mendelian principles
		LO9. plans and conducts investigations and experiments to arrive at and verify the facts, principles, phenomena, or to seek answers to queries on their own	CLO64. Plans and conducts experiments to demonstrate Mendel's law of inheritance	C75. Designs and conducts an experiment to study the monohybrid and dihybrid cross of inheritance

	Inheritance of Two Genes	LO5. Describes contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines	CLO65. Analyzes the observations and conclusions made in Morgan's experiment	C76. Explains the chromosomal theory of inheritance involving and independent segregation of chromosomes.
		LO4. Explains efficiently systems, relationships, processes and phenomena	CLO66. Explains the role of recombination in genetics	C77. Describes linkage and recombination using a cross.
		LO20. calculates using the data given	CLO67. Calculates the probability of genotypic inheritance and phenotypic expression	C78. Calculates the percentage of progeny of different types in the F2 generation to find out the pattern of inheritance, linkages, and recombination
	Polygenic traits	LO3. Applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions such a	CLO68. Describes the importance of polygenic traits	C79. Explains polygenic traits and how the effect of each allele adds to give polygenic traits with an example.
		LO9. Plans and conducts investigations and experiments to arrive at and verify the facts, principles, phenomena, or to seek answers to queries on their own	CLO69. Interprets alleles of multiple genes exhibiting a single phenotypic expression in a population	C80. Analyzes the population to observe the prevalence of polygenic traits
		LO13. draws conclusion on the basis of data collected in activities/ experiments and investigatory projects conducted by them	CLO70. Interprets the data of percentages of progeny of different traits in a cross	C81. Draws conclusion about the pattern of inheritance on the basis of data provided for F2 generation and parents
	Pleiotropy	LO3. Applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions such a	CLO71. Explains pleiotropy	C82. Describes pleiotropy with an example.
		LO2. Relates processes and phenomena with causes and effects	CLO72. Explains how single gene exhibits multiple phenotypic expression	C83. Examines the effect of genes towards different phenotypes
		LO15. applies scientific concepts in daily life and solving problems	CLO73. Applies the laws of inheritance to study types of traits	C84. Applies scientific concepts related with laws of inheritance to understand how recessive traits get expressed in F2 generation

	Sex Determination	LO5. Describes contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines	CLO74. Explains the observations made by Henkings about sex determination in insects	C85. Outlines Henkings's observation in insects
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO75. Differentiates the mechanism of sex determination in different organism	C86. Differentiates between sex determination between humans and birds and how sex determination is different between honeybees and other organisms
		LO18. Exhibits ethics and values of honesty, objectivity, rational thinking and freedom from myth and superstitious beliefs while taking decisions, respect for life	CLO76. Applies the concepts of sex determination to bust social myths	C87. Applies the concepts of sex determination to understand that women should not be blamed for the production of female children
		LO3. Applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO77. Illustrates with the help of flowchart and predict the probability of the sex of an individual in the progeny	C88. Interprets the sex of the progeny in birds, insects and humans
	Mutations	LO2. Relates processes and phenomena with causes and effects	CLO78. Explains mutation and their importance	C89. Elaborates on the role of mutation in inheritance
	Genetic Disorders	LO2. Relates processes and phenomena with causes and effects	CLO79. Describes genetic disorders and methods to study them	C90. Explains the causes of various genetic disorders
		LO4. Explains efficiently systems, relationships, processes and phenomena	CLO80. Analyzes mendelian disorders due to the presence or absence of one or more chromosomes	C91. Examines the pedigree chart and distinguishes between various mendelian disorders
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO81. Distinguishes between different types of genetic disorder	C92. Compares Mendelian disorders and chromosomal disorders
		LO3. Applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO82. Differentiates between Klinefelter's syndrome and Turners syndrome	C93. Examines the karyotype and distinguishes Klinefelter's syndrome and Turners syndrome

		LO2. Relates processes and phenomena with causes and effects	CLO83. Analyzes mendelian disorders with the help of pedigree charts	C94. Uses pedigree to study inheritance and transmission of mendelian disorders
		LO11. Analyzes and interprets graphs and figures	CLO83. Analyzes mendelian disorders with the help of pedigree charts	C95. Examines the pedigree chart and distinguishes between various mendelian disorders autosomal/sex chromosomal disorder, dominant or recessive etc.
VII: Genetic and Evolution 6. Molecular Basis of Inheritance	The DNA	LO6. Makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO84. Describes the salient features of the DNA double helix	C96. Explains the structure of DNA and summarises the observations that led to discovery of double helix structure of DNA
		LO7. Draws labelled diagrams, flow charts, concept maps, graphs	CLO85. Illustrates the structure of DNA	C97. Draws the figure of DNA, showing its structure
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO86. Compares DNA and RNA	C98. Differentiates between the structure of DNA and RNA; euchromatin and heterochromatin
		LO6. Makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts such as	CLO87. Analyzes the variation in base number pair of DNA helix in different organisms	C99. States the number of base pairs in some organisms (bacteriophage phi, bacteriophage lambda, E. coli, humans)
		LO4. Explains efficiently systems, relationships, processes and phenomena	CLO88. Describes the structure of nucleosomes and packing of DNA into chromosome	C100. Summarizes structure of nucleosomes and how a long nucleotide chain is observed as chromosomes in eukaryotes
		LO7. Draws labelled diagrams, flow charts, concept maps, graphs	CLO89. Illustrates the structure of nucleosomes	C101. Creates a neat and labelled figure highlighting the structure of nucleosomes
	The Search for Genetic Material	LO5. Describes contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines etc	CLO90. Explains the characteristic of genetic material and the experiments and observations made by various scientist to discover them	C102. Summarizes the methods, observation, and inferences for experiments performed by Frederick Griffith, by Avery, MacLeod, McCarty, and by Hershey and Chase
	Replication	LO5. Describes contribution of scientists/researchers all over the world in systematic evolution of concepts,	CLO91. Explains the characteristic of genetic material and the experiments and	C103. Summarizes the method, observation, and inferences of the

		scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines	observations made by various scientist to discover them	experiments performed by Matthew Meselson and Franklin Stahl
		LO4. Explains efficiently systems, relationships, processes and phenomena	CLO92. Explains the mechanism of replication of DNA and its importance	C104. Describes semiconservative in the step-by-step mechanism of DNA replication
	Transcription	LO4. Explains efficiently systems, relationships, processes and phenomena	CLO93. Explains the mechanism of transcription	C105. Schematically illustrates a transcription unit and the process by which the information in a strand of DNA is copied into a new molecule of messenger RNA (mRNA)
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO94. Differentiates between transcription in eukaryotes and prokaryotes	C106. Differentiates between eukaryotes and prokaryotes with respect to RNA polymerases and mRNA formation
	Genetic Code	LO12. Uses scientific conventions, symbols, and equations to represent various quantities	CLO95. Determines the features of the genetic code and its importance	C107. States the salient features of the genetic code and converts between amino acid sequence and nucleotide sequence using the codons table
		LO6. Makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO96. Applies mathematical principles in forming genetic codes	C108. Applies the principles of permutation and combination to find 64 codons for amino acids
	Translation	LO4. Explains efficiently systems, relationships, processes and phenomena	CLO97. Explains the process of translation	C109. Explains and illustrates the structure of t-RNA and the step-by-step process of translation
	Regulation of Gene Expression	LO4. Explains efficiently systems, relationships, processes and phenomena	CLO98. Describes the mechanism and importance of regulation of gene expression	C110. Describes the lac operon, its negative regulation, and the effect of lactose or allolactose, defining activator and repressor proteins, operator sequences, and operons
	Human Genome Project	LO4. Explains efficiently systems, relationships, processes and phenomena,	CLO99. Explains the purpose and process of the Human Genome Project	C111. Summarizes the methodology and the major findings of the human genome project
	DNA fingerprinting	LO16. Appreciates technological applications and processes in Biology	CLO100. Explains DNA fingerprinting	C112. Describes the principle underlying DNA fingerprinting

		towards the improvement in the quality of life and sustainable development		using VNTRs, the steps involved, and its importance
VII: Genetic and Evolution 7. Evolution	Origin of Life	LO4. Explains efficiently systems, relationships, processes and phenomena,	CLO101. Explains the big bang theory	C113. Explains the Big Bang theory and formation of atmosphere on earth in brief
		LO5. Describes contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines	CLO102. Explains biogenesis and the experiments done by scientists to support its theory	C114. Describes the observations and conclusion made by Pasteur about generation of life on earth
		LO5. Describes contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines	CLO102. Explains biogenesis and the experiments done by scientists to support its theory	C115. Explains observations and conclusion of Miller's experiment and why it led to the acceptance of chemical evolution
	Evolution of Life Forms – A theory	LO5. Describes contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines	CLO103. Describes the observations and conclusions about the origin of life made by Darwin	C116. Explains natural selection based on the conclusions made by Charles Darwin
	Evidence for Evolution	LO2. Relates processes and phenomena with causes and effects	CLO104. Describes the evidence used to study evolution	C117. Explains fossils, embryological support, and paleontological evidence of evolution
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO105. Differentiates between divergent and convergent evolution	C118. Describes divergent and convergent evolution and homologous and analogous structures with examples
		LO4. Explains efficiently systems, relationships, processes and phenomena	CLO106. Explains evolution by anthropogenic action	C119. Describes evolution by anthropogenic action with the help of examples
		LO4. Explains efficiently systems, relationships, processes and phenomena	CLO107. Explains natural selection with examples	C120. Explains evolution as a stochastic and determined process with the example of dark-winged and white winged moths

	Adaptive Radiation	LO4. explains efficiently systems, relationships, processes and phenomena	CLO108. Describes adaptive radiation with examples	C121. Explains adaptive radiation and convergent evolution using Darwin's finches and marsupials in Australia
	Biological Evolution	LO5. describes contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines	CLO109. Explains how origin of life is dependent on life span	C122. Explains how rate of appearance of new forms is dependent on life span with examples
		LO5. describes contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines	CLO110. Describes the theory of origin of life proposed by Lamarck about origin of life with evidence	C123. Outlines the theory proposed by Lamarck and how it differed from Darwin's theory
	Mechanism of Evolution	LO5. describes contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines	CLO111. Describes the theory of origin of life proposed by Hugo DeVries about origin of life with evidence	C124. Describes saltation proposed by Hugo DeVries and how it differed from Darwin's conclusions
	Hardy-Weinberg Principle	LO6. makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO112. Uses probability to predict the frequency of an allele in a population	C125. Explains Hardy-Weinberg principle and genetic equilibrium in algebraic terms.
		LO2. relates processes and phenomena with causes and effects	CLO113. Analyzes the factors that affect the genetic equilibrium	C126. Explains gene migration, gene flow, and genetic drift can affect the genetic equilibrium
		LO7. Draws labelled diagrams, flow charts, concept maps, graphs	CLO114. Represents the operation of natural selection on different traits	C127. Interprets the graph as stabilizing, directional and disruptive selection
	A Brief Account of Evolution	LO4. explains efficiently systems, relationships, processes and phenomena,	CLO115. Describes the evolution of life on earth	C128. Traces evolution from single-celled organisms (2000 Mya) to dinosaurs (200 Mya)
	Origin and Evolution of Man	LO4. explains efficiently systems, relationships, processes and phenomena	CLO116. Traces the timeline and features of evolution of human	C129. Explains a characteristic feature and timelines of Ramapithecus, Dryopithecus, Australopithecus,

				Homo habilis, Home erectus, Neanderthal man, and Homo sapiens
VIII: Biology in Human Welfare 8. Human Health and Disease	Health	LO4. explains efficiently systems, relationships, processes and phenomena	CLO117. Define health, disease, and immunity	C130. Explains meaning of health and diseases stating factors that affect health and ways to maintain general health
	Common Diseases in Humans	LO4. explains efficiently systems, relationships, processes and phenomena	CLO118. Describes different common pathogenic infection	C131. Summarises the causes, major symptoms, spread and control measures of various pathogenic diseases
		LO4. explains efficiently systems, relationships, processes and phenomena	CLO119. Explains the lifecycle of plasmodium	C132. Describes the life cycle of the malarial parasite with a diagram
	Immunity	LO4. explains efficiently systems, relationships, processes and phenomena	CLO120. Describes features of different types of immunity	C133. Describes the barriers involved in innate immunity.
		LO4. explains efficiently systems, relationships, processes and phenomena	CLO120. Describes features of different types of immunity	C134. Elaborates on the salient features of acquired immunity: specificity, structure of antibodies, primary and secondary immune responses, memory, and humoral and cell-mediated immunity.
		LO1. differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO120. Describes features of different types of immunity	C135. Compares acquired and innate immunity with examples of active and passive immunity
		LO1. differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO121. Explains immunization using vaccination	C136. Explains the different kinds of vaccination based on the molecules introduced in the body.
		LO2. relates processes and phenomena with causes and effects	CLO122. Explains immune memory	C137. Identifies “immune memory” to be the basis of vaccination and immunisation
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO123. Analyses the role of vaccination in humankind	C138. Appreciates technological applications and process in biology towards improvement in quality of life by the technique of vaccination
		LO2. relates processes and phenomena with causes and effects	CLO124. Explains allergy	C139. Describes the cause, symptoms and control measures of allergy

		LO4. explains efficiently systems, relationships, processes and phenomena	CLO125. Explains auto-immunity	C140. Correlates the occurrence of autoimmune diseases to immune cells attacking "self" with example such as rheumatoid arthritis
		LO4. explains efficiently systems, relationships, processes and phenomena	CLO126. Describes lymphoid system and its role	C141. Describes the role of lymphoid organs in immunity
	AIDS	LO3. applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO127. Describe the cause, diagnostic test, and preventive measure of AIDS	C142. Summarizes the causative agent, mode of transfer, susceptible population, diagnostic test, secondary infections, and treatment of HIV.
	Cancer	LO2. relates processes and phenomena with causes and effects	CLO128. Summarizes the causes, detection and diagnosis, and treatment of cancer	C143. Summarises the cause of cancer and its diagnosis
		LO2. relates processes and phenomena with causes and effects	CLO128. Summarizes the causes, detection and diagnosis, and treatment of cancer	C144. Explains the features of different cancerous tumour and the treatments available
	Drugs and Alcohol Abuse	LO4. explains efficiently systems, relationships, processes and phenomena	CLO129. Describes drug and alcohol addiction	C145. Differentiates between the source, action and effect of different drugs
		LO4. explains efficiently systems, relationships, processes and phenomena	CLO129. Describes drug and alcohol addiction	C146. Explains the effects of drug abuse and addiction and its preventive measures
		LO15. applies scientific concepts in daily life and solving problems	CLO130. Spreads the awareness for drugs and alcohol abuse	C147. Applies the awareness about the drug and alcohol abuse for prevention of such habits in young adults
VIII: Biology in Human Welfare 9. 10. Microbes in Human Welfare	Microbes in Household Products	LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO131. Determines the microbes involved in fermentation at home	C148. Explains the usefulness of lactic acid bacteria to humans for curd
	Microbes in Industries	LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO132. Explains the method of beverage production	C149. Explains how different types of alcoholic beverages are produced although the same organism is involved
		LO5. describes contribution of scientists/researchers all over the world	CLO133. Describes how antibiotics discovered	C150. Explains how Alexander Fleming discovered penicillin

		in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines		
		LO2. relates processes and phenomena with causes and effects	CLO134. Summarises antibiotics for treating bacterial diseases	C151. Describes antibiotics and explain how it works
		LO3. applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO135. Enlists the diseases cured by antibiotics	C152. Names some diseases treated with antibiotics
		LO15. applies scientific concepts in daily life and solving problems	CLO136. Classifies antibiotics and justifies their advantages and disadvantages	C153. Enlists the judicious use of antibiotics
		LO15. applies scientific concepts in daily life and solving problems	CLO136. Classifies antibiotics and justifies their advantages and disadvantages	C154. Enlists the basic classification of antibiotics
		LO15. applies scientific concepts in daily life and solving problems	CLO136. Classifies antibiotics and justifies their advantages and disadvantages	C155. Explains the disadvantages of antibiotics
		LO15. applies scientific concepts in daily life and solving problems	CLO136. Classifies antibiotics and justifies their advantages and disadvantages	C156. Describes use and misuse of antibiotics in treatment of diseases for human
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO137. Enlists the uses of different microbes for various purposes	C157. Enlists some chemicals, enzymes, and bioactive molecules produced by microbes and the producing microbes
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO137. Enlists the uses of different microbes for various purposes	C158. States the uses of lipases, pectinases, proteases, streptokinase, cyclosporine A, and statins
		LO3. applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO138. Describes BOD	C159. Explains biochemical oxygen demand or BOD
		LO11. analyzes and interprets graphs and figures	CLO139. Understands the role of BOD in studying pollution	C160. Analyzes and interprets data of BOD of water samples to know their pollution level

		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO139. Understands the role of BOD in studying pollution	C161. Uses the BOD of water samples to spread awareness about the prevention of water pollution at the source
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO140. Describes sewage treatment	C162. Describes sewage treatment—primary and secondary treatment
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO140. Describes sewage treatment	C163. Summarises the role of sewage treatment plants for humankind
		LO18. exhibits ethics and values of honesty, objectivity, rational thinking and freedom from myth and superstitious beliefs while taking decisions, respect for life, etc.	CLO141. Spreads awareness about drinkable and undrinkable water	C164. Spreads awareness about why we should not drink water from borewell or handpump directly
	Microbes in Production of Biogas	LO4. explains efficiently systems, relationships, processes and phenomena	CLO142. Describes the method and usage of biogas production with involved microbe	C165. Describes the role of methanogen in biogas production and the structure and functioning of a biogas plant with diagram
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO143. Reasons the importance of biogas to humankind	C166. Justifies the use of biogas as compared to burning of wood as fuel in villages
	Microbes as Biocontrol Agents	LO1. differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO144. Differentiates between control of pests in organic and conventional farming	C167. Compares the strategy for control of pests in organic and conventional farming
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO145. Justifies the importance of biocontrol agents in modern farming	C168. Evaluates the need for Biocontrol agents in modern farming
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO145. Justifies the importance of biocontrol agents in modern farming	C169. Justifies how Bioherbicides helps in reduction of weeds in cropland

		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO146. Determines the role of microbes in pest control with examples	C170. Explains how Bacillus thuringiensis and baculoviruses helps in pest control a biocontrol agent
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO146. Determines the role of microbes in pest control with examples	C171. Explains how Integrated Pest Management helps in reducing agro-chemical pollution
	Microbes as Biofertilizers	LO2. relates processes and phenomena with causes and effects	CLO147. Describes biofertilizers and their importance	C172. Describes examples of bacteria (symbiotic and free living), fungus (symbiotic), and autotrophs that act as biofertilizers
		LO1. differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO148. Explains methods of farming	C173. Differentiates between organic and conventional farming based on usage of biofertilizers
		LO1. differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO148. Explains methods of farming	C174. Differentiates between manure and biofertilizers based on their role in agriculture
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO149. Summarises the uses of microbes for humans	C175. Justifies how microbes are both good and bad for health
IX: Biotechnology 11. Biotechnology: Principles and Processes	Biotechnology	LO3. applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO150. Defines Biotechnology	C176. Defines biotechnology based on the definition given by European Federation of Biotechnology (EFB) and two core techniques of modern biotechnology
		LO5. Describes contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines etc	CLO151. Explores the contributions of scientists in the field of biotechnology	C177. Explains how the contribution made by various scientists helped to develop the field of biotechnology
	Principles of Biotechnology	LO6. makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO152. Describes the basis of genetic engineering	C178. Explains the principle of genetic engineering

		LO6. makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO152. Describes the basis of genetic engineering	C179. Mentions the basic techniques of genetic engineering
		LO6. makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO152. Describes the basis of genetic engineering	C180. Describes the method of gene cloning and transfer
		LO6. makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO152. Describes the basis of genetic engineering	C181. Describes the role of DNA replication in genetic engineering
		LO5. describes contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines etc.	CLO153. Explains the contribution of researchers to discovering recombinant DNA	C182. Explains the discovery of the first recombinant DNA
		LO6. makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO154. Explains the steps of genetic modification	C183. Summarizes the three basic steps of genetic modification of an organism
	Tools of Recombinant DNA Technology	LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO155. Describes the tools used in genetic engineering	C184. Enumerates the tools of rDNA
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO156. Explains the use and functioning of restriction enzymes in rDNA technology	C185. Describes in detail the naming and functioning of restriction enzymes for the cutting of DNA at a specific location
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO156. Explains the use and functioning of restriction enzymes in rDNA technology	C186. Describes restriction enzymes and its functioning
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO156. Explains the use and functioning of restriction enzymes in rDNA technology	C187. Differentiates between sticky and blunt ends and analyzes the significance of sticky ends
		LO16. appreciates technological applications and processes in Biology	CLO156. Explains the use and functioning of restriction enzymes in rDNA technology	C188. Compares and contrasts the roles of these enzymes (molecular

		towards the improvement in the quality of life and sustainable development		scissors and molecular glue) during cell division
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO156. Explains the use and functioning of restriction enzymes in rDNA technology	C189. Describes the functioning of DNA ligase in producing recombinant DNA
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO157. Summarises the use of gel electrophoresis in rDNA technology	C190. Describes the uses of gel electrophoresis in producing recombinant DNA
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO157. Summarises the use of gel electrophoresis in rDNA technology	C191. Describes and explains how gel electrophoresis is used to separate desired DNA fragments of different lengths
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO158. Describes the role of cloning vectors in rDNA technology	C192. Enlists the features of cloning vectors used in recombinant DNA
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO158. Describes the role of cloning vectors in rDNA technology	C193. Analyses/Discusses the role of bacteria in biotechnology and genetic engineering
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO159. Summarises the ways to identify transformants	C194. Explains methods to identify transformants
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO159. Summarises the ways to identify transformants	C195. Emphasises the role of selectable markers in identifying transformants
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO160. Describes the methods to make cells competent	C196. Describes the process to make cells competent

		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO160. Describes the methods to make cells competent	C197. Explains the need for a competent host and the methods to introduce it into the host
	Processes of Recombinant DNA Technology	LO4. explains efficiently systems, relationships, processes and phenomena	CLO161. Summarises the steps of the process of recombinant DNA technology	C198. Explains the process of isolation of the genetic material (DNA) in its pure form, cutting of DNA at specific locations, and electrophoresis
		LO4. explains efficiently systems, relationships, processes and phenomena	CLO162. Explains the role of PCR in the process of recombinant DNA technology	C199. Illustrates and explains the steps involved in the polymerase chain reaction (PCR) to clone and amplify DNA, including the role of Taq polymerase
		LO15. applies scientific concepts in daily life and solving problems	CLO163. Calculates the number of molecules of DNA produced from one double-stranded starting molecule, after a given number of cycles in a PCR	C200. Applies the concept of PCR in daily life with reasoning while making decisions and solving problems. For example, the three stages of PCR are repeated n times, giving 2n copies of the original
		LO4. explains efficiently systems, relationships, processes and phenomena	CLO164. Describes the role of downstream processing in the process of recombinant DNA technology	C201. Illustrates and describes the structure and functioning of the commonly used bioreactors and their use in producing desired protein from recombinants
		LO4. explains efficiently systems, relationships, processes and phenomena	CLO164. Describes the role of downstream processing in the process of recombinant DNA technology	C202. Explains the steps and the need for downstream processing
		LO2. relates processes and phenomena with causes and effects	CLO165. Summarises the use of bioreactors to ensure proper culture of recombinants	C203. Familiarises with parts and functions of bioreactors and deduces the cause and effect of unsuccessful culture
IX: Biotechnology	Biotechnological Applications in Agriculture	LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO166. Describes the importance of genetically modified organisms (GMO)	C204. Defines GMO and discusses its advantages and disadvantages.

12. Biotechnology and its Applications		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO167. Explains the application of biotechnology	C205. Enlists the critical research areas of biotechnology
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO168. Describes the application of biotechnology to increase the yield in agriculture	C206. Previews the biotechnological applications in agriculture
		LO15. applies scientific concepts in daily life and solving problems	CLO168. Describes the application of biotechnology to increase the yield in agriculture	C207. Justifies that genetic engineering may help to solve the global demand for food by improving the quality and productivity of farmed animals and crop plants, using the examples
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO168. Describes the application of biotechnology to increase the yield in agriculture	C208. Summarises the process and need for producing transgenic Bt cotton
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO168. Describes the application of biotechnology to increase the yield in agriculture	C209. Explains the generation of pest resistant tobacco plants using iRNA
	Biotechnological Applications in Medicine	LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO169. Describes the application of biotechnology to manufacture medicines	C210. Summarises the method of producing recombinant insulin
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO169. Describes the application of biotechnology to manufacture medicines	C211. Outlines how genetic diseases can be treated with gene therapy, using the example of severe combined immunodeficiency (SCID)
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO169. Describes the application of biotechnology to manufacture medicines	C212. Explains the process and importance of gene therapy

		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO169. Describes the application of biotechnology to manufacture medicines	C213. Describes the usage of biotechnological methods for molecular diagnosis of diseases
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO169. Describes the application of biotechnology to manufacture medicines	C214. Analyzes and interprets the results of banding from gel electrophoresis, autoradiography and ELISA diagnostic test
		LO5. describes contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines etc.	CLO170. Describe discovery of stem cell technology	C215. Explains the discovery of different types of stem cells and their applications
		LO15. applies scientific concepts in daily life and solving problems	CLO171. Summarises the importance of stem cell technology in medicine	C216. Outlines the advantages of genetic screening, using the examples of breast cancer (BRCA1 and BRCA2), Huntington's disease, and cystic fibrosis
		LO15. applies scientific concepts in daily life and solving problems	CLO171. Summarises the importance of stem cell technology in medicine	C217. Outlines the advantages of using recombinant human proteins to treat disease, using the examples of insulin, clotting factor VIII, and adenosine deaminase
		LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO172. Describes the tools for the application of biotechnology	C218. Emphasises on identifying biotechnological tools and principles employed in creating various GM resources for medical and agricultural advancements
	Transgenic Animals	LO16. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO173. Explains the importance of transgenic animals	C219. Explains transgenic animals and justifies how their production benefits human with examples
	Ethical Issues Regarding Transgenic Animals	LO18. exhibits ethics and values of honesty, objectivity, rational thinking and freedom from myth and superstitious	CLO174. Evaluates the ethical question regarding genetic modification of organisms	C220. Analyzes the serious ethical questions raised about manipulation of microbes, plants, and animals with examples

		beliefs while taking decisions, respect for life, etc		
		LO18. exhibits ethics and values of honesty, objectivity, rational thinking and freedom from myth and superstitious beliefs while taking decisions, respect for life, etc.	CLO175. Analyses the risk with the procedures and protocols for sanctioning GM drugs	C221. Empathises with the causalities associated with clinical trials on humans and animals
		LO18. exhibits ethics and values of honesty, objectivity, rational thinking and freedom from myth and superstitious beliefs while taking decisions, respect for life, etc.	CLO175. Analyses the risk with the procedures and protocols for sanctioning GM drugs	C222. Understands that all therapeutic approaches are not successful; analyzes the risk involved
		LO4. explains efficiently systems, relationships, processes and phenomena	CLO176. Describes the importance of the ethical committee for transgenic animals in India	C223. Describes the role of the Genetic Engineering Approval Committee (GEAC) in India with specific examples of Basmati crop
		LO4. explains efficiently systems, relationships, processes and phenomena	CLO177. Evaluates the role of biopiracy and bio-patent	C224. Explains the meaning of Biopiracy
		LO4. explains efficiently systems, relationships, processes and phenomena	CLO177. Evaluates the role of biopiracy and bio-patent	C225. Explains and discusses bio-patent and biopiracy with reference to safe guarding traditional indigenous knowledge
X: Ecology 13. Organisms and Populations	Attributes of Population	LO3. applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO178. Defines population and calculates its attributes	C226. Explains the different attributes of the population—sex ratio, birth rates, and death rates; studies using pyramid and density estimation
		LO10. handles laboratory/ agricultural tools, and apparatuses, instruments and devices properly for performing activities/ experiments/ investigations	CLO178. Defines population and calculates its attributes	C227. Conducts an investigation of the difference in species composition in the different quadrats in the school garden
		LO20. calculates using the data given	CLO178. Defines population and calculates its attributes	C228. Calculates the population density and population frequency of species found in the quadrats of the experiment
		LO11. analyzes and interprets graphs and figures	CLO179. Interprets data into graphs to show variation in population density and frequency	C229. Prepares graph to show the variations in population density and

				population frequency in different quadrats of the experiment
		LO7. draws labelled diagrams, flow charts, concept maps, graphs	CLO180. Represents age pyramid	C230. Draws age pyramids for the human population
		LO11. analyzes and interprets graphs and figures	CLO181. Interprets age pyramid	C231. Draws conclusion about the growth of population-rowing stable or declining on the basis of shape of age pyramid
	Population Growth	LO6. makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO182. Analyzes population growth	C232. Summarises the factors that influence population density
		LO2. relates processes and phenomena with causes and effects	CLO183. Analyzes the factors affecting population growth	C233. Compares and contrasts the factors affecting the population density in a developed country and a developing country
		LO11. analyzes and interprets graphs and figures	CLO184. Presents the data of population density of different countries in the form of graphs/pie	C234. Gives interpretations of population density in developed and developing countries in the form of graphs/pie charts, and figures
		LO6. makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO185. Studies different growth models	C235. Describes exponential and logistics growth model
		LO11. analyzes and interprets graphs and figures	CLO186. Studies population growth curve	C236. Interprets the graphical representation of growth curve
		LO9. plans and conducts investigations and experiments to arrive at and verify the facts, principles, phenomena, or to seek answers to queries on their own	CLO187. Plans an experiment to study the population growth	C237. Conducts an investigation of the effects of limited resources (food, space) on population growth a culture of yeast cells
		LO11. analyzes and interprets graphs and figures	CLO188. Makes a graph to represent data from the experiment of population growth	C238. Makes a graph of the yeast population (measured as the total mass of yeast cells, tabulated below) versus time using the collected from the yeast culture
		LO15. applies scientific concepts in daily life and solving problems	CLO189. Calculates carrying capacity (K) from an experiment	C239. Estimates the carrying capacity of population growth of yeast culture in the investigation

		LO14. communicates the findings and conclusions effectively	CLO190. Communicates the results of yeast population growth experiment	C240. Presents the conclusions and data collected from the investigation of population growth of yeast culture in front of peer groups
	Life History Variation	LO2. relates processes and phenomena with causes and effects	CLO191. Evaluates the role of Darwinian fitness	C241. Explains the importance of Darwinian fitness with examples
	Population Interactions	LO4. explains efficiently systems, relationships, processes and phenomena	CLO192. Explains different types of population interaction	C242. Describes different population interactions—predation, competition, parasitism, commensalism, and mutualism—with examples
		LO9. plans and conducts investigations and experiments to arrive at and verify the facts, principles, phenomena, or to seek answers to queries on their own	CLO193. Investigates the different types of population interactions found in a community	C243. Conducts research in pairs/ groups in the school campus / surroundings to observe and record at least ten different types of population interactions found in a community
		LO19. applies/ makes efforts to conserve environment realizing the interdependency and inter-relationship in the biotic and abiotic factors of environment	CLO194. Applies the concept of different population interactions in daily life and solves problems relating to conservation	C244. Carefully analyses the population interactions of the samples in the research and makes effort to conserve organism
		LO18. exhibits ethics and values of honesty, objectivity, rational thinking and freedom from myth and superstitious beliefs while taking decisions, respect for life, etc.	CLO195. Interprets the data collected from the experiment of population interactions with evidence	C245. Interprets the population interactions of the samples using evidence from the research
		LO5. describes contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines etc.	CLO196. Applies that fitness of one species is influenced by presence of other species	C246. Interprets laboratory experiments conducted by ecologists like Gause-competitive exclusion principle and Connell's elegant field experiments
		LO14. communicates the findings and conclusions effectively	CLO197. Communicates the conclusions of the experiment about population interactions	C247. Provides a presentation of the different interactions found in the surroundings to the peer group

		LO1. differentiates organisms, phenomena and processes based on certain characteristics and salient features,	CLO198. Compares different types of population interaction	C248. Differentiates between different population interaction
X: Ecology 14. Ecosystem	Ecosystem–Structure and Function	LO19. applies/ makes efforts to conserve environment realizing the interdependency and inter-relationship in the biotic and abiotic factors of environment	CLO199. Defines ecosystem	C249. Explains ecosystem, its components, and stratification
		LO19. applies/ makes efforts to conserve environment realizing the interdependency and inter-relationship in the biotic and abiotic factors of environment	CLO200. Explains vertical stratification of a forest	C250. Explains the different levels of vertical stratification
		LO7. Draws labelled diagrams, flow charts, concept maps, graphs	CLO201. Illustrates stratification in a tropical forest	C251. Describes vertical stratification in tropical rain forest as Amazon Rain Forest
		LO4. explains efficiently systems, relationships, processes and phenomena	CLO202. Explains the function of ecosystem	C252. Describes the function of an ecosystem – Productivity, Decomposition, Energy flow and Nutrient cycling
	Productivity	LO4. explains efficiently systems, relationships, processes and phenomena	CLO203. Explains productivity in terms of an ecosystem	C253. Explains primary and secondary productivity
		LO20 calculates using the data given	CLO204. Calculates primary and secondary productivity of an ecosystem	C254. Calculates primary and secondary productivity of an ecosystem using given data
		LO20 calculates using the data given	CLO205. Calculates gross and net primary productivity	C255. Explains and calculates gross and net primary productivity
		LO15. applies scientific concepts in daily life and solving problems	CLO206. Compares productivity of different ecosystems	C256. Analyzes the productivity of different ecosystem
	Decomposition	LO4. explains efficiently systems, relationships, processes and phenomena	CLO207. Describes the importance and process of decomposition	C257. Explains the different important steps in the process of decomposition and the factors affecting it
		LO15. applies scientific concepts in daily life and solving problems	CLO208. Observes the steps of decomposition process in nature	C258. Studies the different steps of decomposition process by the help

				of a simple experiment using fallen leaves
		LO7. draws labelled diagrams, flow charts, concept maps, graphs	CLO209. Illustrates the process of decomposition	C259. Explains decomposition process in a terrestrial system diagrammatically
	Energy Flow	LO4. explains efficiently systems, relationships, processes and phenomena	CLO210. Illustrates energy flow in an ecosystem	C260. Explains the energy flow in an ecosystem through food chain and food web
		LO1. differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO211. Differentiates between grazing food chain (GFC) and detritus food chain (DFC)	C261. Explains grazing food chain (GFC) and detritus food chain (DFC) with examples
		LO7. draws labelled diagrams, flow charts, concept maps, graphs	CLO212. Illustrates the flow chart of different types of food chain	C262. Draws flow chart to illustrate the grazing food chain (GFC) and the detritus food chain (DFC)
	Ecological Pyramids	LO1. differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO213. Describes ecological pyramids	C263. Compares and analyzes different types of ecological pyramids
		LO19. applies/ makes efforts to conserve environment realizing the interdependency and inter-relationship in the biotic and abiotic factors of environment	CLO214. Creates awareness about the conservation of organisms, keeping their trophic levels in mind	C264. Makes conscious efforts to conserve organisms of all trophic levels for balance in ecosystem
		LO20. calculates using the data given	CLO215. Calculates the energy of different trophic levels of an ecological pyramid	C265. Calculates energy available for all trophic levels as per the energy available at the first trophic level
		LO7. draws labelled diagrams, flow charts, concept maps, graphs	CLO216. Illustrates different ecological pyramid	C266. Draws ecological pyramid of number, biomass, and energy
		LO11. analyzes and interprets graphs and figures	CLO217. Draws conclusion from different ecological pyramid	C267. Analyses ecological pyramid on the basis of shape and draws conclusion about its stability
		LO7 draws labelled diagrams, flow charts, concept maps, graphs	CLO218. Understands ecological balance and inverted pyramids	C268. Collects data and prepares pyramids figures of the population data of a developed and developing countries
		LO21 applies learning to hypothetical situations	CLO219. Analyses the pyramids of a developed country and a developing country	C269. Compares and contrasts the age pyramids in hypothetical data for a

				developed country and a developing country
		LO9. plans and conducts investigations and experiments to arrive at and verify the facts, principles, phenomena, or to seek answers to queries on their own	CLO220. Investigates the factors affecting the human population growth	C270. Conducts research to evaluate the factors that affect the population growth of the respective human population
		LO15. applies scientific concepts in daily life and solving problems	CLO221. Provides real-life evidence of how the human population is affected	C271. Concludes with examples using the interpretation of the research about how different factors affecting human population
		LO14. communicates the findings and conclusions effectively	CLO222. Communicates the conclusions of the investigation of how factors affect human population growth	C272. Gives a presentation of an investigation of the factors affecting the human population to the peer group
X: Ecology 15. Biodiversity and Conservation	Biodiversity	LO4. explains efficiently systems, relationships, processes and phenomena	CLO223. Describes biodiversity	C273. Explains biodiversity and its significance
		LO4. explains efficiently systems, relationships, processes and phenomena	CLO223. Describes biodiversity	C274. Explains biodiversity at different levels—genetic, species, and ecological diversity
	Biodiversity on Earth and India	LO13. draws conclusion on the basis of data collected in activities/ experiments and investigatory projects	CLO224. Make inferences about biodiversity using data	C275. Describes the richness of animals and plants in India using statistical data
		LO13. draws conclusion on the basis of data collected in activities/ experiments and investigatory projects	CLO224. Make inferences about biodiversity using data	C276. Reads data and justifies that a large fraction of species faces the threat of becoming extinct
	Patterns of Biodiversity	LO4. explains efficiently systems, relationships, processes and phenomena	CLO225. Describes the pattern of biodiversity	C277. Explains the patterns of biodiversity due to latitudinal gradients with examples
		LO4. explains efficiently systems, relationships, processes and phenomena	CLO225. Describes the pattern of biodiversity	C278. Summarises the relation between species richness with an area in a region using equation of Z value by Alexander von Humboldt
	Importance of Species Diversity to the Ecosystem	LO4. explains efficiently systems, relationships, processes and phenomena	CLO226. Justifies the importance of species diversity	C279. Describes rivet popper hypothesis by Paul Ehrlich and observation made by David Tilman's in long-term ecosystem

				experiments to explain the importance of species diversity
	Loss of biodiversity	LO19. applies/ makes efforts to conserve environment realizing the interdependency and inter-relationship in the biotic and abiotic factors of environment	CLO227. Describes the loss of biodiversity	C280. Determines the evidence of species extinction
		LO9. plans and conducts investigations and experiments to arrive at and verify the facts, principles, phenomena, or to seek answers to queries on their own	CLO228. Conducts an investigation to study the invasion species in the locality	C281. Prepares a list of invasive or alien species in the area that are threatening and competing for resources with the native species
		LO15. applies scientific concepts in daily life and solving problems	CLO229. Justifies solutions to solve the problem of the invasion of alien species in the locality	C282. Provides possible solutions to solve the problem of invasion of alien species in the locality
		LO2. relates processes and phenomena with causes and effects	CLO230. Describes the causes of biodiversity loss	C283. Enlists the causes of biodiversity loss
		LO9 Plans and conducts investigations and experiments to arrive at and verify the facts, principles and phenomenon to seek answers to queries on their own	CLO231. Envisions ways and means to prevent the loss of biodiversity	C284. Identifies the species threatened and endangered in the local area and investigates possible measures to prevent the decline of species richness in the ecosystem
		LO18. exhibits ethics and values of honesty, objectivity, rational thinking and freedom from myth and superstitious beliefs while taking decisions, respect for life, etc.	CLO231. Envisions ways and means to prevent the loss of biodiversity	C285. Gives ethical arguments for the conservation of biodiversity and conducts plantation drives of endangered species
	Biodiversity Conservation	LO19. applies/ makes efforts to conserve environment realizing the interdependency and inter-relationship in the biotic and abiotic factors of environment	CLO232. Argues to justify the conservation of biodiversity	C286. Justifies the need to conserve biodiversity using narrowly, broadly utilitarian and ethical arguments with examples
	Ways to conserve the biodiversity	LO19. applies/ makes efforts to conserve environment realizing the interdependency and inter-relationship in	CLO233. Summarises different approaches to conserving biodiversity	C287. Describes the in-situ and ex-situ approach to conserve the biodiversity with examples

		the biotic and abiotic factors of environment		
		LO19. applies/ makes efforts to conserve environment realizing the interdependency and inter-relationship in the biotic and abiotic factors of environment	CLO233. Summarises different approaches to conserving biodiversity	C288. Explains endemism and hotspots with examples
		LO19. applies/ makes efforts to conserve environment realizing the interdependency and inter-relationship in the biotic and abiotic factors of environment	CLO233. Summarises different approaches to conserving biodiversity	C289. Explains the role of 'The Earth Summit' in reducing the rate of biodiversity loss
		LO3. applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO234. Uses scientific terms related to in-situ and ex-situ conservation	C290. Applies scientific terminology to describe terms such as in-situ and ex-situ conservation
		LO9. plans and conducts investigations and experiments to arrive at and verify the facts, principles, phenomena, or to seek answers to queries on their own	CLO235. Investigates the cause of the loss of endemic species in India	C291. Enlists the scientific names of the species endemic to India and investigates how these are threatened due to anthropogenic activities
		LO13. draws conclusion on the basis of data collected in activities/ experiments and investigatory projects conducted by them	CLO236. Suggests solutions to save the endemic species of India based on data collected	C292. Provides solutions to preserve the rich diversity of the species endemic to India
		LO14. communicates the findings and conclusions effectively	CLO237. Communicates the conclusions to the ways to save the endemic species of India	C293. Presents the solutions to saving the endemic species of India to the peer group
		LO13. draws conclusion on the basis of data collected in activities/ experiments and investigatory projects conducted by them	CLO238. Collects information about national and international environmental policies	C294. Finds out the recent amendments in the environmental policies of India and major international policies to preserve our biodiversity and global environmental issues
		LO14. communicates the findings and conclusions effectively	CLO239. Presents the information about national and international environmental policies	C295. Provides the findings about important amendments in the environmental policies of India and

				major international policies in the form of a presentation to the peer group
		LO15. applies scientific concepts in daily life and solving problems	CLO340. Creates a novel environmental policy to prevent biodiversity loss	C296. Designs an environmental policy (in groups or partners) for the country in light of recent extinctions of species and the "Evil Quartet" leading to their loss
		LO18. exhibits ethics and values of honesty, objectivity, rational thinking and freedom from myth and superstitious beliefs while taking decisions, respect for life, etc.	CLO341. Argues that a certain environmental policy is useful or not with logic	C297. Justifies that the proposed environmental policy to prevent biodiversity loss is beneficial for the country

8. SAMPLE PEDAGOGICAL PROCESSES AND ASSESSMENT STRATEGIES

NCERT higher secondary stage learning outcomes document provides a common set of pedagogical processes for each subject. Keeping these as guidelines, specific pedagogical processes and assessment strategies for a topic from one chapter each from classes 11 and 12 have been developed as suggestions and are shared in this section. These instances of pedagogical process and assessment strategies should enable teachers to derive principles for making the alignment between learning outcomes, pedagogical practices and assessment in their classrooms and to use these for creating their lesson plans. The key principles considered while designing the pedagogical processes and assessment strategies are the following:

1. Keeping learner at the centre
    - Since new knowledge is built over existing knowledge, both pedagogy and assessment should focus on students' pre-requisite knowledge, skills, attitudes, and beliefs that they bring in classroom setting.
    - Constructivist approaches to learning with the student being at the centre of the learning process as an active constructor of knowledge must be emphasized.
    - Since students effectively learn by doing, classroom processes should involve activities, analysis and discussions. Systematic experimentation as a tool to discover/verify theoretical principles must be included.
2. Focusing on learning outcomes
    - Learning outcomes indicate what a student will be able to do at the end of an instruction unit by precisely breaking down broad goals of Biology education (apply reasoning to develop conceptual understanding, develop process skills and experimental, observational, manipulative, decision-making and investigatory skills, etc.) to more measurable and observable behaviour for each class.
    - Students learn better when the method of teaching, learning activities and assessment strategies are all aligned well to the learning outcomes. Pedagogical processes and assessment strategies should be aligned to both content domains and cognitive skills as mentioned in this document earlier.
3. Making effective use of assessments
    - Assessment should be viewed as an integral part of pedagogy, and it should focus on giving timely individualized feedback to students. Quality formative assessment

> "The pedagogical practices should be learner centric. It is expected of a teacher to ensure an atmosphere for students to feel free to ask questions. They would promote active learning among students with a focus on reflections, connecting with the world around them, creating and constructing knowledge. The role of a teacher should be that of a facilitator who would encourage collaborative learning and development of multiple skills through the generous use of resources via diverse approaches for transacting the curriculum." [CBSE Curriculum for classes 11-12]

    should be designed as it helps to modulate students' understanding of their own learning and helps teachers adapt their pedagogy based on students' actual learning.
    - Multiple modes of assessment including portfolios, project work, presentations, written and oral assignments should be used to reflect individual capacities of a student.
4. Creating a social and inclusive learning environment

- Cooperative and peer-supported teaching learning activities should be used to empower students to take charge of their own learning.
- Peer assessment involving students assessing work of their peers against set assessment criteria should be used.

Specific pedagogical processes should be used in the classroom that would help those students who may face learning difficulties including language, visual-spatial, or mixed processing problems

SUGGESTED PEDAGOGICAL PROCESSES AND ASSESSMENT STRATEGIES FOR CLASS 11
Content Domain: Enzymes
Chapter 10: Biomolecules

Table VIII: Suggested Pedagogical Processes and Assessment Strategies – Class:11

Learning outcomes	Indicators	Pedagogical Processes	Assessment Strategies
LO3. Relates processes and phenomena with causes and effects	C178. Explains enzymatic reactions and the factors that affect the enzyme activity with examples	• Create a 3-D model of the tertiary structure of an enzyme with an active site and substrate using waste materials. • Demonstrate the lock-and-key using the created model. • Select and use appropriate devices for understanding of structural intricacies of enzymes.	• Assess if students apply that since most enzymes are proteins, they have secondary and primary structures. • Ask questions to students to infer the nature of active sites on enzymes.
		• Design and carry out activities/experiment/investigations to find the answer to their queries: Study the effect of three different temperatures and three different pH on the activity of salivary amylase on starch. • Instruct students note the change in colour after adding iodine in the activity of salivary amylase on starch at different temperatures. • Instruct students note the change in colour after adding iodine in the activity	• Assess the understanding of students about variables and constants in each experiment. • Ask: What should we do to include a positive control condition to confirm enzyme activity? • Ask them: What happened to the rate of reaction (intensity of colour change) at different temperatures? What did you observe about the activity of

		of salivary amylase on starch at different pH.	salivary amylase at different pH? • Ask them to infer the effect of temperature and pH on enzyme activity?
		• Design and carry out activities/experiment/investigations to find the answer to their queries Instruct students note the change in colour after adding iodine in the activity of salivary amylase on starch at three different concentrations of starch.	• Ask: What should we have for positive control condition to confirm enzyme activity in this experiment? • Ask them: What happened to the enzymatic activity (intensity of colour after adding iodine) at different concentrations of substrate? • Ask them to infer the effect of increased level of substrate on the enzyme activity.
		• Present their observations through different graphs showing effect salivary amylase activity due to change in pH, temperature and concentration of substrate	• Ask questions such as what you infer from the curve of each graph. • Remind students that most enzymes are made up of protein, the justify the effect on enzyme activity due to change in these parameters. • Encourage them to infer the optimum temperature, pH and concentration of substrate when the activity salivary amylase was maximum. • Instruct them to find the value of Vmax for the curve of substrate concentration and

			enzyme activity. Ask: What do you think is the significance of Vmax? • Ask questions to students regarding the impact of duplicate key/ compound similar to substrate of enzyme action with reason

SUGGESTED PEDAGOGICAL PROCESSES AND ASSESSMENT STRATEGIES FOR CLASS 12

Content Domain: Process of Recombinant DNA
Chapter 11: Biotechnology: Principles and Processes

Table IX: Suggested Pedagogical Processes and Assessment Strategies – Class:12

Learning outcomes	Indicators	Pedagogical Processes	Assessment Strategies
LO4. explains efficiently systems, relationships, processes and phenomena	C198. Explains the process of isolation of the genetic material (DNA) in its pure form, cutting of DNA at specific locations, and electrophoresis	• Draw flow charts of different steps of the process of Recombinant DNA technology. Instruct them to analyze the importance that the steps are in proper sequence.	• Encourage students to justify the order of steps of recombinant DNA. • Ask: What would happen if host cells were not competent before the recombinant DNA is transferred into them?
		• Design and carry out activities/experiment/investigations: Isolate DNA from available plant material such as spinach, green pea seeds, papaya, etc. Students will conduct the experiments in groups and will note their observations.	• Ask questions about the observations made the experiment: What chemical is used to break the cell wall of the plant cells? • What is the role of alcohol (ethanol) in extracting the DNA from the lysed cell?

			• How can the DNA be separated from cell proteins from the lysed cells? • Will DNA suspend in water or alcohol?
		• Collect information from books, e-books, magazines, journals, libraries, internet, etc., to appreciate the efforts of scientists made over time to discover the restriction enzymes and discuss it with the class. • Encourage students to realize how restriction enzymes know where to make the cut in DNA.	• Ask questions such as: If the vector DNA is cut *Hind III* restriction enzyme, can you use *EcoRI* restriction enzyme to cut the target DNA? • Why is important to use the same restriction enzyme on vector and target DNA?

9. TEST PAPER DESIGN

CLASS 12

Table X: Test Paper Design and chapter-wise mark distribution – Class:12

Content domain	Marks distribution
VI. Reproduction	14-18
VII. Genetics and Evolution	18-22
VIII.Biology and Human Welfare	10-14
IX. Biotechnology and its Applications	10-14
X. Ecology and Environment	8-12
Total	**70**

Table XI: Test Paper Design and question-type mark distribution – Class:12

Question type	Number of questions	Marks distribution

Single correct answer	12	12
Assertion-Reasoning type question	4	4
Case-based questions	2	8
Short answer type questions	5	10
Long answer I type questions	7	21
Long answer II type questions	3	15

Table XII: Test Paper Design and cognitive domain-wise mark distribution – Class:12

Cognitive domain	Marks distribution
Remember and Understand	33-37
Apply	19-23
Analyze, Evaluate and Create	12-16
Total	**70**

Other details of the test paper:

- Maximum marks: 70
- Duration of the test: 3 Hours
- Time for reading question paper: 15 minutes

10. ASSESSMENT OF PRACTICAL/PROJECT WORK

A key component of the Biology curriculum for classes 11-12 is practical work related to the concepts and principles covered in the content domains. Along with discovering or verifying results covered in the curriculum, students are also expected to acquire and practise process skills related to science. The learning outcomes for the curriculum as listed in chapter 5, include the following 5 learning outcomes which are especially relevant for practical work in Biology.

LO10. Prepares slides for study the structural intricacies of life forms and structural organisations, such as, transverse sections of root, stem and leaves, mitosis and meiosis; pollen germination, etc.

LO11. Handles laboratory tools, and apparatuses, instruments and devices properly for performing activities/ experiments/ investigations such as; uses foldscope/microscope for observing internal structure of transverse section of root, stem and leaves, intricacies of chloroplasts, stomata, etc.; digital balance/scale for weighing chemicals; pipette for drawing liquid, etc.

LO12. Plans and conducts investigations and experiments to arrive at and verify the facts, principles, phenomena, or to seek answers to queries on their own, such as, what is the pattern and structure of organisms in nature? Does Pisum sativum carry bisexual and zygomorphic flowers, how do plants grow in length? Do plants breath? What does (mainly which gas) our breath contains?, What happens to cooked rice when we chew and when we do not chew? etc.

LO16. Communicates the findings and conclusions effectively, such as, those derived from experiments, activities, and projects both in oral and written form using appropriate figures, tables, graphs, and digital forms, takes part in the discussions, argumentations etc.

LO20. Exhibits ethics and values of honesty, objectivity, rational thinking and freedom from myth and superstitious beliefs while taking decisions, such as, reports and records experimental data accurately, reveals respect for life by using weed plant for investigatory studies/ activities, etc.,

DESIGN OF THE PROJECT/PRACTICAL BASED ACTIVITIES

Students are expected to conduct experiments, do project-based activities, etc throughout the course of 2 years.

Table XIII. Distribution of marks for the projects/ppt/practical

Activity	Distribution of marks
One Major Experiment Part A	5
One Minor Experiment Part A	4
Slide Preparation Part A	5
Spotting Part B	7

Practical Record + Viva Voce	4
Investigatory Project and its Project Record + Viva Voce	5
Total	**30**

SUGGESTED PROJECTS/ACTIVITIES/PRACTICAL – CLASS 11

Part A: List of Experiments

1. Study and describe locally available common flowering plants, from family Solanaceae (Poaceae, Asteraceae or Brassicaceae can be substituted in case of particular geographical location) including dissection and display of floral whorls, anther and ovary to show number of chambers (floral formulae and floral diagrams), type of root (tap and adventitious); type of stem (herbaceous and woody); leaf (arrangement, shape, venation, simple and compound).
2. Preparation and study of T.S. of dicot and monocot roots and stems (primary).
3. Study of osmosis by potato osmometer.
4. Study of plasmolysis in epidermal peels (e.g., Rhoeo/lily leaves or flashy scale leaves of onion bulb).
5. Study of distribution of stomata on the upper and lower surfaces of leaves.
6. Comparative study of the rates of transpiration in the upper and lower surfaces of leaves.
7. Test for the presence of sugar, starch, proteins and fats in suitable plant and animal materials.
8. Separation of plant pigments through paper chromatography.
9. Study of the rate of respiration in flower buds/leaf tissue and germinating seeds.
10. Test for presence of urea in urine.
11. Test for presence of sugar in urine.
12. Test for presence of albumin in urine.
13. Test for presence of bile salts in urine.

Part B: Careful observation of the following (spotting):

1. Parts of a compound microscope.
2. Specimens/slides/models and identification with reasons - Bacteria, *Oscillatoria, Spirogyra, Rhizopus*, mushroom, yeast, liverwort, moss, fern, pine, one monocotyledonous plant, one dicotyledonous plant and one lichen.
3. Virtual specimens/slides/models and identifying features of - *Amoeba, Hydra,* liverfluke, *Ascaris*, leech, earthworm, prawn, silkworm, honey bee, snail, starfish, shark, rohu, frog, lizard, pigeon and rabbit.
4. Mitosis in onion root tip cells and animal cells (grasshopper) from permanent slides.
5. Different types of inflorescence (cymose and racemose).

6. Human skeleton and different types of joints with the help of virtual images/models only.

SUGGESTED PROJECTS/ACTIVITIES/PRACTICAL – CLASS 12

Part A: List of Experiments

14. Prepare a temporary mount to observe pollen germination.
15. Study the plant population density by quadrat method.
16. Study the plant population frequency by quadrat method.
17. Prepare a temporary mount of onion root tip to study mitosis.
18. Isolate DNA from available plant material such as spinach, green pea seeds, papaya, etc.

Part B: Careful observation of the following (spotting):

1. Flowers adapted to pollination by different agencies (wind, insects, birds).
2. Pollen germination on stigma through a permanent slide or scanning electron micrograph.
3. Identification of stages of gamete development, i.e., T.S. of testis and T.S. of ovary through permanent slides (from grasshopper/mice).
4. Meiosis in onion bud cell or grasshopper testis through permanent slides.
5. T.S. of blastula through permanent slides (Mammalian).
6. Mendelian inheritance using seeds of different colour/sizes of any plant.
7. Prepared pedigree charts of any one of the genetic traits such as rolling of tongue, blood groups, ear lobes, widow's peak and colour blindness.
8. Controlled pollination - emasculation, tagging and bagging.
9. Common disease-causing organisms like Ascaris, Entamoeba, Plasmodium, any fungus causing ringworm through permanent slides, models or virtual images or specimens. Comment on symptoms of diseases that they cause.
10. Models specimen showing symbolic association in root modules of leguminous plants, Lichens, parasitic interaction of cuscuta with host
11. Flash cards models showing examples of homologous and analogous organs.

1. Multiple Choice Question (MCQ)

Content Domain (Chapter name)	Photosynthesis in Higher Plants	
Content Domain Learning outcome	CLO182. Describes the role of chloroplast in photosynthesis	
Indicator	C210. Describes the role of chloroplast pigments in light absorption in thylakoids	
Cognitive level	Apply	
Thinking Process	Apply	
Difficulty level	Medium	
Marks	1 mark	
Time	2-3 minutes	
Item Stem	A light devoid of blue and green region of the light spectrum is illuminated to a plant for a month. Which of these is true?	
Correct answer	The plant would die	Reason: This will test if students understands that blue and red regions of the light spectrum are the most effective in photosynthesis.
Distractor 1	The plant with grow with a slower rate	Explanation: This will test what regions of light spectrum are important for photosynthesis.
Distractor 2	The plant with grow with a faster rate	Explanation: This will test what regions of light spectrum are important for photosynthesis.
Distractor 3	The plant growth will remain constant	Explanation: This will test what regions of light spectrum are important for photosynthesis.

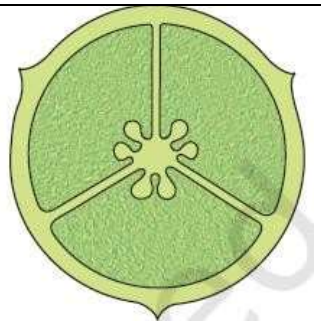
2. Constructed Response Questions

Content domain (Chapter name)	The Living World
Content Domain Learning outcome	CLO4. Differentiates between the basic methods of taxonomic study
Indicator	C8. Explains the branch of study called taxonomy
Cognitive level	Understand
Thinking Process	Explain
Difficulty level	Medium
Marks	4 marks
Time	2-3 minutes
Item stem	External and internal structure, structure of cell, development process and ecological information are the basis of modern taxonomical studies. Explain with examples.

Marking Scheme

Part	**Mark**	**Answer**	**Further Information**
	1	Explains how external and internal structure helps in modern classification and taxonomical studies with an example	Answer may vary
	1	Explains how structure of cell helps in modern classification and taxonomical studies with an example	Answer may vary
	1	Explains how development process helps in modern classification and taxonomical studies with an example	Answer may vary
	1	Explains how ecological information helps in modern classification and taxonomical studies with an example	Answer may vary

3. Constructed Response Questions

Content domain (Chapter name)	Morphology of Flowering Plants
Content Domain Learning outcome	CLO95. Identifies the different types of placentation in plants
Indicator	C114. Describes different types of placentation – marginal, axile, parietal, free central and basal – with examples
Cognitive level	Remember
Thinking Process	Inferring and comparing
Difficulty level	Medium
Marks	3 marks
Time	4-5 minutes
Item stem	Look at the picture showing different types of placentation.   Placentation G | Placentation H A. Identify the type of placentation for both B. How the placentation G is different from placentation H? Support with one example of each.

Marking Scheme

Part	Mark	Answer	Further Information
A	1	Identifies placentation G as axile and placentation H as parietal placentation	

B	1	Writes one difference between axile and parietal placentation	
B	1	Give one example of each	

4. Constructed Response Questions

Content domain (Chapter name)	Cell Cycle and Cell Division
Content Domain Learning outcome	CLO168. Explains the process of mitosis
Indicator	C194. Explains the importance of mitosis and relates mitosis to types of growth patterns in living organisms
Cognitive level	Apply
Thinking Process	Applying and interpreting
Difficulty level	Hard
Marks	3 marks
Time	6-8 minutes
Item stem	Colchicine is an alkaloid drug. Study the data collected when different amount of colchicine is added to the cell culture.

	25 ml of cell culture without colchicine	**25 ml of cell culture with 0.1 ml of colchicine**	**25 ml of cell culture 0.0001 ml of colchicine**
After 45 min	2% cells are in prophase 5% cells are in metaphase 13% cells are in anaphase	90% cells are in metaphase, 10% cells are in prophase	75% cells are in metaphase, 25% cells are in prophase.

	80% cells are in telophase		

A. What is the effect of colchicine on cell division—decreases or increases cell division?
B. Which stage of mitosis is influenced by colchicine? Why?
C. Based on characteristics of that stage, what do you think how does colchicine influence that stage of mitosis?

Marking Scheme

Part	**Mark**	**Answer**	**Further Information**
A	1	Infers that colchicine decreases the cell division ability	
B	0.5	States the stage as 'metaphase'	
B	0.5	Reasons that when colchicine is added most cells are arrested at metaphase and more the colchicine added, a greater number of cells are arrested	
C	1	Reasons that colchicine interferes formation of spindle fibrils since it arrests the cells at metaphase which mainly requires spindle formation to proceed	Answer may vary

5. Constructed Response Questions

Content domain (Chapter name)	Respiration in plants
Content Domain Learning outcome	CLO213. Calculates the total ATP generated in metabolism of one glucose molecule in respiration
Indicator	C250. Calculates the total net number of ATP is generated by respiration of one molecule of glucose in aerobic and anaerobic respiration
Cognitive level	Analyze
Thinking Process	Examining, interpretating, justifying
Difficulty level	Medium
Marks	2 marks
Time	3-4 minutes
Item stem	The energy produced in respiration of actinomyces is 2 ATP molecules/glucose whereas that in respiration of a plant is 36 ATP molecules/glucose. Why? Justify with reasons.

Marking Scheme

Part	**Mark**	**Answer**	**Further Information**
	0.5	Mentions that actinomyces has anaerobic respiration and plant has aerobic respiration	
	1.5	Reasons that anaerobic respiration produces less energy than aerobic since it is incomplete oxidation and happens in absence of oxygen and aerobic is complete and occur in the presence of oxygen	Answer may vary

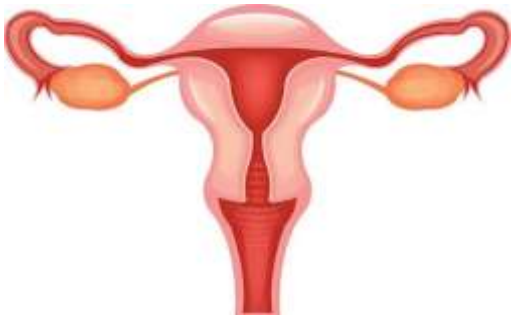
6. Multiple Choice Question (MCQ)

Content Domain (Chapter name)	Evolution	
Content Domain Learning outcome	CLO105. Differentiates between divergent and convergent evolution	
Indicator	C118. Describes divergent and convergent evolution and homologous and analogous structures with examples	
Cognitive level	Apply	
Thinking Process	Describing and applying	
Difficulty level	Easy	
Marks	1 mark	
Time	2-3 minutes	
Item Stem	Which of the following are examples of homologous modification?	
Correct answer	Thorns of bougainvillea and tendrils of cucurbits	Reason: This shows students understand that homologous modification as same structures with different function
Distractor 1	Eyes of octopus and mammals	Explanation: Students may misunderstand homologous modification as structures with same function
Distractor 2	Wings of butterfly and bird	Explanation: Students may misunderstand homologous modification as structures with same function
Distractor 3	Thorns of bougainvillea and spine of opuntia	Explanation: Students may misunderstand homologous modification as structures with same function

7. Multiple Choice Question (MCQ)

Content Domain (Chapter name)	Biotechnology and its Applications	
Content Domain Learning outcome	CLO169. Describes the application of biotechnology to manufacture medicines	
Indicator	C213. Describes the usage of biotechnological methods for molecular diagnosis of diseases	
Cognitive level	Apply	
Thinking Process	Remember, apply	
Difficulty level	Easy	
Marks	1 mark	
Time	2-3 minutes	
Item Stem	As a physician, you have a patient who is diagnosed with an HIV infection. You have to test for HIV infection in the partner of patient who has no symptoms of the infection. Which of these methods you can use to diagnose the infection in the patient?	
Correct answer	Enzyme Linked Immuno-Sorbent Assay (ELISA)	This checks if student understands that ELISA can be used to detect low viral loads
Distractor 1	Analysis of urine	This checks if student misunderstands that urine analysis can be used to detect low viral loads
Distractor 2	Analysis of saliva	This checks if student misunderstands that saliva analysis can be used to detect low viral loads
Distractor 3	Electroporation	This checks if student lacks the understanding and making a random guess

8. Constructed Response Questions

Content domain (Chapter name)	Human Reproduction
Content Domain Learning outcome	CLO38. Describes the reproductive cycle in females
Indicator	C41. Explains and predicts the different changes in the uterus during the different stages of menstrual cycle
Cognitive level	Create
Thinking Process	Construct, assemble
Difficulty level	Medium
Marks	5
Time	10-12 minutes
Item stem	Given below is a diagram of the female reproductive tract.  Create 4 diagram of the same view to show the following events: A. Ovulation B. Menstruation C. Successful copulation D. From fertilization to implantation In each drawing, label the important events and structures.
Marking Scheme	

Part	Mark	Answer	Further Information
A	1	Diagram showing bursting of Graafian follicle in the fallopian tube and regenerating endometrium	
B	1	Diagram showing regressed corpus luteum in the fallopian tube and disintegration of endometrium	
C	1	Diagram showing fertilization in the ampulla, sperms entering through the fimbriae and regenerating endometrium	
D	2	Diagram showing zygote, 2-celled and 4-celled structures, morula and blastocyst, their location, implantation and thick endometrium	

9. Constructed Response Questions

Content domain (Chapter name)	Sexual Reproduction in Flowering Plants
Content Domain Learning outcome	CLO15. Describes role of pollination
Indicator	C17. Summarises outbreeding devices and the pollen-pistil interaction after pollination
Cognitive level	Apply
Thinking Process	Interpret, Relate
Difficulty level	Hard
Marks	3 marks

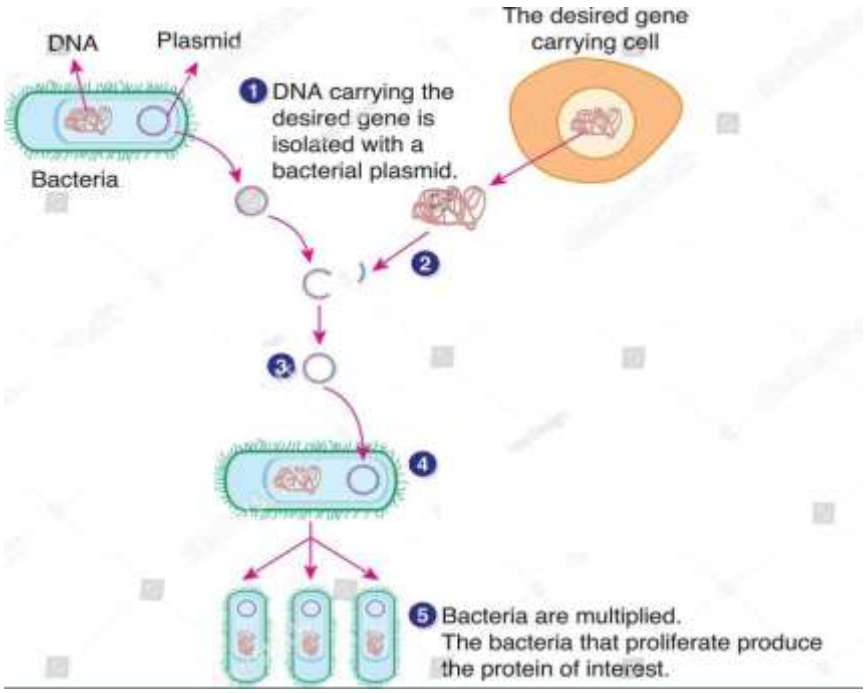
Time	5-7 minutes
Item stem	Set up: An area with different species of plants. A colour tracer is added to the pollen of one species. Findings: The pollen from this species reaches the flowers of this as well as other species. However, pollination occurs only with the flower of the same species. A. Name and explain the phenomenon underlying this finding. B. How can a plant breeder avoid fertilization by unwanted pollen?

Marking Scheme

Part	Mark	Answer	Further Information
A	0.5	Names pistil-pollen interaction	
B	1	Explains that chemical interactions between pollen and pistil cause rejection of unwanted pollen (no pollen germination or pollen tube growth)	
B	1.5	Names and explains emasculation bagging	

10. Constructed Response Questions

Content domain (Chapter name)	Biotechnology: Principles and Processes
Content Domain Learning outcome	CLO156. Explains the use and functioning of restriction enzymes in rDNA technology
Indicator	C186. Describes restriction enzymes and its functioning C189. Describes the functioning of DNA ligase in producing recombinant DNA
Cognitive level	Understand

Thinking Process	Infer and explain
Difficulty level	Medium
Marks	3
Time	4-5 minutes
Item stem	Study the given chart showing the process of Recombinant DNA technology.  (Image source: Source: https://www.shutterstock.com/es/image-vector/gene-cloning-mechanism-bacteria-1835141398 Remove labels and edit as shown) A. Complete the explanation of steps 2, 3 and 4. B. In which step restriction enzymes are used? What is their purpose? C. In which step DNA ligase is used? What is its purpose?
Marking Scheme	

Part	Mark	Answer	Further Information
A	1.5	Completes step 2, 3 and 4 as: Step 2- Cutting of target DNA and vector at a specific location Step 3- Joining of vector and target foreign DNA to form recombinant DNA Step 4 – Transfer of recombinant DNA into the host	
B	1	Mentions that restriction enzymes are used step 2 to cut the vector and target DNA at restriction site.	
C	0.5	Mentions that restriction enzymes are used step 3 to join the end fragments of vector and target DNA.	

CLASS 11 – ASSESSMENTS BASED ON ESSENTIAL IDEAS

Chapter name	The Living World
Essential Idea	Similarities and differences between organisms are used to build certain rules and principles for identification, and classification of organisms.
Item stem	Read the distinct characteristics of animals X, Y, and Z.

	Animal X	Animal Y	Animal Z
Presence of vertebral column	Yes	Yes	Yes
Habitat	Aquatic	Aquatic	Terrestrial
Locomotory appendages	Fins	Fins	Two pairs of limbs
Streamlined body	Yes	Yes	No
Homeostasis	The body temperature changes with external temperature	The body temperature is maintained by its metabolic activity.	The body temperature is maintained by its metabolic activity.
Respiration	Breathes through gills	Breathes through lungs	Breathes through lungs
Presence of scales	Yes	No	No
Presence of mammary glands	No	Yes	Yes

Scientist identified all three animals belong to subphylum vertebrata, animal X shows all the characteristics of class Osteichthyes (Super class: Pieces) and animal Z shows characteristics of class Mammal.

A. Based on the similarities and differences, is animal Y more like animal X or animal Z? Give 1 reason.
B. Which class can Animal Y can be put in?

Marking Rubric

Part	Description	Marks
Sample answer	A. Animal Y is more similar to animal Z. Although the physical features between animal X and animal Y are the same, animal Y shares more evolved physiological features with animal Z. B. Animal Y can be placed in class Mammal.	
Part A	Mentions that animal Y is more similar to Z than X.	0.5
Part A	Provides valid reasons for the selection.	1
Part B	Assigns correct class to animal Y	0.5

Chapter name	The Living World	
Essential Idea	An organism represents/occupies a place or position in the system of classification identified by their taxonomic categories and when all the categories constitute a taxonomic hierarchy	
Item stem	Study the taxonomy related data in a specific order of an organism of the table given below. **Organism** A: Animalia B: Chordata C: Mammalia D: Carnivora E: Felidae F: *Acinonyx* G: *jubatus* Which of these is true?	
Correct answer	E represents family of the organism	Student understands that the order of taxonomic hierarchy
Distractor 1	Taxonomic category is A to G all together in order	Student misunderstands that difference between taxonomic category and hierarchy
Distractor 2	*Jubatus* is the genus of the organism	Student misunderstands the order of taxonomic hierarchy

Distractor 3	Carnivora is the class of the organism	Student misunderstands the order of taxonomic hierarchy

Chapter name	Biological Classification
Essential Idea	The classification system is subject to change over time with improvement in our understanding of morphological, physiological, reproductive characteristics, and evolutionary relationships.
Item stem	Two kingdom classification given by Carolus Linnaeus included bacteria, *Chlamydomonas*, blue green algae, fungi, mosses, ferns, gymnosperms, and angiosperms under 'Plants' based on presence of the cell wall around the cells. A. 'The two-kingdom classification used for a long time was found inadequate'. Justify this statement with one reason. B. Scientists classified these organisms as 'Plants' of two-kingdom classification into five kingdom classification based on improved understanding of their characteristics. What are these characteristics and how were they used for classification?

Marking Rubric

Part	Description	Marks
Sample answer	A. Two kingdom classification is based on a few gross morphologies, but provide no knowledge about organisation of cells, mode of nutrition, methods of reproduction, evolutionary relationships, etc. B. These characteristics are cell type (prokaryotic and eukaryotic cells) and mode of nutrition (autotrophic and heterotrophic). All prokaryotic organisms (bacteria and the blue green algae) were grouped together under Kingdom Monera, and the unicellular eukaryotic organisms (Chlamydomonas) were placed in Kingdom Protista. All heterotrophic organisms—fungi were placed under Kingdom Fungi, and the autotrophic green plants—mosses, ferns, and gymnosperms—were placed under Kingdom Plantae, though they also showed a characteristic difference in their wall composition—the fungi had chitin in their walls, while the green plants had a cellulosic cell wall.	

Part A	Provides a relevant reason justifying the statement	1
Part B	Lists any two of these characteristics: Cell type (prokaryotic and eukaryotic cells), mode of nutrition (autotrophic and heterotrophic), body organisation (unicellular or multicellular), and nature of cell wall.	1
Part B	Explains how different characteristics were used to form 5-kingdom classification	1

Chapter name	Biological Classification	
Essential Idea	The main criteria of the five-kingdom classification are cell structure, body organisation, mode of nutrition and reproduction, and phylogenetic relationships.	
Item stem	Choose the correct statement regarding on five-kingdom classification.	
Correct answer	Mushrooms and green plants are not in the same kingdom because mushrooms are heterotrophs and plants are autotrophs.	Student understands that mode of nutrition is one of the criteria of the five-kingdom classification system.
Distractor 1	Chlorella is classified under Kingdom Fungus because it is a single-celled autotrophic eukaryote.	This checks if the student understands that in the five-kingdom classification system, Kingdom Fungi have multicellular or loose-tissue organisms.
Distractor 2	The Kingdom Monera includes all unicellular organisms, whereas the Kingdoms Protista, Fungi, Plantae, and Animalia include more complex levels of cellular organization.	This checks if the student understands that in the five-kingdom classification system, Kingdom Monera and Protista have unicellular organisms.
Distractor 3	Yeast is phylogenetically closer to ferns than to the fungus *Penicillium chrysogenum*.	This checks if the student understands that organisms in one kingdom are phylogenetically more closely related than organisms in other kingdoms.

Chapter name	Plant Kingdom
Essential Idea	Plant kingdom is classified into divisions—algae, bryophytes, pteridophytes, gymnosperms, and angiosperms—based on the presence or absence of differentiated bodies, vascularized tissues, and seeds.
Item stem	A group of botanists are exploring flora of an inhabited island. They found two unidentified plants—plant X and plant Y. Here are the observed features of these plants: Identify the division of Plantae Kingdom to which each of the plant most likely belongs. Give reason for your answer.

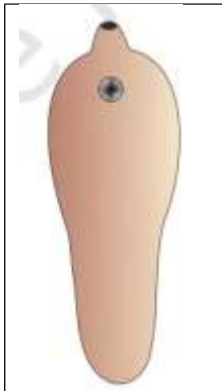
Vascular tissue	Absent	Present
Seeds	Absent	Present
Pollen	Absent	Absent
Roots	Absent	Present
True leaves	Absent	Present
Fruits and flower	Absent	Absent

Marking Rubric

Part	Description	Marks
Sample answer	Organism X: Bryophytes; Undifferentiated body with no seeds, flower, Organism Y: Gymnosperm; Body differentiated into root, stem, leaves, seeds and no fruits and flowers.	
Part A	Identifies the division of each specimen (0.5 marks for each)	1
Part A	Mentions the character that helped in identification of the division (0.5 marks for each)	1

Chapter name	Plant Kingdom	
Essential Idea	We use numerical taxonomy, cytotaxonomy and chemotaxonomy information from many other sources to help resolve difficulties in plant classification.	
Item stem	Read the examples of three different ways to resolve difficulties in classification. X: Umbelliferae and Apiaceae secrete volatile oils but Solanaceae secrete tropane alkaloid. Y: Taxonomical work on bacteria is done by collecting morphological, physiological, and antigenic data of the strain, process it applying statistics to estimate the percentage of similarities and dissimilarities. Z: *Monotropa hypopitys* and *Monotropa hypophegea* are two morphologically similar organisms but separated since *M. hypopitys* is a hexaploid: (2n = 48) and *M. hypophegea* is a diploid (2n = 16). Which of these statements is correct?	
Correct answer	X is an example of chemotaxonomy taxonomy	Student understands the difference between numerical taxonomy, cytotaxonomy and chemotaxonomy.
Distractor 1	Y is an example of both numerical taxonomy and chemotaxonomy taxonomy	Student misunderstands the difference between numerical taxonomy, cytotaxonomy and chemotaxonomy.
Distractor 2	Z is an example of numerical taxonomy	Student misunderstands the difference between numerical taxonomy, cytotaxonomy and chemotaxonomy.
Distractor 3	Z is an example of both numerical taxonomy and cytotaxonomy taxonomy	Student misunderstands the difference between numerical taxonomy, cytotaxonomy and chemotaxonomy.

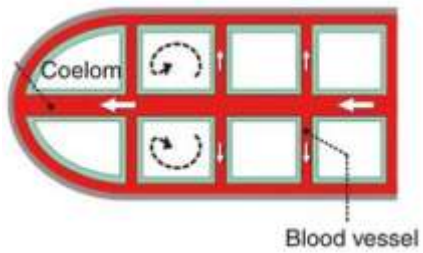
Chapter name	Animal Kingdom
Essential Idea	Animal kingdom is classified into phyla based on level of cellular organization, body symmetry, nature of coelom, patterns of digestive, circulatory or reproductive systems, and presence of notochord.
Item stem	A. Look at these animals.



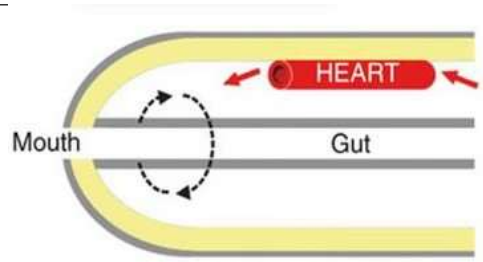
Liver Fluke	*Ascaris*

Identify the phylum of each – Liver fluke and *Ascaris*.
What are the two common features for both these phyla? And which are the two distinguishing characteristics of each phylum?

B.



Circulatory system-type A: found in Annelids



Circulatory system-type B: found in Arthropods

How is the circulatory system-type A different from circulatory system-type B? Give example of another phylum that has these types of circulatory systems.

	Fig: https://onlinelibrary.wiley.com/doi/10.1111/jth.12253

Marking Rubric

Part	Description	Marks
Sample answer	A. Liver fluke belongs to Phylum Plathyhelminthes and *Ascaris* belongs to Phylum Aschelelminthes. Two common features: 1. Platyhelminthes and Aschelminthes have bilaterally symmetrical body. 2. Both have organ system level of organisation. Two differences: 3. Platyhelminthes are acoelomates and Aschelminthes are pseudocoelomates. 4. Platyhelminthes have an incomplete alimentary canal with a single opening, and Aschelminthes have a complete alimentary canal with a separate opening for mouth and anus. B. Circulatory System A represents a closed circulatory system in which the heart pumps blood through vessels that are separate from the interstitial fluid of the body. Circulatory System B represents an open circulatory system where the blood is not enclosed in the blood vessels but pumped into a cavity called a hemocoel. Closed circulatory system is found chordates like aves and mammals and open circulatory system is found in Phylum Echinoderm except cephalochordates.	
Part A	Identifies the phylum of each organism. (0.5 marks for each)	1
Part A	Writes two relevant similarities between Liver fluke and *Ascaris* (0.5 marks for each)	1
Part A	Writes two relevant differences between Liver fluke and *Ascaris* (0.5 marks for each)	1
Part B	Writes two differences between the two circulatory systems (0.5 marks for each)	1
Part B	Writes two examples for each type of circulatory systems (0.5 marks for each)	1

Chapter name	Animal Kingdom	
Essential Idea	Subphylum vertebrata of phylum Chordata are classified into classes based on their presence or absence of jaw, fins or limbs, and reproductive system.	
Item stem	What developmental feature was the major evolutionary change that enabled terrestrial vertebrates—Aves and most Mammals—to be completely free of aquatic habitat?	
Correct answer	Internal fertilisation	Student understands that how internal fertilisation require water to ensure higher survival chances of the species
Distractor 1	Lungs	Student misunderstands that animal with lungs cannot live in water
Distractor 2	Pair of limbs for locomotion	Student misunderstands that animal with limbs cannot live in water
Distractor 3	Four-chambered heart	Student misunderstands that animal with four chamber heart cannot live in water

Chapter name	Morphology of Flowering Plants
Essential Idea	Flowering plants exhibit enormous variation in shape, size, structure, mode of nutrition, life span, habit and habitat.
Item stem	Observe these three flowers:

		
Mustard flower Symmetry: Actinomorphic	Canna Lily flower Symmetry: Asymmetric	Butterfly Pea flower Symmetry: Zygomorphic

(Source of image: https://www.shutterstock.com/search/mustard-flowers, https://www.dreamstime.com/yellow-canna-lily-flowers-white-background-clipping-path-yellow-canna-lily-flowers-white-background-clipping-path-image128394949, https://www.shutterstock.com/search/butterfly-pea-flower)

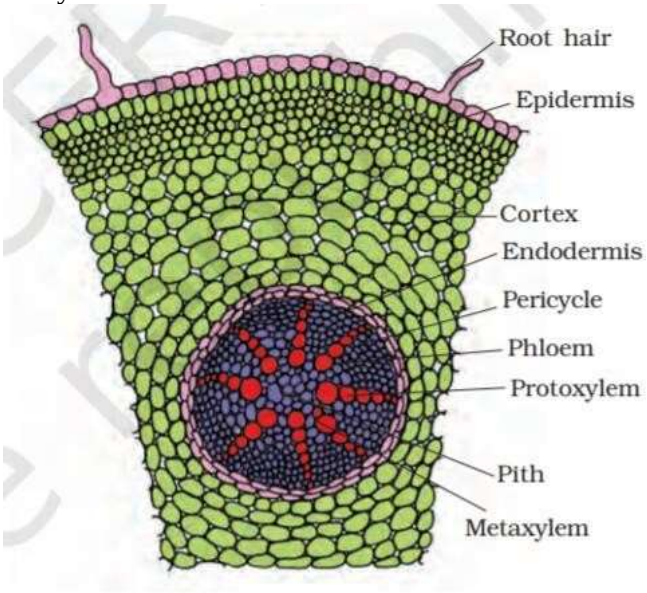
Based on the symmetry of the flower, how flower 1, 2 and 3 are different from each other? Explain with name of their types based on symmetry.

Marking Rubric

Part	Description	Marks
Sample answer	Mustard flower is actinomorphic and it can be divided into two equal radial halves in any radial plane passing through the centre. Canna Lily flower is asymmetric (irregular) if it cannot be divided into two similar halves by any vertical plane passing through the centre. But Butterfly Pea flower is zygomorphic and it can be divided into two similar halves only in one particular vertical plane.	

	Explains the three different types of flowers based on their symmetry for Mustard flower, Canna Lily flower, and Butterfly Pea flower (1 for each)	3

Chapter name	Morphology of Flowering Plants	
Essential Idea	Flowering plants exhibit enormous variation in shape, size, structure, mode of nutrition, life span, habit and habitat.	
Item stem	While gardening, Mathew finds a plant that has a taproot structure with a single thick root, with lateral branches, that grows deep into the soil. What would be type of plant and venation of its leaves?	
Correct answer	Dicot plant; Reticulate venation	Student understands that taproot is found in dicot plants which usually have reticulate venation.
Distractor 1	Dicot plant; Parallel venation	Student misunderstands that dicot plants have parallel venation.
Distractor 2	Monocot plant; Parallel venation	Student misunderstands that taproot is found in monocot plants.
Distractor 3	Monocot plant; Reticulate venation	Student misunderstands that taproot is found in monocot plants.

Chapter name	Anatomy of Flowering Plants
Essential Idea	Apical meristem tissues are the dividing cells responsible for the primary growth of plants, and permanent tissues are non-dividing cells that constitute the epidermal, ground, and vascular tissue systems.
Item stem	Study the transverse section of monocot root with different labelled parts.  A. Endodermal cells present opposite to xylem bundles are called passage cell. What is their function? B. "The vascular bundles in monocot root are radial and polyarch. The xylem in exarch." What does this mean in terms of the arrangement of vascular bundles? C. There are no meristematic cells in the transverse section of the monocot root. What is the significance on the morphology of the root?

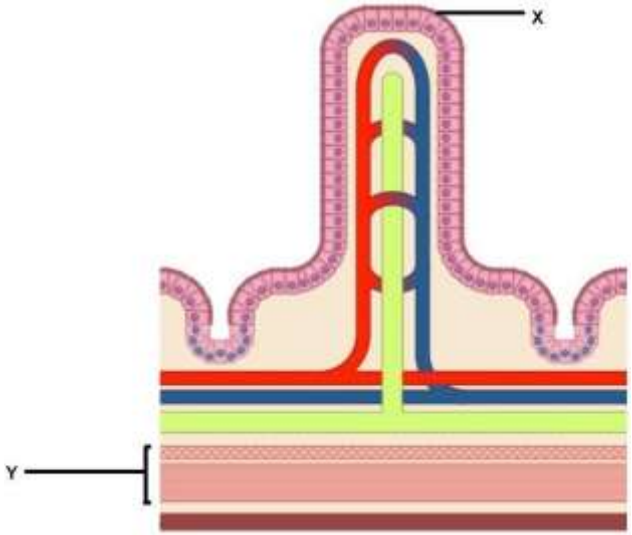
Marking Rubric

Part	Description	Marks
Sample answer	A. Their function is to transfer water and dissolved salts from the cortex into the xylem. B.	

	1. Monocot root vascular bundles are radially arranged. There are equal bundles each of xylem and phloem and this is called polyarch. 2. The xylem in monocot root is exarch as protoxylem is directed towards the periphery and the metaxylem is directed towards the centre. C. There is no vascular cambium i.e. lateral meristem in monocots and so it does not result in the development of a secondary roots.	
Part A	Writes a relevant function of endodermal cells opposite to xylem.	1
Part B	Writes two relevant reasons supporting the statement (0.5 marks for each)	1
Part C	Writes about the lack of secondary roots in monocots.	1

Chapter name	Anatomy of Flowering Plants	
Essential Idea	Monocotyledonous and dicotyledonous plants show marked variation in their internal structures	
Item stem	Shayam is studying the roots of two new plant specimen collected on the field work. Here is the data collected Sample A: Narrower cortex. Endodermis is less thickened and casparian strips are more prominent. The xylem and phloem bundles vary from 2 to 5. Pith is absent or very small. Sample B: Endodermal cells are highly thickened and casparian strips are visible only in young roots. Wider cortex. Xylem and phloem are more than 6. Well-developed pith is present. Which of these is the plant sample most likely to be?	
Correct answer	Sample A is dicot plant	Student understands the characteristic features of dicot root
Distractor 1	Sample B is dicot plant	Student misunderstands characteristic features of dicot root
Distractor 2	Sample A is monocot plant	Student misunderstands characteristic features of monocot root

Distractor 3	Sample A and B are monocot plant	Student misunderstands characteristic features of monocot root

Chapter name	Structural Organisation in Animals
Essential Idea	The structural hierarchy in an animal begins with cells that, in most multicellular organisms, specialise in structure to form organ system.
Item stem	There are four different levels of cellular organisation in a multicellular organism. Look at the image showing two of the different levels of cellular organisation in a section of one of the villi.  (https://ptskills.co.uk/what-personal-trainers-fitness-instructors-need-to-know-about-the-digestive-system/) A. Label X, and Y in terms of the levels of cellular organization. B. Name the other two levels of organisation (other than X and Y) of villi.

Marking Rubric		
Part	**Description**	**Marks**
Sample answer	**A.** X. epidermal **cell** Y. smooth muscle **tissue** B. Organ: Small intestine; Organ system: Digestive system	
Part A	Identifies the name of layers (0.5 marks for each)	1
Part B	Identifies the name of organ and organ system (0.5 marks for each)	1

Chapter name	Structural Organisation in Animals	
Essential Idea	The comparative study of the morphology and anatomy of frogs shows a trend in complexity in the structural organisation and functioning of their bodies.	
Item stem	Given that cockroaches are from the lower taxon and frogs are from the higher taxon, here is a table comparing their organ systems. Complete the table by choosing the option that gives the correct organs for the frog: **Cockroach** / **Frog** **Circulatory system**: Open circulatory system / **N** **Excretory system**: Malpighian tubules / **O** **Nervous system**: Segmentally arranged ganglia with connectives / Brain, a spinal cord, and nerves	
Correct answer	**N:** Closed circulatory system; **O:** Kidneys	Student understands that the structure and function of organ systems evolved as we move from the lower taxon of earthworms to the higher taxon of frogs.
Distractor 1	**N:** Closed circulatory system; **O:** Nephridia	Student misunderstands that frogs have nephridia as an excretory organ
Distractor 2	**N:** Open circulatory system; **O:** Flame cells	Student misunderstands that frogs have an open circulatory system

Distractor 3	**N:** Open circulatory system; **O:** Kidneys	Student misunderstands that frogs have an open circulatory system

Chapter name	Cell-The Unit of Life	
Essential Idea	All living organisms, prokaryotic and eukaryotic, are made of cells that have at least a plasma membrane, genetic material, ribosomes, and cytoplasm.	
Item stem	Antibiotics are medicines used to treat bacterial infections in humans. These medicines kill bacterial cells or stop them from multiplying without affecting human cells. Write the names of at least two parts of the bacterial cell that antibiotics can target. Give a reason for your answer.	
Marking Rubric		
Part	**Description**	**Marks**
Sample answer	Bacterial cells are prokaryotic, and human cells are eukaryotic cells. Antibiotics can target ribosomes and the cell wall. 1. Bacterial cells have a cell wall made of peptidoglycan, but human cells don't. Antibiotics can target the peptidoglycan cell wall, and they won't harm human cells. 2. Bacterial cells have 70S ribosomes, but human cells have 80S ribosomes. By targeting the functioning of 70S ribosomes, antibiotics would harm only bacterial cells and not human cells.	
	0.5 marks each to name two organelles that antibiotics can target. 1 mark each to provide a reason for naming those organelles.	3

Chapter name	Cell-The Unit of Life
Essential Idea	Eukaryotic cells have internal membrane-bound organelles compartmentalising the cell's activities such as genetic control; manufacturing, distribution, and breakdown; energy processing; and structural support, movement, and communication between cells.

Item stem	The components of some plant cells were taken into a test tube and left for a few days in a sterile environment. After a few days, there was a layer of sediment at the bottom of the test tube and an aqueous solution above it Organelles A and B were found in the sediment. Organelle A took up oxygen and produced carbon dioxide, and organelle B took up carbon dioxide and produced oxygen when illuminated. What are these organelles likely to be?	
Correct answer	Organelle A: Mitochondria Organelle B: Chloroplast	Student understands the function of mitochondria and chloroplast
Distractor 1	Organelle A: Ribosomes Organelle B: Nuclei	Student misunderstands that ribosomes play an important role in respiration
Distractor 2	Organelle A: Endoplasmic reticulum Organelle B: Chloroplast	Student misunderstands that the endoplasmic reticulum plays an important role in respiration
Distractor 3	Organelle A: Nuclei Organelle B: Mitochondria	Student misunderstands that the nucleus plays an important role in respiration

Chapter name	Biomolecules
Essential Idea	The relative abundance of carbon, hydrogen, and oxygen is higher in living systems when compared to non-living matter due to the presence of macromolecules like proteins, nucleic acids, and polysaccharides.

Item stem	

Element	% Weight of Earth's crust	Human body
Hydrogen (H)	0.14	0.5
Carbon (C)	0.03	18.5
Oxygen (O)	46.6	65.0
Nitrogen (N)	very little	3.3
Sulphur (S)	0.03	0.3
Sodium (Na)	2.8	0.2
Calcium (Ca)	3.6	1.5
Magnesium (Mg)	2.1	0.1
Silicon (Si)	27.7	negligible

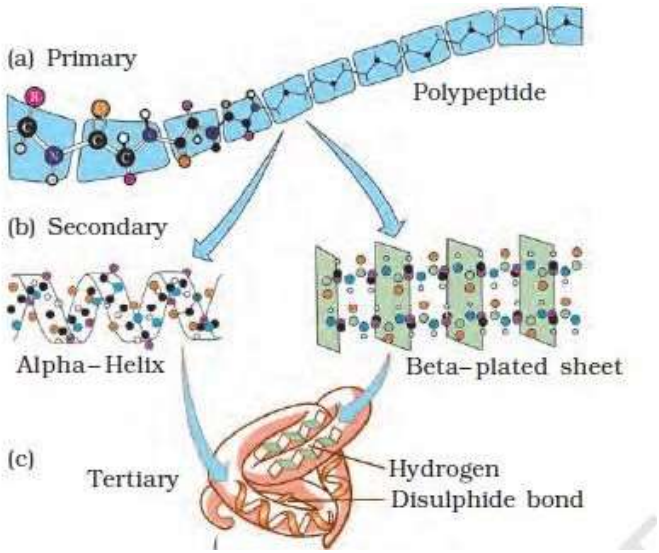
* Adapted from CNR Rao, *Understanding Chemistry*, Universities Press, Hyderabad.

The table above gives a comparison between elements present in the Earth's crust and the human body. How do living systems keep a different composition of elements than their surroundings?

Marking Rubric

Correct answer	The cell membrane selectively allows certain molecules to enter human cells.	Student understands that living organisms the cell membrane works as a gatekeeper for molecules to enter and exit the cell and the food that humans eat contains the elements that form various biomolecules.
Distractor 1	The human beings get their carbon from the atmosphere.	Student misunderstands humans get carbon from the atmosphere.
Distractor 2	Mitochondria produce their own nitrogen as there is very little in the Earth's crust.	Student misunderstands the role of mitochondria.
Distractor 3	Mitochondria in human cells create oxygen for humans.	Student misunderstands the role of mitochondria.

Chapter name	Biomolecules

Essential Idea	Enzymes are proteins or nucleic acids which help carry out rapid chemical reactions in the body by reducing the activation energy needed for the chemical reactions.
Item stem	The image shows two different structures of the same protein:  Given in the image are the primary, secondary and tertiary structures of proteins. In the context of enzyme function, elucidate what information of protein function can one get from a protein's tertiary structure that is not available from examining the protein's primary structure.

Marking Rubric

Part	Description	Marks
Sample answer	Tertiary structure is three-dimensional folding that and is primarily driven by interactions between R groups of the protein backbones. The folding pattern of the tertiary form of protein forms groove or pocket that act as active sites for enzyme binding. Such structures for enzyme binding are absent in the simple linear sequence of primary structure of protein.	

Marking scheme	Writes the presence of active sites in tertiary protein structure but not in primary structure	1
	Supports the answer with difference in the structure of primary and secondary structures	1

Chapter name	Cell Cycle and Cell Division
Essential Idea	In a cell cycle, cell division, DNA replication, and cell growth take place through an ordered, tightly controlled series of steps to ensure the formation of progeny cells.
Item stem	A culture of skin cells is grown in a nutrient-rich medium. A scientist wants to study the various stages of cell division. For this she uses molecules (called inhibitors) to see their effect on cell division. Predict the effect with a reason of the what would happen if these molecules are added to the culture. A. Chemical A – an inhibitor that stops the production of microtubules. B. Chemical B – an inhibitor of the production of regulatory proteins in cytokinesis C. Chemical C – a drug that degrade centrioles in the cells

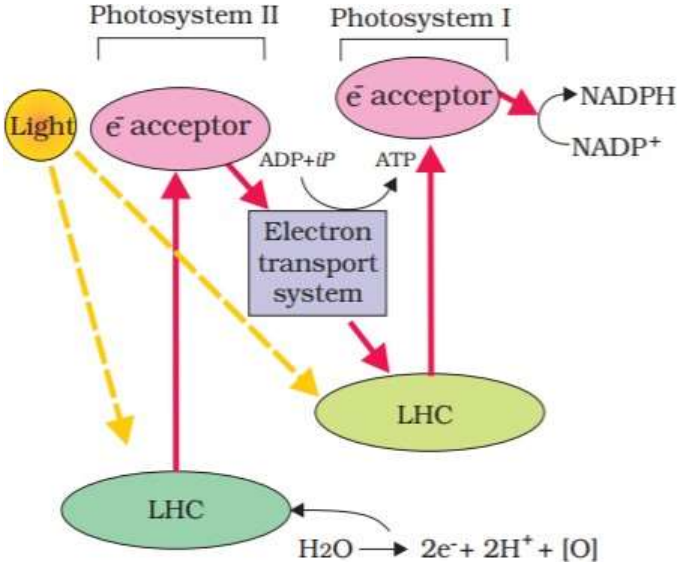
Marking Rubric

Part	Description	Marks
Sample answer	A. The dividing skin cells will be arrested at the metaphase. This is because chemical A will inhibit the production of microtubule that is required for the formation of spindle fibre at the metaphase. Hence the spindle fibre assembly at metaphase won't happen and the process will not proceed. B. Formation of skin cells with two or more nuclei (multinucleated). This is because M phase will not be followed by cytokinesis (cytoplasm division). C. The dividing skin cells will be arrested at the metaphase. This is because chemical B degrade centrioles that form spindle fibres that move all chromosomes to lie at the equator during cell division.	
Part A	Predicts the effect of chemical A on mitosis	0.5
Part A	Describes the reason for the effect of chemical A	0.5

Part B	Predicts the effect of chemical B on mitosis	0.5
Part B	Describes the reason for the effect of chemical B	0.5
Part C	Predicts the effect of chemical C on mitosis	0.5
Part C	Describes the reason for the effect of chemical C	0.5

Chapter name	**Cell Cycle and Cell Division**	
Essential Idea	In mitosis, the number of chromosomes in the parent and two progeny cells is the same, and in meiosis, the number of chromosomes in each of the four progeny cells is half that of the parent cell.	
Item stem	A human skin cell divides into daughter cells every 24 hours. A human germ cell divides to produce gametes in 72 hours. A test-tube containing 10000 skin cells and another test-tube containing 10000 germ cells are grown for 6 days. What will be the number of cells and number of chromosomes in each cell in both these test-tubes?	
Correct answer	64000 skin cells with 46 chromosomes each and 120000 gametes with 23 chromosomes each.	Student understands that in mitosis two diploid cells are formed and in meiosis four haploid cells are produced.
Distractor 1	64000 skin cells with 23 chromosomes each and 120000 gametes with 46 chromosomes each.	Student misunderstands that in mitosis two haploid cells are formed and in meiosis four diploid cells are produced.
Distractor 2	240000 skin cells with 46 chromosomes each and 60000 gametes with 23 chromosomes each.	Student misunderstands that in mitosis four diploid cells are formed and in meiosis two haploid cells are produced.
Distractor 3	240000 skin cells with 23 chromosomes each and 60000 gametes with 46 chromosomes each.	Student misunderstands that in mitosis four haploid cells are formed and in meiosis two diploid cells are produced.

Chapter name	Photosynthesis in Higher Plants

Essential Idea	Light-dependent reactions of photosynthesis capture free energy from light and produce energy-storing molecules, while light-independent reactions use these molecules in a series of reactions to produce glucose.
Item stem	Study the diagram shown in Z scheme of light-dependent reaction.  1. Based on the Z-scheme, list the products formed in a light-dependent reaction of photosynthesis. 2. How are the products formed in the above reactions used in the further reactions of photosynthesis?

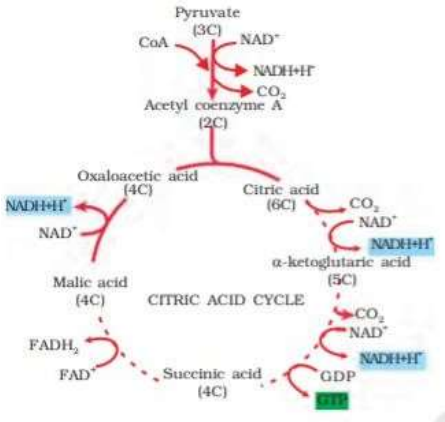
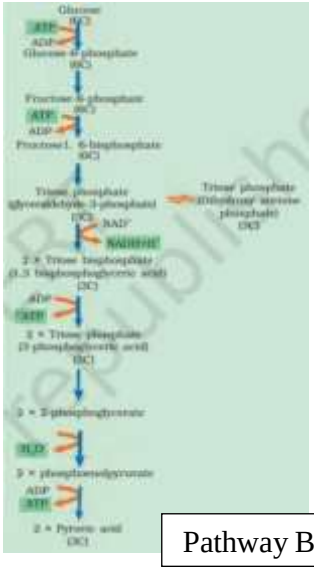
Marking Rubric

Part	Description	Marks
Sample answer	A. The products formed in the light-dependent reaction of photosynthesis are ATP, NADPH, electrons, hydrogen ions (H+) and oxygen atoms. B. Production of **hydrogen ions (H^+)** creates a proton gradient the lumen, whose flow across the photosynthetic membrane provides ATP. The **oxygen atoms** combine to form molecular oxygen (O_2), which is released into the atmosphere.	

	High-energy electrons, which are released as photosystem I absorbs light energy, are used to drive the synthesis of nicotine adenine dinucleotide phosphate (NADPH). **ATP and NADPH** produced are used to make glucose using carbon dioxide in the Calvin cycle.	
Part A	Lists out the products of a light-dependent reaction	0.5
Part B	Describes how ATP and NADPH are used to produce glucose from carbon dioxide in Calvin Cycle of the light-independent reaction and electrons to produce NADPH.	1
	Describes how hydrogen is used to create proton gradient, oxygen atoms to produce molecular gas.	1

Chapter name	Photosynthesis in Higher Plants	
Essential Idea	Some tropical plants have special Kranz anatomy and show a special type of photosynthesis called the C_4 pathway that lacks photorespiration and has a tolerance to higher temperatures.	
Item stem	C_3 and C_4 are the two major CO_2 fixing pathways present in plants. Here are a few statements regarding the pathways: (1) These plants are most common in dry tropical climates. (2) The Calvin cycle in plants takes place in the mesophyll cells. (3) Plants have several layers of bundle sheath cells around the vascular bundles with many chloroplasts, thick walls impervious to gaseous exchange, and no intercellular spaces. (4) The primary CO_2 acceptor is phosphoenolpyruvate (PEP). Choose which of these is correctly assigned to the correct pathway for each statement.	
Correct answer	(1)C_4; (2) C_3; (3) C_4; (4) C_4	Student understands that in C_4 plants, the main photosynthetic function occurs in bundle sheath cells, and they lack photorespiration, which adapts them to high temperatures.
Distractor 1	(1)C_3; (2) C_3; (3) C_4; (4) C_4	Student misunderstands that C_3 plants are adapted to higher temperature.
Distractor 2	(1)C_4; (2) C_3; (3) C_3; (4) C_4	Student misunderstands that C_3 plants have special Kranz anatomy.

Distractor 3	(1)C_4; (2) C_4; (3) C_4; (4) C_3	Student misunderstands that in C_4 plants, the main photosynthetic function occurs in mesophyll cells.

Chapter name	Respiration in plants
Essential Idea	The breakdown of carbohydrates in the cell occurs in 3 main metabolic pathways—glycolysis, the citric acid cycle, and oxidative phosphorylation—to release energy and the trapping of this energy for the synthesis of ATP.
Item stem	Study the pathways of cellular respiration.  Pathway A  Pathway B

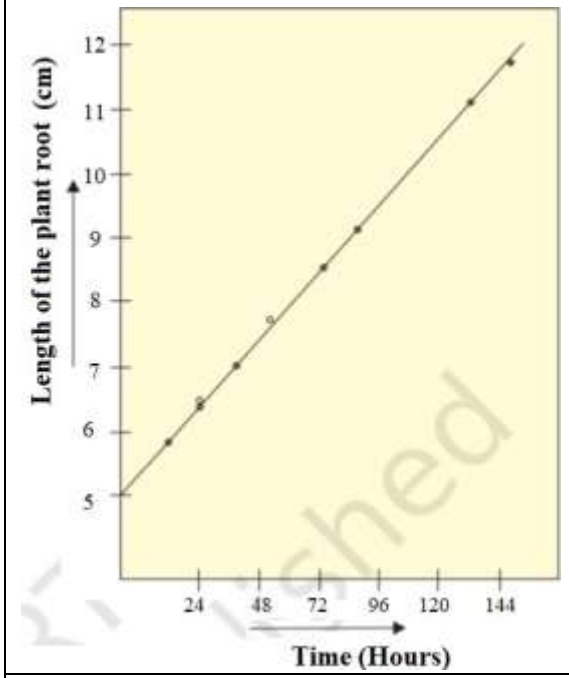
	Justify each of the statements are made about these pathways with one reason. A. Pathway B is a common pathway between aerobic and anaerobic respiration. B. Pathway A in eukaryotes occurs in the matrix of mitochondria which leads to the generation of ATP.

Marking Rubric

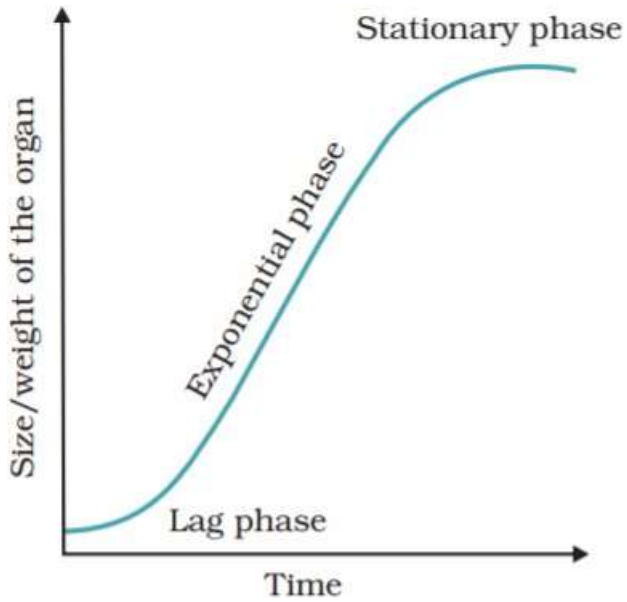
Part	Description	Marks
Sample answer	A. Glycolysis (Pathway B) is the first pathway of the respiration process that occurs in both aerobic and anaerobic organisms. It reduces glucose to pyruvic acids. This pathway does not use oxygen in any of its reactions, and hence is present in anaerobic organisms and aerobic organisms. B. The reactions of TCA cycle (Pathway A) occur in the matrix of mitochondria and provide produce NADH and FADH. These are electron donors, and the transfer of electrons creates a proton gradient across the inner mitochondrial. The potential difference caused allows the production of ATP. Hence the location of TCA in the matrix of mitochondria is crucial for the generation of ATP.	
Part A	Provides a relevant reason to support that glycolysis occurs in both aerobic and anaerobic respiration.	1
Part B	Provides a relevant reason to support how energy currencies generated in TCA cycle are used to create proton gradient in mitochondria through ETS.	1

Chapter name	Respiration in plants	
Essential Idea	The cellular respiratory pathway is amphibolic in nature since it involves catabolic (breakdown) pathways of cellular respiration intersecting with anabolic (biosynthetic) pathways.	
Item stem	Choose the statement that supports that the cellular respiration is an amphibolic process.	
Correct answer	Fatty acids are formed in the body by using acetyl CoA produced from breakdown of glucose.	Student understands that anabolic reactions use energy to synthesise complex molecules (fatty acids) from simpler molecules (acetyl CoA) produced from catabolic glycolysis.
Distractor 1	Proteins are converted to amino acids by the action of a protease.	Student misunderstands that the conversion of protein to amino acid is an anabolic reaction.
Distractor 2	One molecule of glucose undergoes glycolysis to produce two molecules of pyruvic acid.	Student misunderstands that the conversion of glucose to pyruvic acid is an anabolic reaction.
Distractor 3	Fats are hydrolysed into fatty acids and glycerol that subsequently yield acetyl CoA.	Student misunderstands that the conversion of fats to acetyl CoA is an anabolic reaction.

Chapter name	Plant - Growth and Development
Essential Idea	Following cell division in root and shoot apical meristem cells, the growth could be arithmetic or geometrical.
Item stem	Graph I show the growth of a primary root from 5 cm to 12 cm in 6 days. Graph II shows the growth in the size of a plant organ with time.



Growth graph 1



Growth graph 2

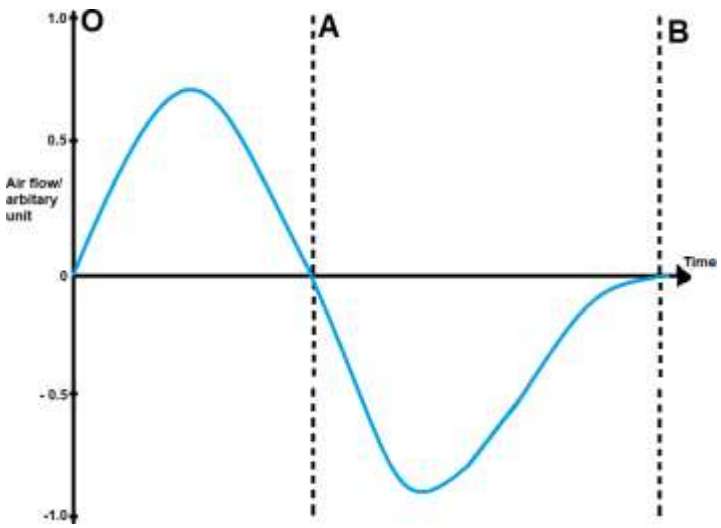
Based on the two graphs given above name two differences in the organs in which these types of growth may occur.

Marking Rubric

Part	Description	Marks

Sample answer	A long, narrow organ like a root is likely to show growth as shown in graph 1, while an organ like a leaf or stem is likely to show growth as shown in graph 2. The probable differences: 1. Graph 1 type growth happens in linear, narrow organs, while graph 2 type growth happens in creating two- or three-dimensional structures. 2. Graph 1 type of growth will take longer as the cell numbers only increase linearly, while they increase exponentially in graph 2 type of growth.	
	Explains that functional and structural differences	2

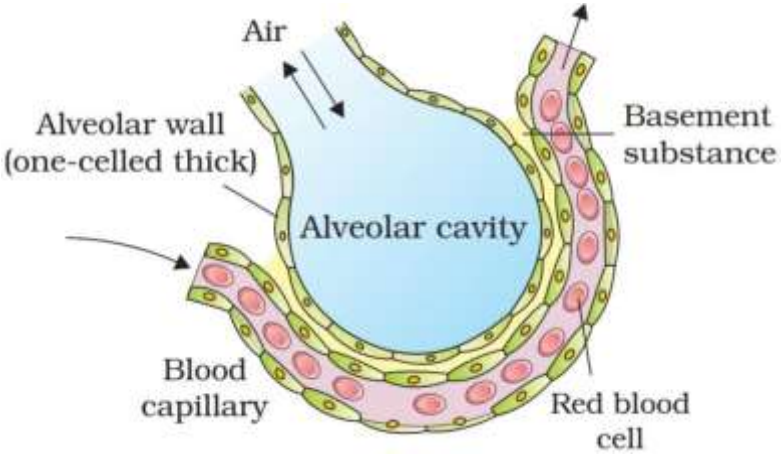
Chapter name	**Plant - Growth and Development**	
Essential Idea	Plant growth and development are regulated by both intrinsic factors – plant growth regulators such as auxins, gibberellins, cytokinin, abscisic acid, and ethylene – and extrinsic factors – light, temperature, nutrition, oxygen status, gravity, etc.	
Item stem	In an experiment, scientists want to promote nutrient mobilisation which helps in the delay of leaf senescence. Which of the following will adversely affect the experiment?	
Correct answer	Cutting the growing root tips	Students understand that root tip produces cytokinin responsible for delaying senescence.
Distractor 1	Removing the flowers	Student misunderstands that growth regulator released in flowers is responsible for delaying senescence.
Distractor 2	Cutting the young buds	Student misunderstands that growth regulator released in young buds is responsible for delaying senescence.
Distractor 3	Cutting the mature fruits	Student misunderstands that growth regulator released in mature fruits are responsible for delaying senescence.

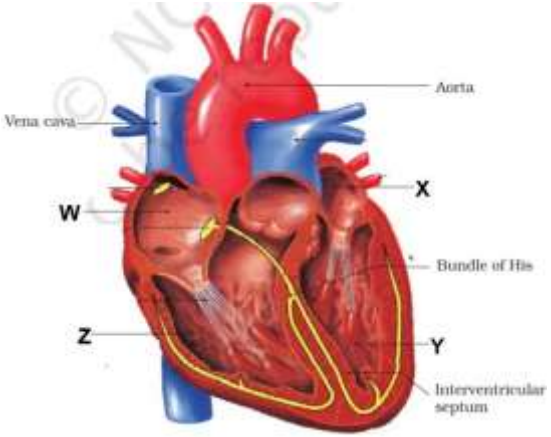
Chapter name	**Breathing and Exchange of Gases**
Essential Idea	Inspiration and expiration are carried out by creating pressure gradients between the atmosphere and the alveoli with the help of specialised muscles – intercostals and diaphragm.
Item stem	The graph represents air flow in and out of the lungs during a normal breath.  A. Which parts of the graph represent inspiration and expiration? B. How does the relationship between the pressure in the lungs and the atmospheric pressure vary between phases OA and AB? C. How is the pressure gradient generated in different phases of breathing?

Marking Rubric

Part	Description	Marks
Sample answer	A. OA represents inspiration and AB represents expiration. B. In phase OA (inspiration), the pressure within the lungs (intra-pulmonary pressure) is less than the atmospheric pressure, and in phase AB (expiration), the pressure within the lungs is slightly above the atmospheric pressure.	

	C. During inspiration, the diaphragm and the external intercostal muscles contract, lifting the ribs and the sternum. This increases the volume of the thoracic chamber and, thereby, the pulmonary volume and leads to a decrease in intra-pulmonary pressure. During expiration, the diaphragm and the inter-costal muscles relax, which returns the diaphragm and sternum to their normal positions and reduces the thoracic volume, which thereby reduces the pulmonary volume and leads to an increase in intra-pulmonary pressure.	
Part A	Identifies the phases of breathing in the graph (0.5 mark for each)	1
Part B	Explains the pressure gradient during expiration and inspiration	1
Part C	Explains how diaphragm and the external intercostal muscles regulate inspiration	1
Part C	Explains how diaphragm and the external intercostal muscles regulate expiration	1

Chapter name	**Breathing and Exchange of Gases**	
Essential Idea	The gases are exchanged between the alveoli and tissues by diffusion, with its rate dependent on the partial pressure gradients of O_2 (pO_2) and CO_2 (pCO_2), their solubility, and the thickness of the diffusion surface.	
Item stem	The diagram below shows a structure involved in gas exchange.  Which of these conditions are important for proper gas exchange?	
Correct answer	pO_2 in alveolar cavity = 104 mmHg pO_2 in pulmonary artery = 40 mmHg	Student understands that the partial pressure of oxygen in the alveoli has to be greater than that of the pulmonary artery to allow oxygen uptake by the blood.
Distractor 1	pO_2 in alveolar cavity = 104 mmHg pO_2 in pulmonary artery = 150 mmHg	Student misunderstands that the partial pressure of oxygen in alveoli has to be less than that of the pulmonary artery to allow oxygen uptake by the blood.
Distractor 2	pCO_2 in alveolar cavity = 40 mmHg pCO_2 in pulmonary artery = 40 mmHg	Student misunderstands that the partial pressure of carbon dioxide in alveoli is the same as that of the pulmonary artery to allow removal of carbon dioxide.
Distractor 3	pCO_2 in alveolar cavity = 40 mmHg pCO_2 in pulmonary artery = 30 mmHg	Student misunderstands that the partial pressure of carbon dioxide in alveoli has to be greater than that of the pulmonary artery to allow removal of carbon dioxide.

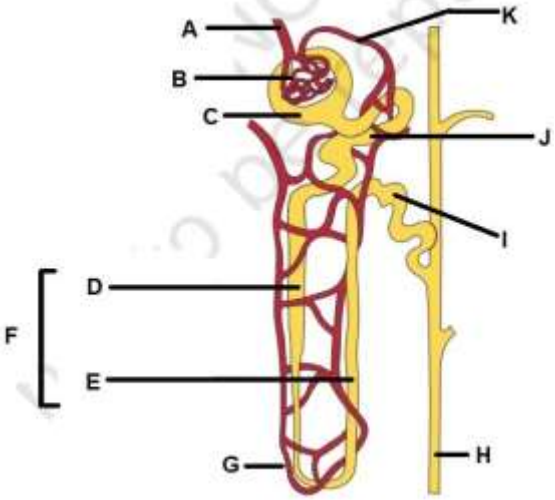
Chapter name	**Body Fluids and Circulation**
Essential Idea	The cardiac cycle is formed by sequential events in the heart—joint diastole, atrial systole, and ventricle systole—which is cyclically repeated and is regulated by neural and hormonal mechanisms.
Item stem	Look at the diagram:  1. Name the structures labelled W--Z. 2. Explain the sequence of 3 events in a cardiac cycle of the heart. 3. A baby is born with a small hole in the wall between the structures Y and Z. How might this affect the oxygen content of the blood pumped out of the heart?

Marking Rubric

Part	Description	Marks
Sample answer	A. W-Right Atrium X- Left Atrium Y- Left Ventricle Z- Right Ventricle A. Atrial and Ventricular diastole: chambers are relaxed and atria are filling in with blood a. Atrial systole: atria contract and remaining blood is pushed into ventricles	

	b. Ventricular systole: ventricles contract and push blood out through aorta and pulmonary artery B. Oxygen content is reduced as oxygen-poor blood returning to the right ventricle from the systemic circuit mixes with oxygen-rich blood of the left ventricle.	
Part A	Identifies each label correctly (0.5 mark for each)	2
Part B	Names each of the 3 events of the cardiac cycle correctly (0.5 mark for each)	1.5
Part B	Explains each of the 3 events of the cardiac cycle correctly (0.5 mark for each)	1.5
Part C	Predicts a logical effect due to hole on the wall	1

Chapter name	**Body Fluids and Circulation**	
Essential Idea	The normal activities of the heart are regulated autonomously by specialised muscles called nodal tissues- sinoatrial node (SA node) and atrioventricular node (AV node).	
Item stem	Choose the correct route through which action potential passes in the heart for the contraction of heart muscle.	
Correct answer	SA node → AV node → Bundle of His → Purkinje fibres → Heart muscles	Student understands that action potential in the heart is generated at the SA node, then to the AV node, then to the bundle of His and then to heart muscles.66
Distractor 1	AV node → SA node → Bundle of His → Purkinje fibres → Heart muscles	Student misunderstands that action potential in the heart is generated at the AV node.
Distractor 2	SA node → Bundle of His → AV node → Purkinje fibres → Heart muscles	Student misunderstands that action potential in the heart is generated at the SA node and then transferred to the AV node through the bundle of His.
Distractor 3	AV node → Bundle of His → SA node → Purkinje fibres → Heart muscles	Student misunderstands that action potential in the heart is generated at the AV node.

Chapter name	**Excretory Products and their Elimination**
Essential Idea	Blood filtrate is refined into urine in the nephron through three main processes: filtration (blood pressure forces water and many small solutes into the nephron), reabsorption of nutrients, salt, and water from the filtrate, and secretion of H^+ and toxins into the filtrate.
Item stem	Study the diagram and answer the questions:  A. Explain how an increase in blood pressure in area (B) would affect the functioning of the nephron. B. Explain why proteins and blood cells are found in area (B) but not in area (J). C. Write the steps of urine formation in nephron. Write in 7 steps.

Marking Rubric

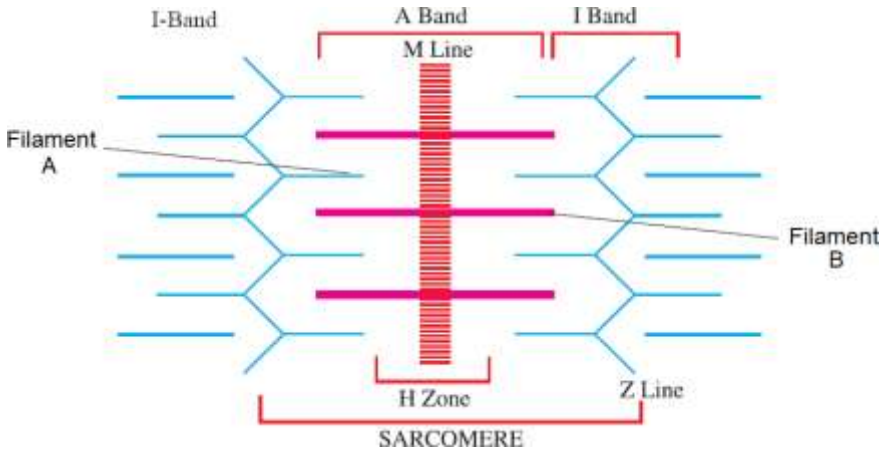
Part	Description	Marks
Sample answer	A. Area (B) is glomerular capillary. The increase in blood pressure causes in glomerular capillary will cause the filtration of blood as it passes into the lumen of the Bowman's capsule through 3 layers, i.e., the endothelium of glomerular blood vessels, the epithelium of Bowman's capsule and a basement membrane between these two layers. B. Blood is filtered so finely through when passing through glomerular capillary into the lumen of the Bowman's capsule, that almost all the constituents of the plasma, except the proteins	

	and cells, pass through. So, glomerular capillary (Area B) has protein and blood cells, but PCT (Area J) doesn't. C. 1. Blood moves through the afferent arteriole into the glomerulus. 2. Molecules except plasma protein and blood cells don't enter the nephron. 3. In PCT, Na^+ is actively transported out of the nephron, followed by Cl^- and HCO_3^-, and water moves from the nephron. 4. Water moves out of the filtrate by osmosis, concentrating salt in the filtrate. 5. Salt diffuses out from the filtrate into interstitial fluid. 6. Nitrogen-containing wastes, excess H^+ ions, and minerals such as K^+ ions are secreted into the filtrate in DCT. 7. Water, salt, and minerals in the collecting duct.	
Part A	Explains the effect of increase in blood pressure causes in glomerular capillary	1
Part B	Provides a relevant justification of how protein in filtered in glomerular capillary	0.5
Part C	Writes 7 steps of the urine formation (0.5 mark for each)	3.5

Chapter name	**Excretory Products and their Elimination**	
Essential Idea	Ammonia, urea, and uric acid are generated by metabolic activities and are the major forms of nitrogenous waste that are excreted by animals.	
Item stem	Read the table. Choose the option that correctly matches the animals with their correct excretory product.	

Excretory product	**Ammonia**	**Urea**	**Uric acid**
A	Frog, Fishes	Humans and birds	Snakes and lizards
B	Frog, Fishes	Snakes and lizards	Humans and birds
C	Fishes	Frog, humans	Birds, snakes, and lizards
D	Fishes, Snakes and lizards	Humans	Frogs and birds

Correct answer	C	Student understands that the main excretory product of reptiles and aves is uric acid. For humans and adult amphibians, it is urea, and for fishes, it is ammonia.
Distractor 1	A	Student misunderstands that the main excretory product of Aves is urea and that for adult amphibians it is ammonia.
Distractor 2	B	Student misunderstands that the main excretory product of humans is uric acid, and for adult amphibians, it is ammonia.
Distractor 3	D	Student understands that the main excretory product of reptiles is ammonia. For adult amphibians, it is uric acid.

Chapter name	**Locomotion and Movement**
Essential Idea	In humans, locomotion and many other movements are facilitated by the coordinated excitability and contractility of the muscle tissues.
Item stem	Look at the diagram of the sarcomere of a muscle and answer the questions:  A. Identify filament A and B. B. What happens to each type of filament during contraction? C. Which of these substances would make the best muscle relaxant, and why? Chemical A: Blocks acetylcholine receptors on muscle cells. Chemical B: Floods the cytoplasm of muscle cells with calcium ions

Marking Rubric

Part	Description	Marks
Sample answer	A. Filament A: Actin Filament B: Myosin B. During contraction, actin and myosin filaments slide past each other longitudinally, so that the degree of overlap between the thin and thick filaments increases and the length of the sarcomere decreases.	

	C. Chemical A would work better, because acetylcholine triggers contraction. Blocking it would prevent contraction. Chemical B would actually increase contraction, because Ca^{2+} allows contraction to occur.	
Part A	Identifies the names of filaments A and B (0.5 marks for each)	1
Part B	Explains what happens to filaments during contraction	1
Part C	Identifies chemical A as the correct chemical for muscle relaxant	0.5
Part C	Writes a relevant justification why chemical A is a better muscle relaxant	1.5

Chapter name	**Locomotion and Movement**	
Essential Idea	The human skeletal system comprises bones and cartilage and is divided into axial and appendicular on the basis of the position of the skeletal structures in the body.	
Item stem	Axial skeleton occupies the longitudinal axis of the body. Choose the option that consists of the names of the skeletal parts present in the axial skeleton.	
Correct answer	Skull, ribs, sternum, vertebral column	Student understands that girdles and limbs are not parts of the axial skeleton.
Distractor 1	Skull, sternum, pelvic girdle, pectoral girdle	Student misunderstands that girdles are parts of the axial skeleton.
Distractor 2	Pectoral girdle, skull, hind limbs, forelimbs	Student misunderstands that girdles and limbs are parts of the axial skeleton.
Distractor 3	Pelvic girdle, pectoral girdle, forelimbs, vertebral column	Student misunderstands that girdles and limbs are parts of the axial skeleton.

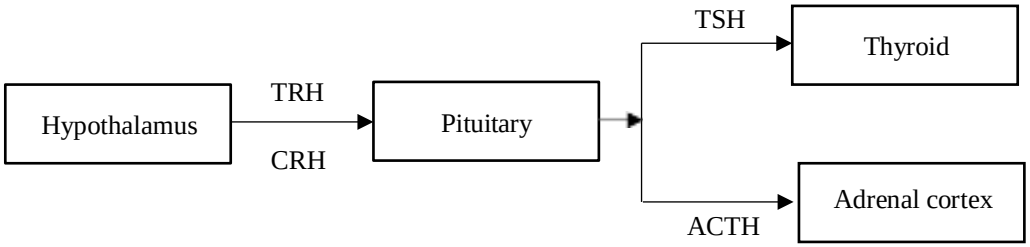
Chapter name	**Neural Control and Coordination**
Essential Idea	The neural system provides an organised network of point-to-point connections for quick coordination by generating and transmitting nerve signals depending on the charge differences across neuron membranes that change in the membrane potential.
Item stem	When you hold a pen, nerve signals are generated in nerve endings in the fingertips and sent to your brain. Once the touch has happened, an action potential (nerve signal) is generated at one end of a neuron. A. What does it mean to generate an action potential on touch? B. What causes the nerve signal to move from that point along the length of the neuron to the other end? Write in 7 steps. C. Why can't a nerve signal go backward?

Marking Rubric

Part	Description	Marks
Sample answer	A. The nerve fibre is in the resting phase when it is not stimulated by any impulse and they possess the potential difference along the membrane, which is known as the resting potential (-70mv). When this potential difference changes due to a signal, it is called a generation of action potential. B. 1. In response to a signal (touch), the membrane becomes permeable to sodium ions rather than potassium ions. 2. A rapid inflow of sodium ions happens. 3. The membrane of the nerve end depolarises as it becomes a positive charge inside and a negative charge outside the nerve fibre. 4. At the peak action potential, permeability to sodium ions decreases and that to potassium ions increases. 5. A rapid outflow of potassium ions happens. 6. The first part of the membrane repolarises 7. The depolarisation spreads down the axon as opened Na^+ gates stimulate neighbouring Na + gates to open. C. When a segment of nerve fibre is depolarised, the previous segment is always in a repolarised state and cannot be depolarised immediately. This is why a nerve signal cannot travel backwards.	

Part A	Explains what exactly "generation of action potential" means, such as:	0.5
Part B	Writes the nerve signal transmission in 8 steps (0.5 marks for each)	3.5
Part C	Provides a correct reason of why nerve signal cannot travel backwards	1

Chapter name	**Neural Control and Coordination**	
Essential Idea	Human neural system consists of two parts: central neural system and the peripheral neural system which are further divided each with a specific and important function.	
Item stem	Ram is thrilled today as he learned and understood a chapter in biology that he thought is difficult. Now, he is motivated and aspired to study like this to become a life-scientist. Which part of his brain responsible for these responses?	
Correct answer	Limbic system of forebrain	Student understands that limbic system of fore brain is involved emotional and motivational response
Distractor 1	Midbrain	Student misunderstands that midbrain is involved emotional and motivational response
Distractor 2	Medulla of hindbrain	Student misunderstands that hind brain is involved emotional and motivational response
Distractor 3	Spinal cord	Student misunderstands that spinal cord is involved emotional and motivational response

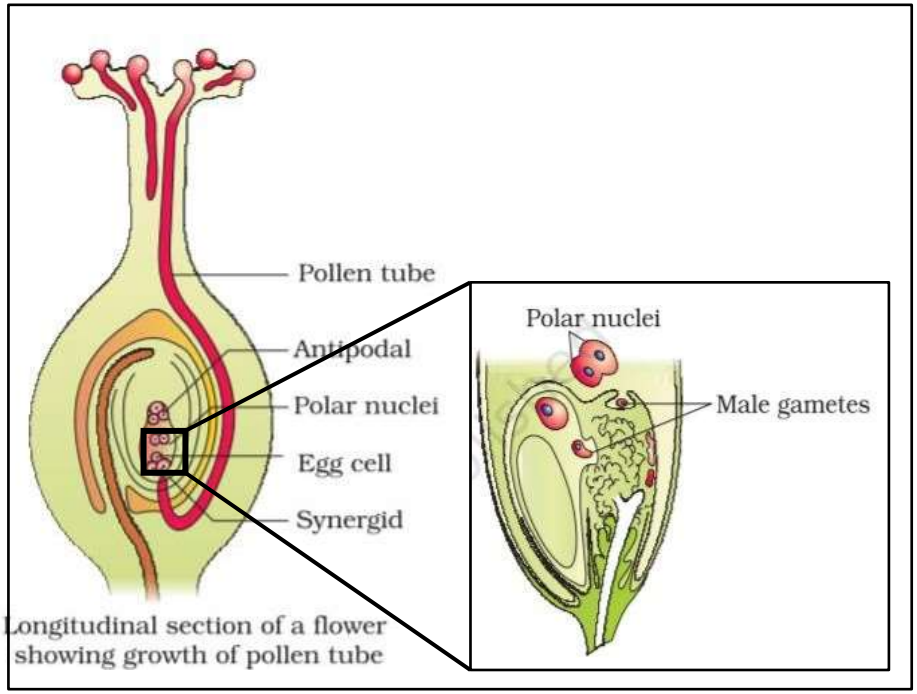
Chapter name	**Chemical Coordination and Integration**
Essential Idea	In humans, the hypothalamus exerts master control by sending signals directly to the pituitary gland, which in turn secretes hormones that influence numerous body functions.
Item stem	Look at the flow chart showing some hormones and their target organs.  A. Name one hormone secreted by thyroid and adrenal cortex and their function. B. An inhibitor has been introduced into the body that inhibits the hypothalamus from secreting any hormone. How will this affect the hormonal action of the thyroid and adrenal cortex? C. Growth hormone is secreted by anterior pituitary gland. A dwarfism disease called Laron dwarfism does not respond to growth hormone treatments (growth hormone injected into the body externally). What could be a possible reason for this type of dwarfism?

Marking Rubric

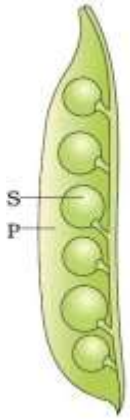
Part	Description	Marks
Sample answer	A. The thyroid gland secretes thyroxine. It plays an important role in the regulation of the basal metabolic rate. The adrenal cortex secretes cortisol, which is involved in carbohydrate metabolism. B. If the secretion of hormones by the hypothalamus is inhibited, then the thyroid and adrenal cortex would not be able to secrete any hormones as well due to a lack of stimulation from	

	the pituitary gland. This, in turn, would lead to a decreased body metabolic rate and reduced carbohydrate metabolism. C. There can be a deficiency in growth hormone receptors. So, even when the growth hormone is supplied externally, no action can be observed.	
Part A	Names one hormone secreted by each gland (0.5 mark for each)	1
Part A	Writes the function of each hormone secreted by the glands (0.5 mark for each)	1
Part B	Writes a relevant and logical answer for the effect of inhibition on hypothalamus	1
Part C	Writes a relevant cause of Laron dwarfism based on given conditions	1

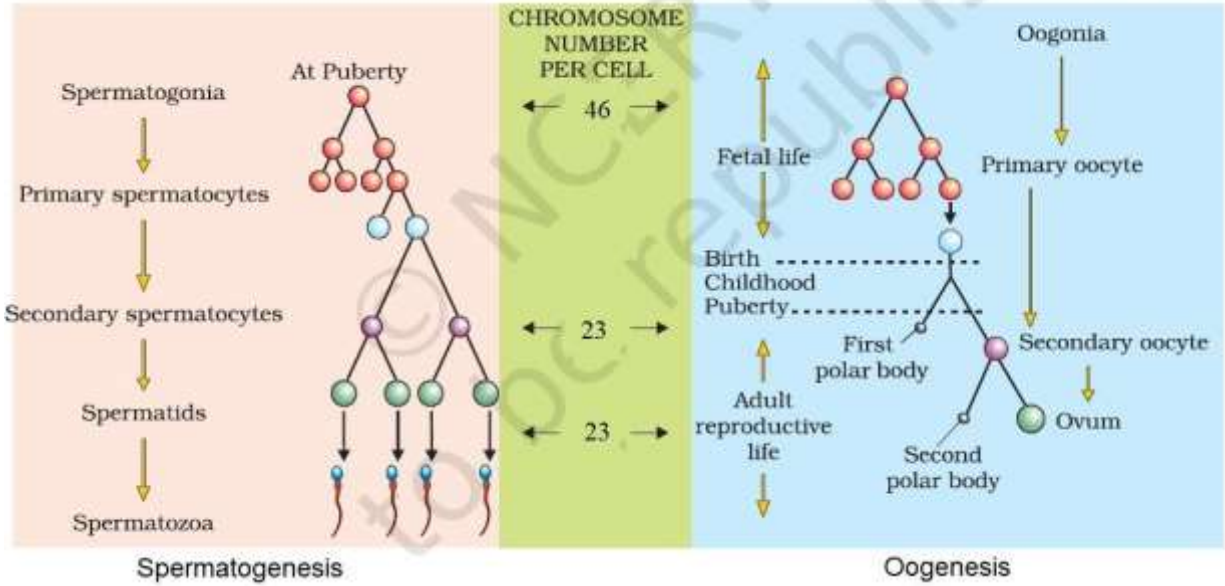
Chapter name	**Chemical Coordination and Integration**	
Essential Idea	Hormones affect cells using two distinct mechanisms – water-soluble hormones bind to plasma membrane receptors and steroid hormones bind to intracellular receptors.	
Item stem	Hormone X is a newly discovered hormone that regulates protein metabolism. Scientists found when that when treated with the water-soluble inhibitors of the secondary messenger of Hormone X , the target cells were unable to metabolise protein. What can you infer from this observation?	
Correct answer	Hormone X is a water-soluble hormone that binds to plasma membrane receptors.	Student understand that a water-soluble hormone binds to plasma membrane receptors and requires the action of a secondary messenger.
Distractor 1	Hormone X is a steroid hormone that binds to intracellular receptors.	Student misunderstands that steroid hormones that bind to intracellular receptors require secondary messengers for action.
Distractor 2	Hormone X is a water-soluble hormone that binds to intracellular receptors.	Student misunderstands that water-soluble hormones can cross the plasma membrane and bind to intracellular receptors.
Distractor 3	Hormone X is a steroid hormone that binds to plasma membrane receptors.	Student misunderstands that steroid hormones cannot cross the plasma membrane and bind to plasma membrane receptors.

Chapter name	**Sexual Reproduction in Flowering Plants**
Essential Idea	Angiosperms involve double fertilization where one male gamete fuses with the egg and another male gamete fuses with two polar nuclei in the embryo sac.
Item stem	Look at the image inset showing the discharge of male gametes in the embryo sac.  Longitudinal section of a flower showing growth of pollen tube Based on the diagram, explain how does the sexual reproduction in flowering plants involve double fertilisation and triple fusion?
Marking Rubric	

Part	Description	Marks
Sample answer	The pollen tube releases the two male gametes into the cytoplasm of the synergid. One of the male gametes fuses with the nucleus of the egg cell, forming the zygote. The other male gamete fuses with two polar nuclei to produce a triploid primary endosperm nucleus (PEN). This involves the fusion of three haploid nuclei. It is termed "triple fusion." As it involves two types of fusion—syngamy and triple fusion—in an embryo sac, the phenomenon is termed "double fertilisation."	
	Explains the process of triple fusion	1
	Explains the process of double fertilisation	1

Chapter name	**Sexual Reproduction in Flowering Plants**	
Essential Idea	After fertilisation, the ovary develops into fruit, ovules develop into seeds, and the embryo of a dicot plant develops and matures, forming two cotyledons and an embryonal axis, whereas the embryo of a monocot plant has a single cotyledon.	
Item stem	Look at the image of a fruit –pea—showing seeds (S) and pericarp (P).  Which of these correctly shows the structure that each part of the pea was before fertilisation?	
Correct answer	S: Ovule P: Ovary wall	Student understands that after fertilisation, the ovary develops into fruit, ovules develop into seeds, and the ovary wall becomes pericarp.

	Fruit: Ovary	
Distractor 1	S: Ovary P: Ovary wall Fruit: Ovule	Student misunderstands that after fertilisation, the ovary develops into a seed.
Distractor 2	S: Ovule P: Zygote Fruit: Ovary	Student misunderstands that after fertilisation, the zygote develops into a pericarp.
Distractor 3	S: Ovary P: Ovule Fruit: Ovary wall	Student misunderstands that after fertilisation, the ovary develops into a seed.

Chapter name	**Human Reproduction**
Essential Idea	The process of gamete formation involves mitosis followed by meiosis of diploid germ cells at different stages of life in males and females.
Item stem	Look at the image showing the process of gametogenesis in both males and females. 

	A. What types of division happen when spermatogonia produce primary spermatocytes and oogonia produces primary oocytes? When in the lifetime of a male and female does this division happen? B. When and what cells undergo the first and second meiotic division in spermatogenesis and oogenesis?

Marking Rubric

Part	Description	Marks
Sample answer	A. Spermatogonia produce primary spermatocytes through mitotic division. It happens in the males at puberty. Oogonia produces primary oocytes through mitotic division. It happens in the females at the foetal stage. B. In spermatogenesis, the first meiotic division occurs in primary spermatocytes to produce secondary spermatocytes, and the second meiotic division occurs in secondary spermatocytes to produce spermatids at puberty. In oogenesis, first meiotic division occurs in primary oocytes starting at child birth to produce secondary oocytes at puberty, and second meiotic division occurs in secondary oocytes to produce an ovum just before fertilisation.	
Part A	Mentions the type of division in males and its time of occurrence (0.5 marks for each)	1
Part A	Mentions the type of division in females and its time of occurrence (0.5 marks for each)	1
Part B	Defines the stages and cells that undergo meiotic divisions in spermatogenesis (0.5 marks for each)	1
Part B	Defines the stages and cells that undergo meiotic divisions in oogenesis (0.5 marks for each)	1

Chapter name	**Human Reproduction**
Essential Idea	The human reproductive cycle and events that occur after puberty are regulated by the secretion of different reproductive hormones.
Item stem	In a woman, blood analysis showed high levels of follicle-stimulating hormones, luteinizing hormone and oestrogen, and a considerably low level of progesterone.

	Which of these is most likely to be the stage of her menstrual cycle?	
Correct answer	End of the follicular phase	Student understands that LH and FSH peaks happen during ovulation at the end of the follicular phase.
Distractor 1	Luteal phase	Student does not know that the level of progesterone remains considerably high in the luteal phase.
Distractor 2	Start of the menstruation phase	Student does not know that the level of oestrogen remains considerably low in the menstruation phase.
Distractor 3	End of the menstruation phase	Student does not know that the level of oestrogen remains considerably low in the menstruation phase.

Chapter name	**Reproductive Health**
Essential Idea	Counselling and creating awareness among people about reproductive organs, adolescence and associated changes, sexual practices, using appropriate contraceptives, sexually transmitted infections (STIs) including AIDS can cause an overall improvement in reproductive health.
Item stem	These are the statements regarding contraception. Write if the statement is true and false with reason. a) Medical Termination of Pregnancy (MTP) is relatively safe during the first 12 weeks of pregnancy. b) Diaphragms are made of rubber that are used to cover the penis to prevent the ejaculated semen enter into the female reproductive tract. c) Intra-Uterine Devices (IUDs) release copper ions that increase sperm motility and fertilising capacity of sperms.

Marking Rubric

Part	Description	Marks
Sample answer	a) **True**. MTPs are considered relatively safe during the first trimester, i.e., up to 12 weeks of pregnancy. Second trimester abortions are much riskier. b) **False**. Diaphragms are made of rubber that are inserted into the female reproductive tract to cover the cervix during coitus. c) **False**. IUDs increase phagocytosis of sperms within the uterus and the Cu ions released suppress sperm motility and the fertilising capacity of sperms.	
	States true/false correctly (0.5 marks for each)	1.5 marks
	Provides valid reason for each answer (0.5 marks for each)	1.5 marks

Chapter name	Reproductive Health	
Essential Idea	Reproductive health refers to a total well-being in all aspects of reproduction, i.e., physical, emotional, behavioural and social.	
Item stem	Which of the these can be considered as reproductively healthy?	
Correct answer	Women can go safely through pregnancy and childbirth without health hazards.	Student understands that reproductive health means total well-being of physical, emotional, behavioural and social aspects of reproduction.
Distractor 1	The needs of the pregnant females are ignored and unmet.	Student misunderstands that reproductive health doesn't involve emotional, behavioural and social aspects of reproduction.
Distractor 2	A woman in the distress of carrying an unwanted pregnancy.	Student misunderstands that reproductive health doesn't involve emotional, behavioural and social aspects of reproduction.
Distractor 3	Increased cases of domestic violence.	Student misunderstands that reproductive health doesn't involve emotional, behavioural and social aspects of reproduction.

Chapter name	**Principles of Inheritance and Variation**
Essential Idea	Inheritance pattern of distantly located factors (now called genes), assort independently and closely located linked genes assort together, and then combine in all permutations and combinations.
Item stem	The flower colour gene of rose and snapdragon plants show incomplete dominance. When their pure breeds of red and tall plants are crossed with white short ones, F1 generations that are pink and tall are produced. In snapdragon, when the F1 is self-crossed, the ratio of F2 phenotypes was 3 red tall: 6 pink tall: 3 white tall:1 red short: 2 pink short: 1 white short. In rose plants, when F1 is self-crossed, the ratio of F2 phenotypes was 1 red tall: 2 pink tall: 1 white short. From the ratios of the F1 and F2 generations, what can you conclude about the inheritance pattern for flower colour and plant height in snapdragon and rose?

Marking Rubric

Part	Description	Marks
Sample answer	In snapdragon plants, the flower colour gene and plant height gene are unlinked and assort independently. Dihybrid cross of snapdragon plants: Parents RRTT rrtt F1 generation RrTt (Pink and tall) F2 generation	

Gametes	RT	Rt	rT	rt
RT	RRTT Red and tall	RRTt Red and tall	RrTT Pink and tall	RrTt Pink and tall
Rt	RRTt Red and tall	RRtt Red and short	RrTt Pink and tall	Rrtt Pink and short
rT	RrTT Pink and tall	RrTt Pink and tall	rrTT White and tall	rrTt White and tall
rt	RrTt	Rrtt	rrTt	rrtt

	Pink and tall	Pink and short	White and tall	White and short

In rose plants, the flower colour gene and plant height gene in snapdragon plants are completely linked and do not separate out during crossing over.

Dihybrid cross of the rose plants:

Parents: RRTT × rrtt

F1 generation: RrTt (Pink and tall)

Complete linkage

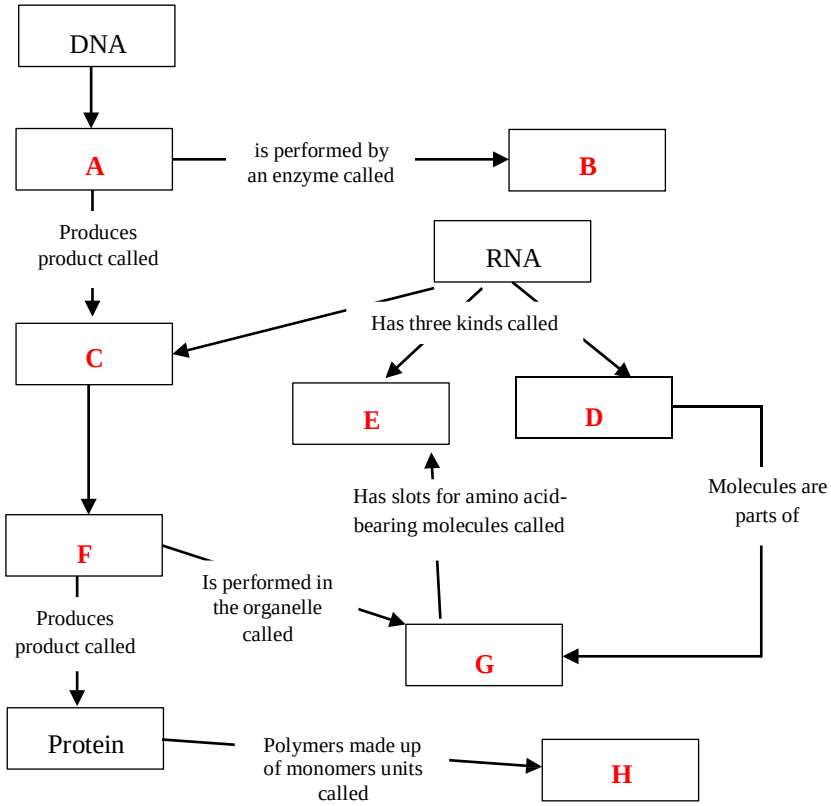
F2 generation

Gametes	RT	Rt
RT	RRTT Red and tall	RrTt Pink and tall
rt	RrTt Pink and tall	Rrtt Pink and short

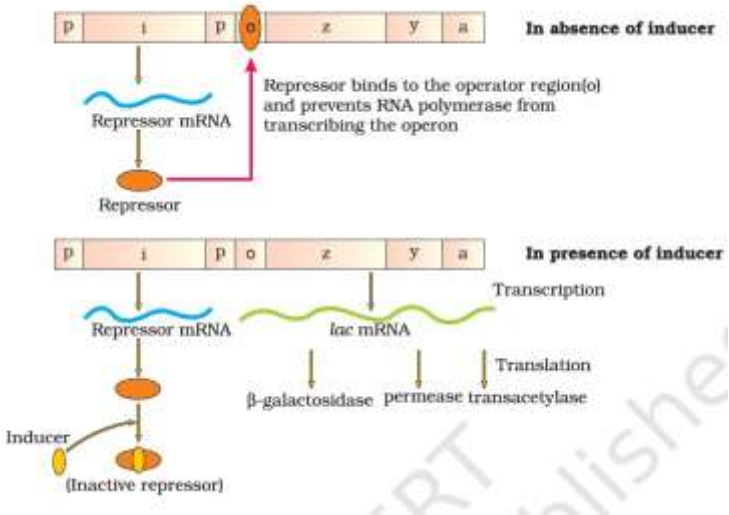
Finally, we can also say that for both snapdragon and rose, the flower colour exhibits co-dominance. While the tall plant phenotype is dominant over the short plant height phenotype.

	Provides justification that rose plants have linked genes but the genes in snapdragon plants are assorting independently.	1
	Illustrates the dihybrid cross of F2 generation of rose plants	1
	Illustrates the dihybrid cross of F2 generation of snapdragon plants	1

Chapter name	**Principles of Inheritance and Variation**	
Essential Idea	Inheritable genetic disorders can be studied by generating a pedigree of a family.	
Item stem	Colour blindness is a X-linked recessive disease. Tina and her friend Ketan are suffering colour-blindness. Which of these would true for both?	
Correct answer	Tina's father is colour-blind, and Ketan's mother is either a carrier or colour-blind.	Student understands that a woman to be colour-blind, the X chromosome passed on by the father (who has just one X chromosome) must have colour-blindness trait
Distractor 1	Tina's mother must be colour-blind, but Ketan's father is a carrier.	Student misunderstands that a male (XY) inherits the colour-blindness allele from father (who passes Y chromosome to the son).
Distractor 2	Tina's father is colour-blind, but Ketan's father is a carrier.	Student misunderstands that a male (XY) inherits the colour-blindness allele from father (who passes Y chromosome to the son).
Distractor 3	Tina's mother must be colour-blind and father must be normal, but Ketan's mother is either a carrier or colour-blind.	Student misunderstands that a female (XY) to be colour-blind, she must inherit X chromosomes bearing the colour-blindness allele from both parents

Chapter name	**Molecular Basis of Inheritance**
Essential Idea	In all organisms, DNA stores genetic information and the flow of genetic information occurs from DNA to RNA to protein.
Item stem	Complete the flow chart of movement of genetic information in a cell. The unknowns contain molecules and names of processes. 

Correct answer	A: transcription; B: RNA polymerase; C: mRNA; D: rRNA; E: tRNA; F: translation; G: ribosomes; H: amino acids	Student understands the flow of genetic information in central dogma
Distractor 1	A: transcription; B: DNA polymerase; C: mRNA; D: rRNA; E: tRNA; F: translation; G: ribosomes; H: amino acids	Student misunderstands that DNA polymerase performs transcription
Distractor 2	A: translation; B: DNA polymerase; C: rRNA; D: mRNA; E: tRNA; F: transcription; G: ribosomes; H: amino acids	Student misunderstands that rRNA is produced as a product in transcription and mRNA is a part of ribosomes
Distractor 3	A: transcription; B: RNA polymerase; C: rRNA; D: tRNA; E: mRNA; F: translation; G: ribosomes; H: amino acids	Student misunderstands that tRNA is a part of ribosomes and mRNA carries amino acid with them

Chapter name	**Molecular Basis of Inheritance**
Essential Idea	Transcription and translation are energetically very expensive processes and so are tightly regulated in different ways in prokaryotes and eukaryotes.
Item stem	Look at the lac operon in a bacterium.  Predict how these mutations would affect the function of the operon in the presence and absence of lactose(inducer): A. Mutation of regulatory gene (i); mutated repressor won't bind to lactose but will bind to operator. B. Mutation of operator (o); repressor will not bind to operator. C. Mutation of promoter (p); RNA polymerase will not attach to promoter.

Marking Rubric

Part	Description	Marks
Sample answer	A. The mutated repressor binds to the operator on the DNA, and would continuously repress the operon; enzymes for lactose utilization would not be made, whether or not lactose was present. B. The lac genes would continue to be transcribed and the enzymes made, whether or not lactose was present. C. RNA polymerase would not be able to transcribe the genes and no proteins would be made, whether or not lactose was present.	

	Predicts what happens to the functioning of lac operon in case of each mutation (1 mark each)	3

Chapter name	**Evolution**
Essential Idea	Natural selection is the process of differential survival and reproduction that results in the change of allele frequencies in a population over time.
Item stem	A type of bird is preying on snails and in this process, they break their shell open on rocks, eat the soft bodies, and leave the shells. In this snail population, there are two forms—smooth and rough-shelled. In one area, a group of scientists counted both live snails and broken shells.

	Rough-shelled	Smooth-shelled	Total
Living	264	296	560
Broken	486	377	863

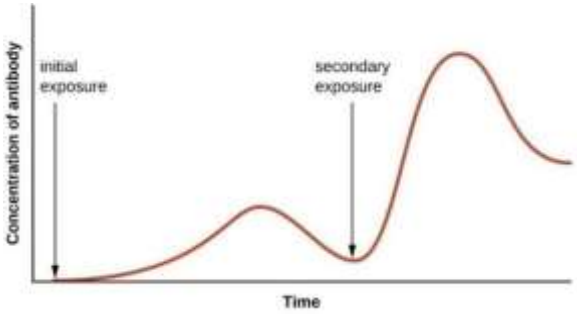
A. Which snail form seems better adapted to this environment? Why?
B. Assuming that all the broken shells result from the meals of birds, predict how the frequencies of smooth and rough snails might change in the future. Name the type of natural selection.

Marking Rubric

Part	Description	Marks
Sample answer	A. The smooth-shelled snails appear to be better adapted. Rough-shelled snails make up 47% of the living population but 56% of the broken shells. B. The bird predation would reduce the frequency of rough-shelled snails and the frequency of unstriped individuals would increase. It is showing directional selection.	
Part A	Mentions smooth-shelled snails to be better adapted	0.5
Part A	Provides appropriate reason for the choice using given data	0.5

Part B	Predicts correctly how would the frequency of the population would change and names the type of natural selection	1

Chapter name	**Evolution**	
Essential Idea	The Hardy-Weinberg principle states that allele and genotype frequencies will remain constant if a population is large, mating is random, and there is no mutation, gene flow, or natural selection.	
Item stem	For coat colour of mice, black (Bb) appears dominant to albino (bb). In an experiment, a large population of laboratory mice are randomly mated. It contains 36% albino mice. Since this population has no mutation, gene flow, or natural selection, what is the frequency of heterozygous alleles (Aa) in this population?	
Correct answer	0.48	Student understands that as $a^2 = 0.36$, then a = 0.6; A + a = 1, then A = 0.4; then Aa is 0.48 (2Aa = 2 x 0.4 x 0.6 = 0.48).
Distractor 1	0.40	Student misunderstands that frequency of heterozygous alleles is same as frequency of dominant allele
Distractor 2	0.60	Student misunderstands that frequency of heterozygous alleles is same as frequency of recessive allele
Distractor 3	0.24	Student misunderstands that frequency of heterozygous alleles is same as frequency of Aa instead of 2Aa

Chapter name	**Human Health and Diseases**
Essential Idea	At the entry of pathogens into the body, specific antibodies are produced by B cells to kill the pathogens and retain memory of them. On subsequent exposure to the same pathogen, the immune response is rapid and more intense. This forms the basis of the protection afforded by vaccination and immunisation.
Item stem	The graph given below is showing the levels of antibodies against a pathogen in a person's body.  A. What do the two peaks mean? Why are they different in size? B. It was observed that if a person had previously contracted cow pox, they would be immune to smallpox. Why is that so? How does this theory and observation help to develop a technique to immunise a person against attack by various disease-causing organisms?

Marking Rubric

Part	Description	Marks
	A. Peak 1 represents primary and peak 2 represents secondary immune responses. The size of the two peaks is different since the increase in antibody levels in the blood due to infection in the primary response is less intense than that of the secondary response, which is aided by memory antibodies. B. The causative agents of cowpox are similar to those of smallpox. A cowpox infection induces active immunity (produces memory antibodies in the blood) that protects people from small pox. Vaccination happens by artificially stimulating the body to develop antibodies against infectious disease by the administration of antigens, attenuated disease-causing organisms,	

	or toxoids. Therefore, by exposing an individual to an antigen in a controlled way, their body will then be able to protect itself from disease-causing organisms later in life.	
Part A	Mentions the name of peaks in term of immunity.	0.5
Part A	Explains the reason for the difference in the levels of antibodies generated in primary and secondary response.	0.5
Part B	Provides the reason for active immunity against small pox when infected with cow pox.	1
Part C	Identifies and explains vaccination as the technique used to prevent the disease.	1

Chapter name	**Human Health and Diseases**	
Essential Idea	Diseases like typhoid, cholera, pneumonia, fungal infections of skin, malaria and many others are a major causes of distress to human beings and if not treated, may prove fatal.	
Item stem	A patient is suffering from sustained high fever (39° to 40°C), weakness, stomach pain, constipation, headache and loss of appetite. As a doctor, which of the test you suggest to diagnose the disease?	
Correct answer	Widal test	Student understands that the symptoms are sign of typhoid.
Distractor 1	ELISA for HIV	Student misunderstands that the symptoms are sign of HIV.
Distractor 2	Complete blood count (CBC) test	Student misunderstands that the symptoms are sign of malaria.
Distractor 3	RT-PCR test	Student misunderstands that the symptoms are sign of viral fever.

Chapter name	**Microbes in Human Welfare**
Essential Idea	Microbes are used to produce useful household products, industrial products and in sewage treatment.
Item stem	A biologist has inoculated equal amount of bacteria A, fungus B, and both bacteria A and fungus B on 3 different sterile petri dishes. Bacteria A is a pathogen. After 24 hours, she observed growth in all three.

Culture in the Petri dish	Bacteria A (Plate 1)	Fungus B (Plate 2)	Bacteria A + Fungus B (Plate 3)
Number of colonies	46 small round colonies	9 medium round colonies	4 small round colonies and 10 medium round colonies

1. Based on the difference in the growth of bacteria A and Fungus B in Plate 3 as compared to when grown individually, what conclusion can you draw about effect of one on another? Explain.
2. Can bacteria A or fungus B be of any use to human health? How?
3. Give an example of a fungus and its product used for similar purposes.

Marking Rubric

Part	Description	Marks
Sample answer	1. Fungus B is inhibiting the growth of bacteria A. When both organisms were grown together, the number of colonies of bacteria A was less but fungus B was the same. 2. Yes. Fungus B can be used for producing antibiotics. These antibiotics can be used to treat humans infected with bacteria A. 3. Penicillin produced *Penicillium notatum*	
Part 1	Fungus B is inhibiting the growth of bacteria A	0.5
Part 1	Explains what result shows that fungus B is inhibiting the growth of bacteria A	0.5
Part 2	Infers the logical use of fungus B for human health	1
Part 3	Gives a correct example of a fungus product used as antibiotics	1

Chapter name	**Microbes in Human Welfare**	
Essential Idea	Microbes are also used to produce biogas, preventing our dependence on non-renewable resources for energy, and to kill harmful pests as biocontrol, avoiding the heavy use of toxic pesticides for controlling pests.	
Item stem	For the last 2 years, Ramesh has used chemical fertilisers and pesticides in his paddy field to increase crop yield. This has led to a decrease in the content of organic matter, humus content of the soil, altered pH of the soil and stunted plant growth. Which of these do you suggest he should practise to replenish soil nutrients?	
Correct answer	Using cyanobacteria and blue green algae containing biofertilizer	Student understands the importance of biofertilizers
Distractor 1	Using the method of drip irrigation	Student misunderstands that drip irrigation can replenish soil nutrients.
Distractor 2	Using different brand of chemical fertilizer	Student misunderstands that chemical fertiliser can be used to replenish soil nutrients.
Distractor 3	Using *E. coli* and *S. Cerevisiae* containing biofertilizer	Student misunderstands that biofertilizers contain *E. coli* and *S. cerevisiae.*

Chapter name	**Biotechnology - Principles and Processes**
Essential Idea	Modern biotechnology using genetically modified organisms was made using the knowledge to alter the chemistry of DNA using various enzymes and construct recombinant DNA using various tools and techniques.
Item stem	In recombinant DNA technology, different target cells can be made ‘competent’ through three different methods– $CaCl_2$ treatment, gene gun (biolistic), and micro-injection.

There are three target cell samples:

Sample A	Carrot cells
Sample B	Escherichia coli cells
Sample C	Rat skin cells

(a) Explain what is meant when a cell is competent.
(b) Which method of can be used to make cells of each of the samples competent?
(c) Describe each process that molecular biologists apply to induce competency in cells.

Marking Rubric

Part	Description	Marks
Sample answer	a. A cell is competent means it has ability to take up foreign (extracellular), hydrophilic DNA from its surrounding environment through hydrophobic cell membrane. b. Sample A – gene gun (plant cells) Sample B – $CaCl_2$ treatment (bacterial cells) Sample C - micro-injection (animal cells) c. Gene gun - Cells are bombarded with high velocity micro-particles of gold or tungsten coated with DNA $CaCl_2$ treatment – Bacterial cells are treated with divalent cation (calcium) and exposed to cold and high temperature alternatively. Micro-injection - recombinant DNA is directly injected into the nucleus of an animal cell	
Part a	Describes the meaning of a competent cell	1
Part b	Identifies the correct method for plant, animal and bacterial cell samples. (0.5 mark for each)	1.5
Part c	Describes the process of three methods correctly (0.5 mark for each)	1.5

Chapter name	**Biotechnology - Principles and Processes**	
Essential Idea	The process of recombinant DNA involves the use of restriction endonucleases, DNA ligase, appropriate plasmid or viral vectors to isolate and ferry the foreign DNA into host organisms, expression of the foreign gene, and extraction and purification of the gene product.	
Item stem	A scientist wants to engineer *E. coli* to produce human growth hormone (HGH). He has all the necessary tools and an appropriate DNA probe for selecting transformants. Select the correct arrangement of these processes in the sequence they should be used to create HGH producing *E.coli*. a) Isolate plasmids from a culture of E. coli. b) Bacteria will then replicate plasmids and multiply, producing clones of bacterial cells. c) Allow E. coli to take up recombinant plasmids. d) Join the plasmids and the fragments of human DNA with ligase. e) Identify a transformants carrying and expressing the HGH gene using a nucleic acid probe. f) Cut the plasmids and the human DNA containing the HGH gene with the restriction enzyme to produce molecules with sticky ends. g) Grow large amounts of the bacteria and extract and purify HGH from the culture.	
Correct answer	(a), (f), (d), (c), (b), (e), (g)	Student understands the step-by-step method of recombinant DNA technology
Distractor 1	(a), (d), (f), (c), (b), (e), (g)	Student misunderstands that in recombinant DNA technology, ligation of desired gene happens before cutting it using restriction enzymes
Distractor 2	(a), (f), (d), (c), (b), (g), (e)	Student misunderstands that in recombinant DNA technology, large-scale growth of recombinants happens before their identifications using selectable marker
Distractor 3	(a), (f), (d), (g), (c), (b), (e)	Student misunderstands that in recombinant DNA technology, large-scale growth of recombinants happens before cells take up desired gene

Chapter name	**Biotechnology and its Application**
Essential Idea	Modern biotechnology provides significant applications to increase quality and quantity in medicine for diagnosis and gene therapy, and in agriculture for producing genetically modified organisms, such as Bt cotton and pest-resistant plants.
Item stem	Some strains of *Bacillus thuringiensis* produce protein called Bt toxin coded by cry genes in their growth phase. It can kill certain insects but not bacteria. Why does Bt toxin kill insects but not Bacillus? How does this property of Bt toxin benefit in controlling pests of crop plants? There are two crops: Cotton crops A: infested by cotton bollworm Maize crops B: infested by corn borer. Look at the different cry genes in the DNA of a strain of Bacillus.  Which cry gene should be isolated and incorporated into the cotton crop A and maize crop B to control its pest?

Marking Rubric

Part	Description	Marks
Sample answer	A. Bt toxin protein cannot harm *Bacillus* since when it is present in the bacteria, it exists in the form of a crystalline inactive protoxins. In insects, Bt toxin is converted into an active form of toxin due to the alkaline pH of the insect gut which binds to the surface of midgut epithelial cells and create pores that cause cell swelling and lysis and eventually cause death of the insect. B. The specific Bt toxin genes are isolated from *Bacillus thuringiensis* and incorporated into the several crop plants to produce transgenic plant that contains Bt toxin and can kill pest insects. C. *cryIAc* or *cryIIAb* gene should be isolated to control the infestation of bollworms in cotton crops A. *cryIAb* gene should be isolated to control the infestation of corn borer in maize crops B.	
Part A	Explains inactiveness of Bt toxin in Bacteria	0.5
Part A	Explains how Bt toxin harm insects when ingested	1

Part B	Explains how Bt toxin gene in plants can act as pest control	1.5
Part C	Identifies correct *cry* gene to be incorporated based on plants and pests	1

Chapter name	**Biotechnology and its Application**	
Essential Idea	The current interest in biotechnological practises involving the manipulation of microbes, plants, and animals has raised a need for ethical standards to evaluate the morality of all human activities that might help or harm living organisms.	
Item stem	With technological advancements, it is easy to make transgenic plants and animals. Which of these is not an important safety and ethical issue in using recombinant DNA technology?	
Correct answer	Increased in the cost in biotechnological research.	Student understands the ethical issues concerning RDT and that cost of the research won't fall in ethical issue.
Distractor 1	Public access to information about the biology of the process to make informed decisions.	Student does not understand that public point of view is also relevant in ethical issues regarding RDT.
Distractor 2	Anticipate and deal with possible unforeseen and negative consequences.	Student does not understand the ethical issues concerning RDT.
Distractor 3	Adequate benefit sharing between developed and developing countries.	Student does not understand the ethical issues concerning RDT.

Chapter name	Organisms and Populations
Essential Idea	Ecological effects of any factors on a population are generally reflected in its size and growth which is measured through birth, deaths, immigration, and emigration rates.

Item stem

In a genetics study, a specific gene related to the wing shape of fruit fly Drosophila was mutated. Post 1 day of mutagenesis the alive flies (F_0 generation) were used for breeding to produce offspring (F_1 generation). Consider that it takes a week for a fruit fly to reach adulthood from its birth. An equal number of flies did not undergo mutagenesis and this was taken as a control population for the experiment.

Mutant = Flies that undergo mutation
Control population= Flies that do not undergo mutation

Consider all mutant drosophila are completely mutated. The following observations were noted.

	Number of flies taken in the group	No. of flies alive 1 day after mutagenesis	No. of offspring in the F_1 generation					No. of offspring that reach adulthood in 5 days
			Day 1	Day 2	Day 3	Day 4	Day 5	
Mutant	5000	4000	100	300	250	250	100	100
Control	5000	4500	700	500	400	600	800	2500

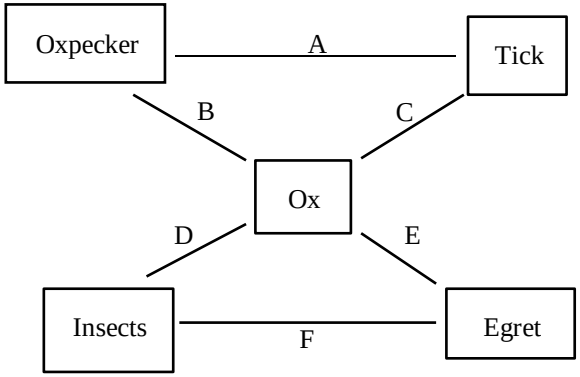
Answer the following questions using the data given above

A. Post 1 day of mutagenesis, what was the death rate in the initial F_0 population for both mutant and control groups.
B. Calculate the birth rate and death rate for the offspring F_1 generation belonging to both mutant and control parents.
C. Does the mutation experiment affect the survival of the F_0 and F_1 generation flies? Give a reason for your argument.

Marking Rubric

Part	Description	Marks

Sample answer	A. Death rate for the mutant group: (5000-4000)/5000 = 0.2 individual per fruit fly per day Death rate for control group: 0.1 individual per fruit fly per day. B. Birth rate for Mutant F1 generation: (1000-100)/1000= 0.9 individual per fruit fly per 5 days Birth rate for control F1 generation: (3000- 2500)/3000= 0.167 individual per fruit fly per 5 days C. Yes. The birth rate for the mutant group is lower than that of control group shows that mutation affects the survival of the population.	
Part A	Calculates for death rate for mutant and control group using correct formula	1
Part B	Calculates for death rate for mutant and control group using correct formula	1
Part C	States yes and a reason comparing the death rates/birth rates for mutant and control groups	1

Chapter name	**Organisms and Populations**	
Essential Idea	In nature, populations of different species in a habitat do not live in isolation but interact in many ways.	
Item stem	While grazing, oxen disturb insects in the grass as they move. Egrets feed on these insects. There is no effect on oxen due to the activities of insects and egrets. Oxpecker (a bird) feeds on the ticks from the skin of the ox, reliving them from the parasites.  Describe the relationships labelled by the alphabets.	
Correct answer	A and F: Predation; C: Parasitism; D: Amensalism; B and E: Commensalism	Student understands the different interactions between two organisms in a population.
Distractor 1	A: Predation; C and F: Parasitism; D: Amensalism; B and E: Commensalism	Student misunderstands the difference between parasitism and predation.
Distractor 2	A: Predation; C: Parasitism; D: Commensalism; B and E: Amensalism	Student does not understand that in commensalism, one organism is benefitted and the other one remains unaffected.
Distractor 3	A and F: Predation; C: Amensalism; D: Parasitism; B and E: Commensalism	Student misunderstands the difference between parasitism and amensalism.

Chapter name	**Ecosystem**
Essential Idea	Productivity, decomposition, energy flow, and nutrient cycling are the four important components of an ecosystem.
Item stem	A group of ecologists studying the rate of biomass production in the rainforests of Andaman and Nicobar Islands reported the following results for a given year. Gross Primary Productivity (GPP) = 5000 g/m^2/year Net Primary Productivity (NPP) = 2200 g/m^2/year A. Using the above data calculate the amount of GPP is utilised by plants in respiration. B. A similar group was studying the rate of biomass production in the Thar desert. According to you, should their GPP observations be more or less than that for the Andaman and Nicobar rainforest? Justify. C. In the rainforest ecosystem, wolves feed on deer, and deer feed on plants. If the plants eaten by the deer are able to trap 657 MJ of energy through the process of photosynthesis, how much energy is available for the deer and wolves?

Marking Rubric

Part	Description	Marks
Sample answer	A. GPP – R = NPP R = GPP – NPP = 5000 – 2200 = 2800 g/m^2/year Respirational loss is 2800 g/m^2/year B. GPP of thar desert will be less than that of the rainforest. This is due to lesser biomass production in Thar as compared to a rain forest. C. Energy is available for the deer: 65.7 MJ (10% of what was trapped by plants) Energy is available for wolves: 6.57 MJ (10% of what was available for deer)	
Part A	Gives the correct formula for the relationship between GPP, NPP and Respirational losses.	0.5
Part A	Calculates respirational losses with proper units.	1
Part B	States that GPP of thar desert will be less than that of the rainforest	0.5
Part B	Gives appropriate justification involving biomass production	1
Part C	Calculates energy available for the deer and wolves using 10% rule (1 mark each)	2

Chapter name	**Ecosystem**	
Essential Idea	Decomposition involves three processes—fragmentation of detritus, leaching and catabolism., complex organic compound—where detritus is converted to carbon dioxide, water and inorganic nutrients by the decomposers.	
Item stem	Ryan performed an analysis of two different soil samples from two areas A and B. He recorded these results: Soil A: Lignin = 37%; Sugar = 5%; Chitin = 40%; Nitrogen = 18% Soil B: Lignin = 5%; Sugar = 35%; Chitin = 15%; Nitrogen = 45% Which of these is true about their rate of decomposition in both the soil?	
Correct answer	Soil A has slower rate of decomposition than soil B	Student understands decomposition rate is slower if soil detritus is rich in lignin and chitin but low on nitrogen and water - soluble substances like sugars.
Distractor 1	Soil A has faster rate of decomposition than soil B	Student misunderstands that decomposition rate is faster if soil detritus is rich in lignin and chitin but low on nitrogen and water - soluble substances like sugars.
Distractor 2	Both have the same rate of decomposition	Student misunderstands that lignin, chitin, sugar and nitrogen do not tell us about rate of decomposition.
Distractor 3	Insufficient information	Student misunderstands that lignin, chitin, sugar and nitrogen do not tell us about rate of decomposition.

Chapter name	**Biodiversity and Conservation**	
Essential Idea	Biodiversity exists at all levels of biological organisation--ecological, genetic and species.	
Item stem	Shayam and Rita have a house garden of same area. Shayam's garden is well-maintained, whereas Rita's garden is poorly maintained. Whose garden do you think will have more species diversity?	
Marking Rubric		
Part	**Description**	**Marks**
Sample answer	Rita's garden, which is poorly maintained, would have higher species diversity. A well-maintained garden will have all the weeds and unwanted plants removed, but a garden that is not cared for will have weeds and different plants with different abundance.	1
	Mentions Rita's Garden has higher biodiversity	0.5
	Explains the reason for the choice	0.5

Chapter name	**Biodiversity and Conservation**	
Essential Idea	Habitat loss, invasive species, overharvesting, pollution, and climate change are major threats to biodiversity and there is a need for conservation may be *in situ* as well as *ex situ*.	
Item stem	Area A and Area B have equal biodiversity (species richness). Plant species, Q, was introduced into both areas. Plant species Q couldn't get suitable soil conditions to grow in area B, but it grows very fast in area A. Which of these is true?	
Correct answer	The biodiversity of area A would decrease.	Student understands that the introduction of invasion species creates a threat to indigenous species, thereby decreasing biodiversity.
Distractor 1	The biodiversity of area B would decrease.	Student does not understand that the introduction of invasion species would decrease biodiversity.

Distractor 2	The biodiversity of area A would remain the same.	Student does not understand that the introduction of invasion species has an effect on biodiversity.
Distractor 3	The biodiversity of area A would increase.	Student does not understand that the introduction of invasion species would decrease biodiversity.

12. REFERENCE DOCUMENTS

1. Position paper: National focus group on teaching Social Studies, NCERT 2006
2. CBSE Draft Learning Objectives.
3. National Curriculum Framework, NCERT 2005
4. Biology Curriculum Document, 2021-22, NCERT
5. NCERT Class 11 Textbook – Biology
6. NCERT Class 12 Textbook – Biology

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